Message from the Chairman of Syllabus Committee

There was a long felt need for revising the Marine Engineering syllabus. In this version, the approach was to prepare Learning Objectives which are not only useful for shipboard functions but also fit for other purposes of higher studies etc.

In the Detailed Teaching Syllabus for each Subject/Course, an outcome-based learning process has been laid out with action verbs establishing the level of required comprehension along with the student learning time. This will help the Teacher on what is expected from the Learner. Also, the intensity of approach to the topics will be uniform across the University while disseminating knowledge.

The layout has ensured a vertical progression of basic and engineering concepts. The good spacing towards the end Semesters of the Programme provides for easy and free learning of new topics.

The Mechanical and Electrical content have been blended well, considering the multi-disciplinary nature of core Marine Engineering. The practical exercises including content on Electronics focus on concepts and applications. Provisions for credits transfer of few subjects, which may pave way for obtaining Minor degrees have been made.

The elective Micro-Credit Course baskets have been created providing scope for knowledge capture of latest developments by periodic additions and thereby updating the student's knowledge, without reworking on the Syllabus.

It is believed that these dynamic changes would provide the student a good base, if higher studies are aspired for. On the other hand, the enhancement of associated disciplines will also increase the employment opportunities in allied shore-based sectors.

It may be seen that the elements of New Education Policy and the AICTE Model Courses have been well considered. Further, the STCW requirements have been incorporated in word and spirit by adopting the IMO Model Course elements.

We welcome Faculty and other users of this Syllabus to provide inputs for improvements.
We earnestly hope that this effort will fare well among the Marine Engineering aspirants.

Dr Rajoo Balaji

Acknowledgements

The Committee wishes to thank all the Faculty Members of IMU Chennai & Kolkata Campuses, Tolani Maritime Institute and Samundra Institute of Maritime Studies who had contributed to shaping the Detailed Teaching Syllabus.

The help extended by all other support staff (Smt. Lalitha, Shri. Prabhu, Ms. Saira Banu of IMU CC), Dr. Pushpa for language checks and Dr. Odakkal Johnson for inputs on maritime heritage related learning objectives is acknowledged with gratitude.

The Committee wishes to acknowledge the inputs from DGS, various Industry stakeholders (e.g., MTIs, Shipping Companies etc.) and all others who had been supportive of these efforts.

Dr. Rajoo Balaji (Director IMU, Chennai Campus)
Dr. Sanjeet Kanungo (Vice Principal, Tolani Maritime Institute)
Mr. Jims Andrews (Principal, Samundra Institute of Maritime Studies)
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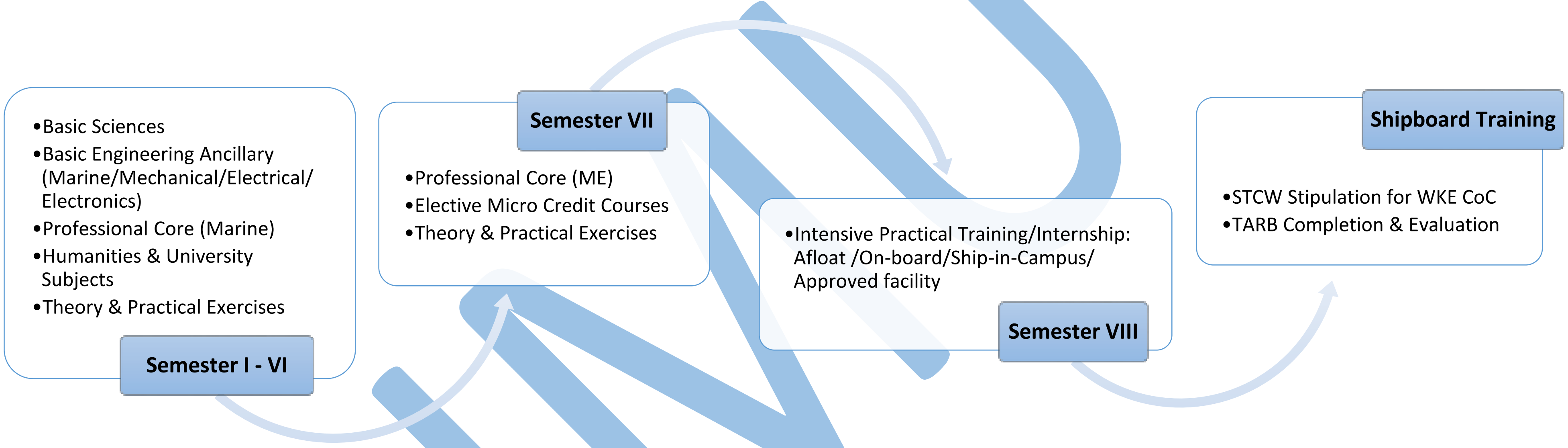
Mr. K. Anbazhahan (Associate Professor, IMU-Chennai Campus)

BACHELOR OF TECHNOLOGY (MARINE ENGINEERING)

PROGRAMME FLOW CHART



Notes:

1. The UG Degree is awarded after the successful completion of the required number of credits.
2. The Shipboard Training (additional 6 months) is applicable for shipboard career aspirants.

BACHELOR OF TECHNOLOGY (MARINE ENGINEERING)

General Notes:

1. The conduct of the Programme shall be in accordance with the Academic Calendar of IMU.
2. All examinations/evaluations/assessments (e.g., formative; summative; LMS based; practical examinations etc.) shall be in accordance with IMU Guidelines.
3. All Practical Examinations have to be completed by respective Institutes and documented well as per IMU's Guidelines.
4. The terms 'Subject' and 'Course' are used interchangeably; no grouping of Courses under a particular Subject has been done, except in case of Micro-Credit Courses where the groupings are under Baskets.
5. The reference to Semesters is conventionally in Arabic numerals or with ordinal numbering and at places may be in Roman numerals.
6. In case of any doubt, the Guidelines and decisions of IMU shall be final.

Reference:

The following were referred to while working on the Syllabus:

[1]. Standards of Training, Certification & Watchkeeping for Seafarers 1978 (as amended in 2010)

[2]. IMO Model Course 7.04 Officer in Charge of an Engineering Watch (2014)

[3]. IMO Model Course 7.02 Chief Engineer Officer and Second Engineer Officer (2014)

[4]. AICTE Model Curriculum for Undergraduate Courses for Engineering & Technology, Vol I & II (2018)

[5]. AICTE Credit Notification: AICTE (Credit Framework for online learning course through SWAYAM) Regulations, 2016 F. No. AICTE/P&AP/SWAYAM/2016.

[6]. NPTEL Basics of Credit Transfer

Mapping of Programme Education Outcomes [PEO] to Programme Learning Outcomes [PLO]

Programme Learning Outcomes [PLO]		Achievement of PEO		
		Three to five years after graduation, the graduate would be:		
		A Maritime professional who partakes and leads teams in problem solving tasks through analytical thinking and effective communication	A Maritime professional who continues to advance the knowledge and competencies to explore future developments in the maritime and related industries	A Maritime professional who practices ethical and professional values in providing services to the recipients and providers of the maritime industry and society at large
At the end of the programme, graduates should be able to:		PEO 1	PEO 2	PEO 3
PLO 1	[APPLY ENGINEERING KNOWLEDGE] Apply knowledge of mathematics, science, engineering fundamentals and engineering specialisation principles to defined and applied engineering procedures, processes, systems or methodologies [C, P]	H		
PLO 2	[BE COMPETENT] Understand and solve marine engineering problems systematically to reach substantiated results, using tools and techniques in a competent manner [C, P]	H		
PLO 3	[DESIGN SOLUTIONS] Design solutions for broadly-Defined engineering technology problems, and to design systems, components or processes to meet specified needs with appropriate consideration for public health and safety, as well as cultural, societal, environmental and sustainability concerns [C]	M		
PLO 4	[DO BASIC RESEARCH] Plan and conduct experimental investigations of broadly-defined problems, using data from relevant sources [C, P]		L	
PLO 5	[USE MODERN TOOLS] Select and apply appropriate techniques, resources and modern engineering tools for problem solving with an understanding of their limitations [C, P]		M	
PLO 6	[LEAD] Function effectively as individuals, and as members or leaders in diverse technical teams [P, A]		M	
PLO 7	[COMMUNICATE] Communicate effectively with the engineering community and society at large [P]	M		
PLO 8	[CARE FOR HEALTH, SAFETY, SOCIETY] Demonstrate an awareness of and consideration for societal, health, safety, legal and cultural issues and their consequent responsibilities [A, P]			H
PLO 9	[BE ETHICAL] Demonstrate an understanding of professional ethics, responsibilities and norms of engineering technology practices [A]	H		
PLO 10	[BE AN ENTREPRENEUR] Demonstrate an awareness of management, business practices and entrepreneurship [C, P]			M
PLO 11	[UNDERSATND SUSTAINABILITY] Demonstrate an understanding of the impact of engineering practices, taking into account the need for sustainable development [C, P]		M	
PLO 12	[PURSUE LIFELONG LEARNING] Recognise the need for professional development and to engage in independent and lifelong learning [C]			H

Domains: [C] Cognitive; [P] Psychomotor; [A] Affective **Impact:** H High; M Medium; L Low

INDEX

Notes:

1. MC Courses are grouped under various Baskets and placed under Section 'Appendix to Syllabus Micro Credit Courses'.
2. Skeletal Guidelines on Micro Credit Courses are provided in the Section 'Appendix to Syllabus Micro Credit Courses'.

LEGEND FOR COURSE CURRICULUM/DTS

1. Learning Mode: LECTURE [L]; TUTORIAL [T]; PRACTICAL [P]; SELF-LEARNING [SL]; ASSESSMENTS [As]
2. Domains: Cognitive [C]; Psychomotor [P]; Affective [A]
3. Impact: High [H]; Medium [M]; Low [L]

Subjects/Courses Classification:

4. Basic Science [BS]
5. Basic Engineering Ancillary [BEA]
6. Professional Core [PC]
7. Humanities University Courses [HUC]
8. Micro Credit Elective [MCE]

STCW Functions:

9. Marine Engineering at the Operational/Management Level [F1]
10. Electrical, Electronic and Control Engineering at the Operational/Management Level [F2]
11. Maintenance and Repair at the Operational/Management Level [F3]
12. Controlling the Operation of the Ship and Care for Persons on Board at the Operational/Management Level [F4]

COURSE CURRICULUM

S.No.	COURSES	Code	IMU Code	L	T	P	SL	As	TOTAL	CREDITS	IMPACT	CLASSIFY	DOMAIN/ STCW FUNCTION
	First Semester												
1	Mathematics 1	101	UG11T4101	45	15		90	10	160	4	M	BS	C; F1
2	Physics	102	UG11T4102	45			45	10	100	3	M	BS	C; F1
3	Computers	103	UG11T4103	30	15		60	10	115	3	M	BS	C; P
4	Industrial Chemistry	104	UG11T4104	30			30	10	70	2	M	BS	C; F1
5	Workshop Technology	105	UG11T4105	30			15	10	55	2	H	PC	C; F1; F3
6	Maritime Awareness	106	UG11T4106	30			60	10	100	2	M	HUC	C; A
7	English and Communication	107	UG11T4107	45			45	10	100	3	M	HUC	C; A; F1
8	Essence of Indian Traditional Knowledge	108		30			30	10	70	0	L	HUC	C; A
9	Constitution of India and Merchant Shipping Act	109		15			30	10	55	0	L	HUC	C; A
	Practical Laboratories/Workshops												
1	Physics	110	UG11P4101			30	5	10	45	1	M	BS	P; F1
2	Workshop Technology	111	UG11P4102			60	5	10	75	2	H	PC	P; F1; F3
3	Marine Engineering Graphics	112	UG11P4103			45	15	10	70	1.5	M	PC	P; F1
4	English and Communication Lab	113	UG11P4104			45	5	10	60	1.5	M	HUC	P; A; F1
				300	**30**	**180**	**435**	**130**	**1075**	**25**			

S.No.	COURSES	Code	IMU Code	L	T	P	SL	As	TOTAL	CREDITS	IMPACT	CLASSIFY	DOMAIN/ STCW FUNCTION
	Second Semester												
1	Mathematics 2	201	UG11T4201	45	15		75	10	145	4	M	BS	C;F1
2	Basic Electrical Engineering	202	UG11T4202	45			75	10	130	3	H	BEA	C;P;F2
3	Basic Electronics	203	UG11T4203	45			105	10	160	3	H	BEA	C;P;F2
4	Engineering Mechanics	204	UG11T4204	45	15		75	10	145	4	H	BEA	C;P;F1
5	Basic Thermodynamics	205	UG11T4205	45	15		95	10	165	4	H	BEA	C;P;F1
6	Marine Electrical Power Generation and Distribution	206	UG11T4206	15	15		15	10	55	2	H	PC	C;P;F2
	Practical Laboratories/Workshops												
1	Basic Electrical Engineering	207	UG11P4201			15	5	10	30	0.5	H	BEA	
2	Basic Electronics	208	UG11P4202			45	5	10	60	1.5	H	BEA	
3	Marine Engineering Drawing	209	UG11P4203			60	30	10	100	2	H	BEA	C;P;F1
4	Ship Familiarization	210	UG11P4204			45	5	10	60	1.5	H	PC	C
5	Marine Workshop (Mechanical)	211	UG11P4205			60	5	10	75	2	H	PC	P;F1;F3
				240	**60**	**225**	**490**	**110**	**1125**	**27.5**			

S.No.	COURSES	Code	IMU Code	L	T	P	SL	As	TOTAL	CREDITS	IMPACT	CLASSIFY	DOMAIN/ STCW FUNCTION
	Third Semester												
1	Basic Control Engineering	301	UG11T4301	45			45	10	100	3	H	BEA	C;P;F2
2	Solid Mechanics	302	UG11T4302	45			45	10	100	3	H	BEA	C;P;F1
3	Fluid Mechanics	303	UG11T4303	30			30	10	70	2	H	BEA	C;P;F1
4	Applied Thermodynamics	304	UG11T4304	45			60	10	115	3	H	BEA	C;P;F1
5	Statistics and Data Analysis using Python and R	305	UG11T4305	30	15		45	10	100	3	L	BEA	C;P
6	Marine Machinery Systems	306	UG11T4306	45	15		45	10	115	4	H	PC	C;F1;F2;F3
7	Electrical Machines	307	UG11T4307	45	15		45	10	115	4	H	PC	C;P;F2
8	Mechanics of Machines	308	UG11T4308	15	30		15	10	70	3	H	PC	C
	Practical Laboratories/Workshops												
1	Basic Control Engineering	309	UG11P4301			25	5	10	40	1	H	BEA	P;F2
2	Solid Mechanics	310	UG11P4302			30	5	10	45	1	H	BEA	P;F1
3	Fluid Mechanics	311	UG11P4303			30	5	10	45	1	H	BEA	P;F1
4	Applied Thermodynamics and Industrial Chemistry	312	UG11P4304			30	5	10	45	1	H	BEA	P;F1
5	Marine Workshop (Electrical Safety, Maintenance and Repair)	313	UG11P4305			45	5	10	60	1.5	H	PC	P;F2;F3
				300	**75**	**160**	**355**	**130**	**1020**	**30.5**			

S.No.	COURSES	Code	IMU Code	L	T	P	SL	As	TOTAL	CREDITS	IMPACT	CLASSIFY	DOMAIN/ STCW FUNCTION
	Fourth Semester												
1	Strength of Materials	401	UG11T4401	45			45	10	100	3	H	BEA	C;F1
2	Marine Turbo Machinery	402	UG11T4402	30	15		45	10	100	3	H	PC	C;F1
3	Marine Internal Combustion Engines and Technology 1	403	UG11T4403	60			60	10	130	4	H	PC	C;F1
4	Marine Pollution Prevention and Safety	404	UG11T4404	60			60	10	130	4	H	PC	C;A;F4
5	Electro Technology	405	UG11T4405	45			45	10	100	3	H	PC	C;F2
6	Marine Boilers and Steam Systems	406	UG11T4406	60			60	10	130	4	H	PC	C;F1
7	Automation, Control Engineering and Safety Devices	407	UG11T4407	45			45	10	100	3	H	PC	C;F2
8	Refrigeration and Air Conditioning	408	UG11T4408	45			45	10	100	3	H	PC	C;F1
	Practical Laboratories/Workshops												
1	Automation, Control Engineering and Safety Devices	409	UG11P4401			25	5	10	40	1	H	PC	P;F1;F3
2	Marine Engineering Skills	410	UG11P4402			60	5	10	75	2	H	PC	P;F1;F3
				390	**15**	**85**	**415**	**100**	**1005**	**30**			

S.No.	COURSES	Code	IMU Code	L	T	P	SL	As	TOTAL	CREDITS	IMPACT	CLASSIFY	DOMAIN/ STCW FUNCTION
	Fifth Semester												
1	Introduction to CFD	501	UG11T4501	45			90	10	145	3	L	BEA	C
2	Marine Internal Combustion Engines and Technology 2	502	UG11T4502	60			60	10	130	4	H	PC	C;F1
3	Marine Auxiliary Systems and Deck Machinery	503	UG11T4503	60			60	10	130	4	H	PC	C;F1
4	Marine Steam Plant	504	UG11T4504	45			90	10	145	3	H	PC	C;F1
5	Naval Architecture 1	505	UG11T4505	60			120	10	190	4	H	PC	C;F4
6	Ship Structure and Marine Shafting	506	UG11T4506	30			60	10	100	2	H	PC	C;F1;F4
7	Marine Design: Pressure Vessels, Machinery Components and Vibrations	507	UG11T4507	30	15		35	10	90	3	H	PC	C;F1
8	Marine Electrical Motors: Starters and Drive Controls	508	UG11T4508	15	15		15	10	55	2	H	PC	C;F2
9	Heat Transfer and Marine Heat Exchangers	509	UG11T4509	30	15		60	10	115	3	H	PC	C;F1
	Practical Laboratories/Workshops												
1	Marine Steam Plant	510	UG11P4501			15	5	10	30	0.5	H	PC	C;P;F1
2	Marine Simulators: Plant and Machinery Systems	511	UG11P4502			60	5	10	75	2	H	PC	C;P;F1
				375	**45**	**75**	**600**	**110**	**1205**	**30.5**			

S.No.	COURSES	Code	IMU Code	L	T	P	SL	As	TOTAL	CREDITS	IMPACT	CLASSIFY	DOMAIN/ STCW FUNCTION
	Sixth Semester												
1	Artificial Intelligence and Machine Learning	601	UG11T4601	30			30	10	70	2	M	BEA	C
2	Marine Machinery Systems and Design	602	UG11T4602	60	15		60	10	145	5	H	PC	C;F1
3	Marine Propulsion Plant: Configuration and Characteristics	603	UG11T4603	30			30	10	70	2	H	PC	C;F1
4	Marine Propulsion Plant and Auxiliary Machinery: Performance Assessment	604	UG11T4604	30	30		45	10	115	4	H	PC	C;P;F1
5	Naval Architecture 2	605	UG11T4605	60			60	10	130	4	H	PC	C;F4
6	Shipboard Safety Management	606	UG11T4606	30	30		45	10	115	4	H	PC	C;P;A;F4
	Practical Laboratories/Workshops												
1	Marine Simulators: Electrical, Propulsion and Manoeuvring	607	UG11P4601			60	5	10	75	2	H	PC	C;P;F1
2	Marine Propulsion Plant: Configuration and Characteristics	608	UG11P4602			30	5	10	45	1	H	PC	C;P;F1
3	Technical Report writing and Engineering Models	609	UG11P4603			25	25	10	60	1	M	PC	C;P;A
4	Practical Hydraulics and Pneumatics	610	UG11P4604			45	5	10	60	1.5	H	PC	C;P
				240	**75**	**160**	**310**	**100**	**885**	**26.5**			

S.No.	COURSES	Code	IMU Code	L	T	P	SL	As	TOTAL	CREDITS	IMPACT	CLASSIFY	DOMAIN/ STCW FUNCTION
	Seventh Semester												
1	Piping and Pumping Systems: Design and Operation	701	UG11T4701	30	15		45	10	100	3	H	PC	C; F1
2	PLC and Automation Control	702	UG11T4702	45			45	10	100	3	H	PC	C; F2
3	Management Principles of Ship Operation	703	UG11T4703	60			60	10	130	4	M	PC	C; F4
4	Maritime Law and Ship's Business	704	UG11T4704	45	15		60	10	130	4	L	PC	C; F4
5	Marine Materials	705	UG11T4705	45			45	10	100	3	H	PC	C; F1; F3
6	Fuels and Lubricants	706	UG11T4706	45			45	10	100	3	H	PC	C; F1
7	Sea Trials, Dry docking, Shipyard	707	UG11T4707	30	15		45	10	100	3	H	PC	C; F3
8	Micro Credit Course	MC71			8		7	10	25	1	M	MCE	C
9	Micro Credit Course	MC72			8		7	10	25	1	M	MCE	C
10	Micro Credit Course	MC73			8		7	10	25	1	M	MCE	C
11	Micro Credit Course	MC74			8		7	10	25	1	M	MCE	C
	Practical Laboratories/Workshops												
1	PLC and Automation Control	708	UG11P4701			30	5	10	45	1	H	PC	C; P; F2
2	Maintenance and Repair of Electrical, Electronic and Automation Systems	709	UG11P4702			60	5	10	75	2	H	PC	P; F2; F3
				300	**77**	**90**	**383**	**130**	**980**	**30**			

S.No.	COURSES	Code	IMU Code	L	T	P	SL	As	TOTAL	CREDITS	IMPACT	CLASSIFY	DOMAIN/ STCW FUNCTION
	Eighth Semester												
1	Practical Training with Assignment and Project Work (With TARB)	801	UG11P4801			700		10	710	15	H	PC	P; A; F1; F2; F3; F4
				0	**0**	**700**	**0**	**10**	**710**	**15**			
				2145	**377**	**1675**	**2988**	**820**	**8005**	**215**			
	Totals									**215**			
	Total L+T+P (Hours)					**4197**							
	Total LTP + As (Hours)					**5017**							
	Total SLT (LTPAs + SL)					**8005**							

Notes:

1. Subject/Course Codes: Where no IMU Codes are present, General Code will be referred to.

2. Lecture, Tutorial, Practical hours: Indicative only. Can vary depending on the intensity and the assimilation capacity of the cohorts.

3. Assessment hours: Approximate hours for internal/final examinations/tests and preparation. Indicative only. Actual hours will vary.Not for strict adherence.

4. Self-Learning hours: Approximate (non-contact) hours spent by the student. Indicative only. Actual hours will vary. Not for strict adherence.

5. Micro Credit Courses: The hours are indicative only. The actual hours for Micro-Credit will vary depending on the intensity of the included topics.

6. TARB: The Training, Assessment Record Book refers to the MTI's practical training (e.g., Ship-in-Campus; Afloat; Approved Marine Workshops etc.).*

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BACHELOR OF TECHNOLOGY (MARINE ENGINEERING)

DETAILED TEACHING SYLLABUS

Notes:

1. All Objectives are prefixed with the words 'At the end of the lecture, the learner/student should be able to …'
2. If SLOs are descriptive with the action verb 'Able to', it is redundant; but it implies the same as Note #1.
3. If SLOs are non-descriptive with action verbs, it will imply that the 'learner/student will be able to explain' the mentioned Objective.
4. If Action Verbs do not confirm strictly to the Taxonomy Domain or more than one Action Verb is employed (e.g., Explain and demonstrate; Define and explain etc.), the Trainers may use their discretion during deliveries on the intensity and depth required. The Lesson Plans may be structured accordingly.
5. At few instances, Additional Objectives are provided for guidance during dissemination and self-learning.
6. The Additional Objectives are intended to help in progressing to next level under the same Subject/Course.
7. Also, the Additional Objectives may be effectively used for framing assessment questions.
8. Instances of topics' repetition are due to relevance to the context as also for comprehensiveness (e.g., IMO Model Course content). Trainers may structure the Lesson Plans for deliveries to avoid repetition of same SLOs.
9. Prerequisites are identified for easier dissemination of knowledge only. It is not to be construed that the student must have completed the requisite Subject/Course with no arrears etc.
10. The L, T, P hours are indicated based on experience of Trainers, IMO Model Course etc. The Trainers may use their discretion during deliveries based on the student cohorts' background, assimilation capacities as also the intensity and depth requirements for the Specific Learning Objectives.
11. Where mentioned, Assessment and Self-Learning hours are for guidance only and not for strict adherence during deliveries.
12. Practical Exercises (Laboratory/Workshops etc.) have been grouped separately for easier dissemination and assessments.
13. Under the Theory portion of the DTS if there be scope for practical work, the same may be adopted.
14. During Practical exercises, apart from available equipment, desk top models, simulator images, engineering drawings, images etc., may be used for illustration, both by the Trainer and the Student, where required.
15. For Practical Laboratory Exercises, Working Manuals may be generated and used (e.g., Practical Hydraulics & pneumatics). Such works may be shared between MTIs/Campuses.
16. It is suggested that modern eLearning tools may be used freely to complement training through direct contact and distance (e.g., online) modes (e.g., Virtual Lab; LMS question generators; video training packages; CBTs etc.).

SEMESTER 1

Subject Name/Code: Mathematics 1/101

Instructional hours:

Lecture	: 45 hours
Tutorial	: 15 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. AICTE Model Course: Prerequisite for Mechanical/Electrical Engineering UG Programmes.

Recommended Text:

1. B.S. Grewal (2015); Higher Engineering Mathematics; Khanna Publishers; 43rd Edition.

Reference:

1. Dennis G. Zill and Warren S. Wright (2011); Advanced Engineering Mathematics; Fourth Edition; Jones & Bartlett.
2. G.B. Thomas and R.L. Finney (2002); Calculus and Analytic geometry; 9th Edition; Pearson.
3. Erwin Kreyszig (2006); Advanced Engineering Mathematics; 9th Edition; John Wiley & Sons.
4. Veerarajan T. (2008); Engineering Mathematics for first year; Tata McGraw Hill; New Delhi.
5. Ramana B.V. (2010); Higher Engineering Mathematics; Tata McGraw Hill New Delhi; 11th Reprint.
6. N.P. Bali and Manish Goyal (2008); A text book of Engineering Mathematics; Laxmi Publications.

Table of Topics

Section	Topics	Hours (L:T)
A1-A3	**Calculus** **Sub-Topics:** Calculus of single variable, Multivariable Differential Calculus, Multivariable Integral Calculus	34 : 11
B1	**Linear Algebra** **Sub-Topics:** Matrices	11 : 4
	Total	**45:15**

Learning Objectives	L : T
A. Understand the mathematical techniques and constructs based on calculus	
General Learning Objective Understand basics of calculus and apply in problems **A1 Sub-topic: Calculus** **Sub-subtopics & SLOs** 1.1 Successive Differentiation 1.2 Taylor's and Maclaurin series 1.3 Indeterminate forms and L'Hospital's rule 1.4 Beta and Gamma functions and their properties 1.5 Surface areas and volumes of revolutions	**12: 3**
Specific Learning Objectives: **1.1 Successive Differentiation** 1.1.1 Define Successive differentiation and notation 1.1.2 Find the n^{th} order derivatives of standard functions 1.1.3 Find the n^{th} order derivatives using trigonometric identities 1.1.4 Find the n^{th} order derivatives using partial fractions 1.1.5 State Leibnitz' Theorem. 1.1.6 Use Leibnitz' Theorem in problem solving	3 : 0
Specific Learning Objectives: **1.2 Taylor's and Maclaurin series** 1.2.1 State Taylor's and Maclaurin's theorem 1.2.2 Expand standard functions e^x, sinx, cosx, tanx, sinhx, coshx, tanhx, log(1+x), $\sin^{-1} x$, $\cos^{-1} x$ 1.2.3 Apply Maclaurin's and Taylor's series to solve problems	3 : 0
Specific Learning Objectives: **1.3 Indeterminate forms and L'Hospital's rule** 1.3.1 Explain Seven types of Indeterminate forms 1.3.2 State the L'Hospital's rule 1.3.3 Use L'Hospital's rule to evaluate the limit of the given indeterminate form	1 : 1
Specific Learning Objectives: **1.4 Beta and Gamma functions and their properties** 1.4.1 Define Beta and Gamma functions 1.4.2 State and prove the following Properties: a) $\lceil 1 = 1$ b) $\lceil 0 = \infty$	3 : 1

c) $\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$ d) $\Gamma(n+1) = \begin{cases} n! & \text{if n is integer} \\ n\,\Gamma(n) & \text{if n is noninteger} \end{cases}$ e) $\beta(m,n) = \beta(n,m)$ f) $\int_0^{\pi/2} \sin^p\theta \cdot \cos^q\theta\, d\theta = \frac{1}{2}\beta\left(\frac{p+1}{2}, \frac{q+1}{2}\right)$ g) Relation between Beta and Gamma $\beta(m,n) = \frac{\Gamma(m)\,\Gamma(n)}{\Gamma(m+n)}$ 1.4.3 Evaluate the given integral by using Beta function 1.4.4 Evaluate the given integral by using Gamma function	
Specific Learning Objectives: **1.5 Surface areas and volumes of revolutions** 1.5.1 Evaluate Surface area and volume of revolution about an x axis of given Cartesian curve 1.5.2 Evaluate Surface area and volume of revolution about an x axis of given parametric curve 1.5.3 Evaluate Surface areas and volume of revolution about an x axis of given polar curve	2 : 1
General Learning Objective Understand Multivariable Calculus of real and vector functions with applications **A2 Sub-topic: Multivariable Calculus (Differentiation)** **Sub-subtopics & SLOs:** 2.1 Partial Differentiation 2.2 Application of Partial differentiation 2.3 Velocity and Acceleration of moving particle on curve 2.4 Gradient 2.5 Divergence and Curl	**11 : 4**
Specific Learning Objectives: **2.1 Partial Differentiation** 2.1.1 Define functions of several variables 2.1.2 Define partial derivatives and geometrical interpretation of the derivatives 2.1.3 Find the first and higher order partial derivatives of given function 2.1.4 Define total differentials and Chain Rule 2.1.5 Solve problems using chain rule 2.1.6 Define Composite function and Implicit function 2.1.7 Solve problems based on composite and implicit functions 2.1.8 Define Homogeneous function 2.1.9 State Euler's theorem on homogeneous functions with two and three independent variables 2.1.10 Use Euler's theorem to solve problems	3 : 1
Specific Learning Objectives: **2.2 Application of Partial differentiation** 2.2.1 Define maxima, minima and saddle point of a function of two variables 2.2.2 Find maxima, minima and saddle point of a given function of two variables 2.2.3 Solve problems using Lagrange's method of undetermined multipliers	2 : 1
Specific Learning Objectives: **2.3 Velocity and Acceleration of moving particle on curve** 2.3.1 Define curve, tangent of a vector function 2.3.2 Define velocity and acceleration 2.3.3 Find the unit tangent vector to the given curve 2.3.4 Find the velocity and acceleration from the given position vector of particle	1 : 1
Specific Learning Objectives:	2 : 0

2.4 Gradient 2.4.1 Define scalar point functions and fields 2.4.2 Define gradient of a scalar point function 2.4.3 Explain the geometrical interpretation of the gradient 2.4.4 Find the gradient of a given scalar point function 2.4.5 Find the directional derivative of a given scalar point function	
Specific Learning Objectives: **2.5 Divergence and Curl** 2.5.1 Define vector point functions and fields 2.5.2 Define divergence and curl of a vector point function 2.5.3 Find the divergence and curl of a vector point function. 2.5.4 Explain the physical interpretation of the divergence and curl of a vector point 2.5.5 Explain the concept of solenoidal and irrotational vector fields 2.5.6 Check whether the given vector field is a solenoidal vector field 2.5.7 Check whether the given vector field is an irrotational vector field	3 : 1
General Learning Objective Understand Multivariable Calculus of real and vector functions with applications **A3 Sub-subtopic: Multivariable Calculus (Integration)** **Sub-subtopics & SLOs:** 3.1 Double integrals 3.2 Triple integrals 3.3 Applications of Multiple Integrals 3.4 Vector Integral calculus	**11 : 4**
Specific Learning Objectives: **3.1 Double integrals** 3.1.1 Define double Integral and its region of integration 3.1.2 Evaluate the given double integrals with given limits 3.1.3 Evaluate the given double integrals with given region of integration 3.1.4 Change the order of the integration and evaluate the given double integration 3.1.5 Solve the given double integral using polar coordinate	3 : 1
Specific Learning Objectives: **3.2 Triple integrals** 3.2.1 Define Triple Integral 3.2.2 Evaluate the given triple integrals with given limits 3.2.3 Evaluate the given triple integrals over the given solid 3.2.4 Analyse the given triple integral by using spherical polar coordinate 3.2.5 Evaluate the given triple integral by using cylindrical polar coordinate	2 : 1
Specific Learning Objectives: **3.3 Applications of Multiple Integrals** 3.3.1 Find the area bounded by the given curves by double integration 3.3.2 Find the mass of lamina 3.3.3 Find the centroid for given lamina 3.3.4 Find the volume of the given solid 3.3.5 Find the mass of the given solid 3.3.6 Find the centroid for given solid	3 : 1
Specific Learning Objectives: **3.4 Vector Integral calculus** 3.4.1 Evaluate the given line integral 3.4.2 Find the work done in moving the particle along the curve under the force F 3.4.3 Show that the given force is conservative vector filed 3.4.4 Use Stokes theorem to evaluate given surface integral 3.4.5 Use Greens theorem to evaluate given line integral 3.4.6 Use Gauss theorem to evaluate the given surface integral	3 : 1
B. Understand Linear Algebra applications and solve technical situations	

General Learning Objective: Understand Matrices and their applications **B1 Sub-subtopic: Matrices** **Sub-subtopics & SLOs:** 1.1 Rank of matrix and System of linear equations 1.2 Applications of System of linear equations 1.3 Eigenvalues and eigenvectors 1.4 Applications of eigenvalues and eigenvectors 1.5 Linear dependence and independence of vectors 1.6 Cayley-Hamilton Theorem	**11 : 4**
Specific Learning Objectives: **1.1 Rank of matrix and System of linear equations** 1.1.1 Define rank of matrix 1.1.2 Define row echelon form of a matrix 1.1.3 Obtain the rank of given matrix by reducing it to the row echelon form 1.1.4 Solve the examples on systems of nonhomogeneous equations 1.1.5 Solve the examples on systems of homogeneous equations	4 : 1
Specific Learning Objectives: **1.2 Applications of System of linear equations** 1.2.1 Define Kirchhoff's current and voltage law 1.2.2 Solve the given electrical network problem 1.2.3 Solve the given traffic flow problem	1 : 1
Specific Learning Objectives: **1.3 Eigenvalues and eigenvectors** 1.3.1 Define Eigen values and Eigen vectors 1.3.2 Find the Eigen values and Eigen vectors of given matrix of order two 1.3.2 Find the Eigen values and Eigen vectors of given matrix of order three	2 : 0
Specific Learning Objectives: **1.4 Applications of eigenvalues and eigenvectors** 1.4.1 Solve the given elastic deformation problem 1.4.2 Solve the given mass spring problem	2: 1
Specific Learning Objectives: **1.5 Linear dependence and independence of vectors** 1.5.1 Define Linearly independent and dependent vectors 1.5.2 Check whether the given set of vectors are linearly dependent or independent	1 : 0
Specific Learning Objectives: **1.6 Cayley-Hamilton Theorem** 1.6.1 State Cayley Hamilton theorem 1.6.2 Use Cayley Hamilton theorem and find the inverse of given matrix and find A^n 1.6.3 Find the characteristic equation of the symmetric matrix hence obtained A^{-1} and express linear polynomial in A	1 : 1

Subject Name/Code: Physics/102

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom lectures and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Electrical Technology volume 1 by B. L. Theraja.
2. Applied Mechanics, J. Hannah and M.J. Hiller, Longman,1998, ISBN:9780582256323.

Reference:

1. A textbook of Engineering Mechanics by R.S Khurmi.
2. A textbook of Engineering Mechanics by Dr. K Bansal.
3. Engineering Mechanics Statics and Dynamics by Rajasekaran, S. and Sankarasubramanian, G.

Table of Topics

Section	Topics	Hours (L)
A1-A2	**Electrostatics** **Subtopics**: Static electricity, Permittivity, Coulomb's laws, forces in an electric field, electric intensity, Gauss's Law, Biot Savart's law, Electric potential, Potential difference, Potential at a point, equipotential point, potential gradient, dielectric strength.	5
B1:B2	**Electric current** **Subtopics**: Ohm's law, Drift of Electrons and the Origin of Resistivity, Limitations of Ohm's Law, Resistivity of various Materials, Temperature Dependence of Resistivity, Electrical Energy, Power.	6
C1-C2	**Electrical Conductivity** **Subtopics**: Electrical conductivity of and electrolyte, Flow of electric current and current generator	4
D1-D2	**Stationary magnetic field and magnetic** **Subtopics:** Magnetic phenomenon, Diamagnetic, Paramagnetic and ferromagnetic, Gyromagnetic effect.	3
E1	**Electromagnetic Induction and Quasi-stationary alternating current** **Subtopics:** Three phase and single-phase AC system, Mutual inductance	5
F1	**Introduction to Mechanics** **Subtopics:** scalar and vector quantities, Define force, graphical representation of force, characteristics of force, system of forces.	2
G1	**Composition and Resolution of forces** **Subtopics:** Resultant force, resolution of forces, composition of forces, triangle law of forces, law of parallelogram of forces, polygon law of forces, equilibrium of forces, free body diagrams, Lami's theorem, equilibrium conditions for coplanar concurrent forces.	8
H1	**Moment of force, couple and support reactions** **Subtopics:** Moment of force about a point, principle of moments, couple, moment of couple, types of supports, equilibrium conditions for non-coplanar, non-concurrent force system.	6
I1	**Introduction to friction and its application** **Subtopics:** Principles of friction, equilibrium of body on rough surface, application of friction	6
	Total	**45**

Learning Objectives	(L)
A. Electrostatics (7.04,2014: F2/2.1.1, F2/2.1.2)	**5**
General Learning Objective Understand the basics of electricity at rest i.e., static electricity and the laws governing it **A1. Sub-topic: Static Electricity and forces** **Sub-subtopics & SLOs** 1.1 **Static Electricity** 1.2 **Forces in electric field**	2
1.1 Static Electricity 1.1.1 Explain Static Electricity 1.1.2 Define absolute and relative permittivity of medium 1.1.3 State Laws of electrostatics 1.1.4 State Coulomb's law 1.1.5 Explain Biot Savart's Law	1
1.2 Forces in electric field 1.2.1 Explain tubes of force in electric field 1.2.2 Define electrostatic induction Explain flux and Faraday's tubes 1.2.3 Define electric intensity	1
A2. Sub-topic: Electric Potential **Sub-subtopics & SLOs** **2.1 Electric potential**	3
2.1 Electric potential 2.1.1 Explain idea of electric potential 2.1.2 Explain potential and potential difference 2.1.3 Derive expression for potential at a point 2.1.4 Explain potential of a charged conducting sphere 2.1.5 Explain equipotential surfaces 2.1.6 Define potential gradient 2.1.7 Explain dielectric strength and its boundary conditions	3
B. Electric current (7.04,2014: F2/2.1.1, F2/2.1.2)	**6**
General Learning Objective Understand the basics of resistance, resistivity, work and power related to electricity **B1. Sub-topic: Basics of resistance** **Sub-subtopics & SLOs** 1.1 **Resistance** 1.2 **Temperature effect on resistance**	4
1.1 **Resistance** 1.1.1 Explain electric current and Electric Currents in Conductors 1.1.2 Define electron drift velocity 1.1.3 Explain charge velocity and velocity of field propagation 1.1.4 Explain resistance, its unit and law of resistance 1.1.5 Explain resistivity 1.1.6 Define conductance and conductivity 1.1.7 Explain Ohm's law and its limitations	2
1.2 **Temperature effect on resistance** 1.2.1 Explain the effect of temperature on resistance 1.2.2 Define temperature coefficient of resistance 1.2.3 Explain value of α at different temperatures	2
B2. Sub-topic: Work and power **Sub-subtopics & SLOs** 2.1 Explain Joule's Law 2.2 Explain work and power 2.3 Explain thermal efficiency in electrical heating	2
C. Electrical Conductivity (7.04,2014: F2/2.1.1, F2/2.1.2)	**4**

General Learning Objective Understand the basics of electric current and conductivity, types of electrolytes and flow of current through metals and semiconductors **C1. Sub-topic: Electrical conductivity and electrolyte** **Sub-subtopics & SLOs** 1.1 Explain conductivity for electric current 1.2 Explain the material having conductivity like metals, semiconductors 1.3 Explain different types of electrolytes and flow of current through it 1.4 Define skin effect 1.5 Explain chemical and thermal current generators	2
C2. Sub-topic: Direct current **Sub-subtopics & SLOs** 2.1 Explain linear circuits 2.2 Explain Kirchhoff's laws 2.3 Explain short and open circuits 2.4 Explain current division rule 2.5 Explain voltage division rule	2
D. Stationary Magnetic field and magnetics (7.04,2014: F2/2.1.1, F2/2.1.2)	**3**
General Learning Objective Understand magnetic phenomenon and learn the properties of different material relating magnetism **D1. Sub-topic: Magnetic phenomenon** **Sub-subtopics & SLOs** **1.1** Magnetism and magnetic Intensity **1.2** Permanent magnet and Electromagnet **1.3** Relation between B, H, I and K **1.4** Explain Hall effect	3
Specific Learning Objectives: **1.1 Magnetism and Magnetic Intensity** 1.1.1 Explain terms magnetism, magnetic intensity, magnetic potential, and flux per unit 1.1.2 Explain laws of magnetic force 1.1.3 Explain composite series magnetic circuits 1.1.4 Compare electric and magnetic circuit	0.5
Specific Learning Objectives: **1.2 Permanent magnet and electromagnet** 1.2.1 Explain the difference between permanent magnet and electromagnet 1.2.2 Explain applications of electromagnet	0.5
Specific Learning Objectives: **1.3 Relation between B, H, I and K** 1.3.1 Explain magnetic flux density and magnetic field strength 1.3.2 Plot BH curve 1.3.3 Explain Ampere circuital law and solve numerical	1
D2. Sub-topic: Diamagnetic, Paramagnetic and ferromagnetic, Gyromagnetic effect **Sub-subtopics & SLOs** 2.1 Define Diamagnetic, paramagnetic and ferromagnetic material and identify them 2.2 Compare paramagnetic and ferromagnetic material 2.3 List the devices in which above materials are used 2.4 Explain Gyromagnetic effect	1
E. Electromagnetic Induction and Quasi-stationary alternating current (7.04,2014: F2/2.1.1, F2/2.1.2)	**5**
General Learning Objective	

Understand single phase and three phase values of quantities and analyse Quasi-Stationary alternating current **E1. Sub-topic: Three phase and single-phase ac system** **Sub-subtopics & SLOs** **1.1.** Single phase and Three phase AC systems **1.2.** Electromagnetic Induction **1.3.** Mutual Induction	
Specific Learning Objectives: **1.1 Single phase and Three phase AC system** 1.1.1 Understand single phase and three phase AC 1.1.2 Calculate and Define RMS and average value of AC 1.1.3 Define terms frequency, cycle, time period 1.1.4 Draw the wave forms for AC current and voltage, identify leading and lagging waveforms 1.1.5 Explain three terminal networks and four terminal networks	1
Specific Learning Objectives: **1.2 Electromagnetic induction** 1.2.1 Explain laws of electromagnetic Induction 1.2.2 State Lenz's law 1.2.3 Explain Fleming's right hand rule and Fleming's left hand rule 1.2.4 Define Quasi-stationary alternating current	2
Specific Learning Objectives: **1.3 Mutual Induction** 1.3.1 Explain the concept of self and mutual Inductance 1.3.2 List the equipment in which self-induction and mutual induction principle used	2

Learning Objectives	**(I)**
F. Introduction to Mechanics	**2**
General Learning Objective Understand the importance of Engineering mechanics and basic fundamental concepts associated **F1. Sub-topic: Scalar and vector quantities and concept of force system** **Sub-subtopics & SLOs (IMO 7.04, Appendix IV,2014)** **1.1** Scalar and vector quantities **1.2** Concept of force system	2
Specific Learning Objectives: **1.1 Scalar and vector quantities** 1.1.1 Define scalar and vector quantity 1.1.2 Difference between scalar and vector quantity 1.1.3 Examples of scalar and vector quantities	1
Specific Learning Objectives: **1.2 Concept of force system** 1.2.1 Definition of force 1.2.2 Characteristics of a force 1.2.3 Graphical representation of force 1.2.4 Definition of force system 1.2.5 Types of force system	1
G. Composition and Resolution of forces	**8**
General Learning Objective Understand the composition and resolution of forces for determination of resultant force and equilibrium conditions **G1. Sub-topic: Resolution of forces, resultant force and laws of forces** **Sub-subtopics & SLOs (IMO 7.04, Appendix IV,2014)** **1.1** Resolution of forces **1.2** Composition of forces **1.3** Resultant force **1.4** Free body Diagram	8

1.5 Lami's theorem **1.6** Equilibrium conditions	
Specific Learning Objectives: **1.1 Resolution of forces** 1.1.1 Find force components 1.1.2 Find Resultant force	1
Specific Learning Objectives: **1.2 Composition of forces** 1.2.1 Find resultant of multi force system through projection 1.2.2 Explain graphical method of resultant determination	1
Specific Learning Objectives: **1.3 Resultant force and laws of forces** 1.3.1 Explain definition of resultant force 1.3.2 Find resultant force using various laws of forces 1.3.3 Explain statement and proof of Triangle and law of parallelograms 1.3.4 Explain statement of polygon law of forces 1.3.5 Explain application of triangle and law of parallelogram of forces	2
Specific Learning Objectives: **1.4 Free body diagram** 1.4.1 Define free body diagram 1.4.2 Explain construction of various free body diagrams	1
Specific Learning Objectives: **1.5 Lami's theorem** 1.5.1 Explain statement of Lami's theorem and its proof 1.5.2 Explain numerical analysis on Lami's theorem	1
Specific Learning Objectives: **1.6 Equilibrium conditions** 1.6.1 Explain various static equilibrium conditions 1.6.2 Explain numerical analysis on equilibrium conditions	2
H. Moment of force, couple and support reactions	**6**
General Learning Objective Understand the concept of moment of force, principle of moments and support reactions **H1. Sub-topic: Moment of force and support reactions** **Sub-subtopics & SLOs (IMO 7.04, Appendix IV,2014)** **1.1** Moment of force 1.2 Principle of moments 1.3 Couple and moment of couple 1.4 Types of supports and support reactions	6
Specific Learning Objectives: **1.1 Moment of force** 1.1.1 Define moment of force. 1.1.2 Find moment of force about a point	1
Specific Learning Objectives: **1.2 Principle of moment** 1.2.1 Define principle of moments 1.2.2 Explain numerical analysis on moment principle	2
Specific Learning Objectives: **1.3 Couple** 1.3.1 Define couple and moment of couple 1.3.2 Explain reduction of force system into couple	1
Specific Learning Objectives: **1.4 Support reactions** 1.4.1 Define various types of supports 1.4.2 Define calculations of support reactions	2
I. Friction	**6**
General Learning Objective Understand basic laws governing dry friction and application of friction	6

I1. Sub-topic: Principles and application of friction **Sub-subtopics & SLOs (IMO 7.04, Appendix 1 ,2014)** 1.1. Principles of friction 1.2. Equilibrium of a body on a rough surface 1.3. Application of friction	
Specific Learning Objectives: **1.1 Principles of friction** 1.1.1 Define frictional force and normal reaction 1.1.2 Explain Coulomb's law of dry friction 1.1.3 Define and explain limiting friction and impending motion 1.1.4 Explain angle of friction and angle of repose 1.1.5 Define and determine coefficient of friction	2
Specific Learning Objectives: **1.2 Equilibrium of a body on a rough surface** 1.2.1 Define Equilibrium of a body on a rough horizontal surface 1.2.2 Explain Equilibrium of a body on a rough inclined surface 1.2.3 Describe Impending motion of a connected bodies	2
Specific Learning Objectives: **1.3 Application of friction** 1.3.1 Define Ladder friction 1.3.2 Define Wedge friction	2

Subject Name/Code: Computers/103

Instructional hours:

Lecture	: 30 hours
Tutorial	: 15
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of Classroom/online lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. IMO Model Course 7.02.
2. AICTE Model Course Prerequisite for Engineering Programmes.

Recommended Text:

1. Introduction to computer and communication (2006), TMH by D. Ravichandran.
2. 'Let Us C' 17th edition (September 2020), BPB Publications, By Yashwant Kanetkar.
3. Computer Fundamentals and Programming, Theraja, R, Oxford University Press.

Reference:

1. Information Technology for management (2013), Tata McGraw Hill by Henry Lucas.
2. Computer Fundamentals and Programming in C (2013), Oxford University Press; 2nd edition by Pradip Dey, Manas Ghosh.
3. Basics of Computer Science (2009) Cengage Learning, By Behrouz Forouzan, Firouz Maosharraf, Mostafavi.
4. Programming in ANSI C, 8/e (2019, McGraw Hill Education by E. Balagurusamy.

Table of Topics

Section	Topics	Hours (L:T)
A1-A3	**Introduction to computers:** **Sub-Topics:** Number systems and Binary Codes, Magnetic Media Technology and Multimedia Applications	5:5
B1-B5	**Computer organization and Communication:** **Sub-Topics:** Input and Output devices, Computer Memory, Logic Circuits, Computer network, Internet and Intranet applications.	10:5
C1-C2	**Programming for Problem Solving** **Sub-Topics:** Introduction to ANSI C, Functions and Pointers	15:5
	Total	**30:15**

Learning Objectives	(L:T)
A Introduction to computers (MO 7.02,2014: Introduction/Computer Applications)	**5:5**
General Learning Objective Understand different number systems and multimedia applications **A1 Sub-topic: Introduction to Computers** **Sub-subtopics & SLOs** **1.1** Introduction to Number system and mutual conversion	
Specific Learning Objectives: **1.1 Introduction to Number system and mutual conversion** 1.1.1 Explain the use of number system and concept of bits, bytes and words in computers 1.1.2 Explain different types of number system like Binary, octal, decimal & hexadecimal in detail 1.1.3 Describe how to convert from Binary number system to other number system and vice versa 1.1.4 Explain Binary coded decimal, fixed and floating point numbers, ASCII codes	1:2
A2 Sub-topic: Magnetic Media and Multimedia Applications **Sub-subtopics & SLOs** **1.2** Care and storage of magnetic media **1.3** Utility programs for identifying disk problems and fixes **1.4** Installation and setup of multimedia application **1.5** Backup management	
Specific Learning Objectives: **2.1 Care and storage of magnetic media** 2.1.1 Explain types of magnetic storage media 2.1.2 Explain different ways to handle and care magnetic media	1:1
Specific Learning Objectives: **2.2 Utility programs for identifying disk problems and fixes** 2.2.1 Explain the use of utility programs in OS 2.2.2 Describe how to identify disk problems using any utility program 2.2.3 Describe how to fix disk problems using any utility program	1:1
Specific Learning Objectives: **2.3 Installation and setup of multimedia application** 2.3.1 Explain different types of multimedia applications	1:1

2.3.2 Explain uses of multimedia applications 2.3.3 Describe multimedia installation	
Specific Learning Objectives: **2.4 Backup management** 2.4.1 Explain what is backup management and advantages of taking Backup 2.4.2 Explain types of backup process 2.4.3 Explain Backup management process and strategy	1:0
B Computer organization and Communication (MO 7.02,2014: Introduction/Computer Applications)	**10:5**
General Learning Objective Understand basic computer organization and computer architecture. Students will also learn the applications of logic gates in computer science **B1 Sub-topic: Input and Output Devices:** **Sub-subtopics & SLOs** **1.1** Input and Output Devices	
Specific Learning Objectives: **1.1 Input and Output Devices:** 1.1.1 List the types of input and output devices 1.1.2 Explain different types of input devices and their functions 1.1.3 Explain different types of output devices and their functions	2:1
B2 Sub-topic: Computer Memory: **Sub-subtopics & SLOs** **2.1** Computer Memory and its types	
Specific Learning Objectives: **2.1 Computer Memory and its types** 2.1.1 Explain computer memory 2.1.2 Describe different types of computer memory 2.1.3 Describe Random Access Memory and its types 2.1.4 Explain Read Only Memory and its types 2.1.5 Explain direct access memory and virtual memory	2:1
B3 Sub-topic: Logic Circuits: **Sub-subtopics & SLOs** **3.1** Logic gates and its application	
Specific Learning Objectives: **3.1 Logic gates and its application** 3.1.1 Explain basic logic gates 3.1.2 Explain use of logic gates in digital circuits 3.1.3 Explain use of multiplexer 3.1.4 Explain analogue to digital and digital to analogue converter	2:1
B4 Sub-topic Computer network: **Sub-subtopics & SLOs** **4.1** Computer Network and its types	
Specific Learning Objectives: **4.1 Computer Network and its types** 4.1.1 Explain a computer network 4.1.2 Explain types of communication networks 4.1.3 Explain advantages of communication networks	2:1

B5 Sub-topic Internet and Intranet applications: **Sub-subtopics & SLOs** **5.1** Internet and Intranet	
Specific Learning Objectives: **5.1 Internet and Intranet** 5.1.1 Explain basic Internet terminology 5.1.2 Explain use of modems 5.1.3 Explain applications of Internet and Intranet 5.1.4 Differentiate Internet and Intranet	2:1
C Programming for Problem Solving (AICTE CS syllabus and Previous syllabus)	**15:5**
General Learning Objective: Understand and perform Fundamental Computing, Analysis, Logical reasoning and decision making using C programming language **C1 Sub-topic: Introduction to C** **Sub-subtopics & SLOs** **1.1** Introduction to ANSI C.	
Specific Learning Objectives: **1.1 Introduction to ANSI C: (2hrs/sub topic SLO)** 1.1.1 Explain Overview, Structure of a C program, Statements, Basic Data Types, Variables& Constants 1.1.2 Explain Input & Output statements: Managing / formatting input-output Statements 1.1.3 Explain Operators and Expressions, Precedence of operators, Types of operators, Simple C programs 1.1.4 Explain Decision making & Branching: if. else, if-else-if, nested if, Multiple Branching Structures: switch. case statement 1.1.5 Explain Decision making & Looping: for loop, while loop, do; While loop, Jump Statements break, continue and go to	10:3
C2 Sub-topic: Functions and Structures in C **Sub-subtopics & SLOs** **1.2** Introduction to Functions and Pointers in ANSI C	
Specific Learning Objectives: **2.1 Introduction to Functions and Pointers in ANSI C: (2hrs/sub topic SLO)** 2.1.1 Explain Arrays and Pointers: One- & two-dimensional arrays, strings, manipulation of arrays, Introduction to Pointer, declaring pointer variable, initialization of pointer variable, accessing address of variable, pointer expressions 2.1.2 Functions: Introduction, modular approach of programming, creating user Define functions with and without parameters, Parameter passing mechanism and returning values from functions 2.1.3 Structures &Unions: Defining structure, declaring and accessing structure members, initialization of structure, Advantages of using structures and unions	5:2

Subject Name/Code: Industrial Chemistry/104

Instruction hours:	
Lecture	: 30 hours
Total Contact hours	: 30 hours
Credits	: 2

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. K. L. Kapoor, A Textbook of Physical chemistry, (volume-2 and 3) Macmillan, India Ltd, 1994.
2. K.S. Venkateswarulu, Water Chemistry, New age publications.

Reference:

1. N. Krishnamurthy, P Vallinayagam, D. Madhan Engineering Chemistry, 3rd edition, PHI Publications Delhi, 2014.
2. Rajeshwar, K. Gupta, Sohan L. Chawla, Material Selection for corrosion control ASM International.
3. S.P. Srivastava, Jenő Hancsók, Fuel and Fuel additives, John Wiley & sons.
4. Water and Waste water analysis by D.R. Khanna and R. Bhutiani.

Section	Topics	Hours (L)
A	Chemical fundamentals & Colligative properties of Dilute Solutions	6
B	Water testing and Treatment	10
C	Corrosion	10
D	Introduction to Fuels and Lubricants	4
	Total	**30**

Learning Objectives	L
General Learning Objectives: Understand fundamentals of matter, fuels and lubricants, water and their properties and water analysis. Appendix 5 **(IMO/ 7.04 / 2014 1.1) Pg.256)**	
A Chemical fundamentals & Colligative property of Dilute Solutions: **Sub topics & SLOs** Explain the following: 1.1 Define: atoms, molecules, elements, compounds, mixtures 1.2 Define: Solutions, Solubility, saturated solution, suspension, Precipitations 1.3 Define and explain the Concepts: Colligative Properties, Relative Lowering of vapour pressure 1.4 Explain Elevation of Boiling Point, Depression of freezing point 1.5 Explain relation between molecular weight and elevation in boiling point and depression in freezing point 1.6 Describe effect of Pressure on melting and Boiling point, Abnormal Colligative properties; Introduction to Van't Hoff factor	6
B Acidity & Alkalinity (Water Testing and Treatment) Appendix 5 **(IMO /7.04 / 2014 / 1.2 & 1.4) pg.256 -258)** **Sub topics & SLOs** Describe the following: 1.1 Define: Hydrogen ion, Hydroxyl ion, p H, Litmus test, etc., 1.2 List the sources of water, Types of water 1.3 Explain softening water Ion exchange process 1.4 Explain properties of Boiler feed water, 1.5 Explain terms like Priming, foaming etc. (encountered during in operation) 1.6 Explain Sludge and Scale formation in Boilers, caustic embrittlement 1.7 Boiler Corrosion – Removal of DO, CO_2, and acids etc. 1.8 Potable water – Treatment Process for removal of impurities 1.9 Break point chlorination 1.10Desalination & Electro dialysis 1.11 Reverse Osmosis, and its applications 1.12 Various water testing such as Chloride & alkalinity 1.13 Hardness 1.14 Iron 1.15 Phosphate etc.	10
C Corrosion Appendix 5 **(IMO / 7.04 / 2014 / 1.3) pg.256 -257** **Sub topics & SLOs**	10

Explain the following: 1.1 Corrosion definitions, Principle, factors influencing corrosion 1.2 Mechanism of Corrosion – Dry Corrosion and their type 1.3 Mechanism of Corrosion – Wet or Electrochemical Corrosion 1.4 Various types of Corrosion – Pitting, Crevice, Pipeline 1.5 Fretting, fatigue, erosion, stress corrosion 1.6 Microbiological, Inter granular corrosion 1.7 Selective Leaching – Dezincification, Decarburization 1.8 Material selection, alternative environment 1.9 Cathodic Protection, sacrificial anode method 1.10 Protective coating, Metallic coatings –Organic and Inorganic Coatings Protection by paints 1.11 Corrosion Inhibitors, corrosion rate expression and rate measurements 1.12 Biofouling control, antifouling coatings etc.,	
D Introduction to Fuel and Lubricants Appendix 5 **(IMO / 7.04 / 2014 / 1.5) pg.258)** **Sub topics & SLOs** Explain the following: 1.1 Solid, liquid and gaseous fuel 1.2 Calorific value of a fuel, Bomb calorimeter 1.3 LHV, HHV, Flue gas analysis 1.4 Classification of coal, varieties of coal, analysis of moisture content 1.5 Volatile matter ash content, and carbon etc., 1.6 Ultimate analysis – Carbon and hydrogen, Nitrogen, sulphur and oxygen 1.7 Classification of petroleum, refining, cracking, synthesis of gasoline, Petrol, knocking, leaded petrol, reforming, diesel oil, etc., 1.8 Natural gas, CNG, LPG, Producer gas, water gas 1.9 Flammability, upper flammable limit, lower flammable limit 1.10 Flash and fire point, cloud and pour point etc., 1.11 Viscosity, Determination of viscosity of lube oil using redwood viscometer 1.12 Lubricants, Functions, classification, and Mechanism	4

Subject Name/Code: Workshop Technology/105

Instructional hours:

Lecture	: 30 hours
Total contact hours	: 30 hours
Credits	: 2

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, practical in workshops and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Workshop Technology V [I], S.K. Hajra Chaudhary. Media promoters & publishers Pvt. Ltd.
2. Workshop Technology V [II], S.K. Hajra Chaudhary. Media promoters & publishers Pvt. Ltd.

Reference:

1. A Text Book of Workshop Technology, R.S. Khurmi& J.K. Gupta. S. Chand& company Pvt. Ltd.
2. Workshop Technology, W.A.J. Chapman Vol I & Vol II, Published by Routledge (1972).
3. Elements of Manufacturing processes, B.S. Nagendra Parashar& R.K Mittal. PHI Learning Pvt. Ltd.

Table of Topics

Section	Topics	Hours (L)
A1-4	**Safety Measures** **Sub-Topics:** Safe working practice, Safety, while working on Rotating Machinery, Personal protective equipment and Fire and Electrical safety. Types of Guards and Safety Devices, Risk assessment	2
B1-3	**Common Workshop Tools** **Sub-Topics:** Bench Fitting Tools, Carpentry and Pattern Makers Tools, Smithy and Moulding Tools	4
C1-2	**Theory of Metal Cutting** **Sub-Topics:** Principle of machining processes. Tool geometry, Tool signature, Orthogonal and Oblique cutting, Types of chips, cutting fluid and machinability.	2
D1-5	**Lathe machine and operations** **Sub-Topics:** Introduction, function and specifications of lathe machine, Classification of lathe machine, Main parts and accessories, General operations, Operating conditions	5
E1-2	**Drilling and Allied operations** **Sub-Topics:** Specifications, classifications of Drilling machine, General constructions, Main parts, accessories and work holding devices and General operations.	2
F1-2	**Shaping, Planning Machine & Operations** **Sub-Topics:** Specification, classification of Shaping and Planning machine, General constructions and mechanism, Main parts and Holding devices and General operations	2
G1-2	**Milling machine and Operations** **Sub-Topics:** Classifications, Specifications of Milling Machine, General construction (Main parts, accessories & holding devices), General operations and Milling processes	2
H1-2	**Finishing Processes** **Sub-Topics:** Introduction of abrasive & abrasive machining processes, Grinding machine construction and classifications, Grinding wheel, construction. Process of making grinding wheel, characteristics and selection, Different types of Abrasives used in grinding, Fine-finishing operations like lapping, honing, polishing and buffing	2
I1-5	**Measurement and Quality in Manufacturing** **Sub-Topics:** Principle of Metrology, Quality, Inspection and Reliability, Interchangeability, Limit, fits and tolerance, Measuring and Inspection Instrument, Optical methods of measurement, Jigs and Fixtures standardization	4
J1-5	**Joining Processes** **Sub-Topics:** Advantages of joining processes, Classification of joining process, Welding process, Safety requirements during welding, Pre welding requirements types of welding joints, welding techniques, Arc welding, Gas welding, Resistance welding, TIG, MIG, Submerged, Thermit welding, Welding defects, Brazing and Soldering	5
	Total	**30**

Learning Objectives	L
A. Safety measures	**2**
General Learning Objective (IMO 7.04,2014, F3/3.15 P135 and 7.02 D3/3.3 P144-146) Understand and develop the safety culture in the student while working on board and in industry ambience. **Sub-Topics: Safety measures** **Sub-subtopics & SLOs:** 1.1 Safe working practice 1.2 Safety, while working on Rotating Machinery, Personal protective equipment and Fire and Electrical safety 1.3 Types of Guards and Safety Devices 1.4 Risk assessment	
Specific Learning Objectives: **1.1 Safe working practice** Explain the following: 1.1.1 Objective of Safety 1.1.2 Various definitions with examples of the various terms related to safety 1.1.3 The losses of accidents 1.1.4 The main element and cause of accidents 1.1.4 The important preventive measure to avoid accidents.	0.5
Specific Learning Objectives: **1.2 Safety, while working on Rotating Machinery, shop floor and Engine room, and Personal protective equipment. Fire and Electrical safety** Explain the following: 1.2.1 Clothing and safety equipment for lathe & grinding machine 1.2.2 Precaution to be taken before operating any rotating machinery 1.2.3 General safety precautions 1.2.4 The purpose & benefits of housekeeping 1.2.5 Precautions to be taken while working in the Engine room 1.2.6 Head, face, leg, Eye and Hearing protection 1.2.7 Precautions to be taken while working with electrical equipment. 1.2.8 Method of protection for fire	0.5
Specific Learning Objectives: **1.3. Types of Guards and Safety Devices** 1.3.1 Describe about Fixed, Interlocking, Automatic, Trip and Distance guard 1.3.2 Describe the importance of guards on a running machinery	0.5
Specific Learning Objectives: **1.4 Risk assessment** 1.4.1 Explain about Risk, Hazard 1.4.2 Explain how the risk is estimated and evaluated 1.4.3 Describe HIRA (Hazard identification & risk assessment) 1.4.4 Describe about the common workplace hazard & how to prevent that	0.5
B. Common Workshop Tools	**4**
General Learning Objective (IMO 7.04,2014, F3/3.16) P136 Understand the use of various hand operated and power operated/ assisted tools **Sub-topic:** Common Workshop Tools	

Sub-subtopics & SLOs: 2.1Bench Fitting Tools 2.2 Carpentry and Pattern Makers Tools 2.3 Smithy and Moulding Tools	
Specific Learning Objectives: **2.1Bench Fitting Tools** 2.1.1 Sketch and describe about work holding device like Bench vice, Hand vice, pipe & leg vice, pin vice and v-block with clamp 2.1.2 Sketch and describe about Striking tools (Ball-peen, cross-peen, straight-peen, Double-headed and soft hammer) 2.1.3 Sketch and describe about cutting tools (Chisels, files, scraper and Hacksaw) 2.1.4 Explain about the method of filling, scraping and chipping 2.1.5 Sketch and describe about Measuring and marking tools (Callipers, surface plate, scriber, punches, angle plate, Tri-square, combination set, Trammel, Straight edge, Vernier height gauge etc.) 2.1.6 Sketch and describe about Twist drill nomenclature and angle 2.1.7 Sketch and explain about Tap & Die and procedure of Tapping & die operations	2
2.2 Carpentry and Pattern Makers Tools 2.2.1 Sketch and describe about Marking and measuring tools (Marking gauge, mortise gauge, fold rule, Try square, Mitre square, pattern Maker scale, calliper and sprit level etc.) 2.2.2 Sketch and describe about cutting tools (Saw, chisels and Gouges) 2.2.3 Sketch and describe about Planing tools (Jack plane, smoothing plane, plough plane, Router plane and spoke shave etc.) 2.2.4 Sketch and describe about different boring tools & striking tools used in carpentry & pattern Maker shop (Bradawl, gimlet, Brace & bits, mallet and claw hammer) 2.2.5 Explain the different holding tool used in carpentry shop (Bench vice, G-cramp, T- cramp and Hand screw etc.)	1
2.3 Smithy and Foundry Tools 2.3.1 Sketch and describe all hand tools and appliances used by the blacksmith in various forging operation (Anvil, swage block, hammers, tongs, chisel, fullers, flatters, punches & drift etc.) 2.3.2 Name & explain some Smith forging operations (Upsetting, drawing down, setting down, punching & forge welding) 2.3.3 Draw and explain about different types of foundry hand tools like Rammer, vent wire, slick, swab, bellow, strike- off bar, rapping plate and moulding flasks etc.	1
C. Theory of Metal Cutting	**2**
General Learning Objective (IMO 7.04,2014, F3/3.16) P136 Understand machine tools, their classification, mechanism of cutting, tool failure, tool life, tool geometry, use of cutting fluids **Sub-topic: Theory of Metal Cutting** **Sub-subtopics & SLOs:** 3.1 Principle of machining processes. Tool geometry, Tool signature 3.2 Orthogonal and Oblique cutting, Types of chips, cutting fluid and machinability	
Specific Learning Objectives: **3.1 Principle of machining processes, Tool geometry, Tool signature** 3.1.1 Define the metal cutting process and importance of machining 3.2.1 Sketch and describe single point cutting tool nomenclature, terminology & signature 3.2.2 Explain the different types of cutting tool and its material used for metal cutting	1
3.2 Orthogonal and Oblique cutting, Types of chips, cutting fluid and machinability 3.2.1 Sketch and describe of orthogonal and oblique cutting process and what are the difference between them 3.2.2 Sketch and explain the different types of chips, chips breakers and importance of chips breakers during machining 3.2.1 Explain purpose of using cutting fluids	1

3.2.2 Explain the desirable properties of cutting fluids 3.2.3 Explain the different types and choice of cutting fluids 3.2.4 Define machinability index and rating	
D. Lathe machine and operations	**5**
General Learning Objective (IMO 7.04,2014, F3/3.16) P317 Understand Lathe machine construction, their classification, mechanism and different operations that performed by different lathe **Sub-topic: Lathe machine and operations** **Sub-subtopics & SLOs:** 4.1 Introduction, function and specification of lathe machine 4.2 Classification of lathe machine 4.2 Main parts and accessories 4.3 General operations on lathe & screw thread nomenclature 4.4 Operating conditions	
Specific Learning Objectives: **4.1 Introduction, function and Specifications of lathe machine** 4.1.1 Define lathe machine and history 4.1.2 Sketch and describe the working principal and function of lathe machine 4.1.3 How a lathe machine is specified describe with suitable sketch (Swing over bed, swing over carriage, swing over gap bed etc.)	1
4.2 classification of lathe machine 4.2.1 Explain the different types of lathes (Centre, automatic, capstan & turret lathe)	1
4.2 Main parts and accessories 4.2.1 Explain the principal component of Centre lathe in details (Head stock, tail stock, bed, carriage, feed mechanism & screw cutting mechanism) 4.2.2 Explain the application of different accessories & holding devices using for machining different components (Chuck, Face plate, catch plate, lathe carrier, mandrel & rests etc.) 4.2.3 Differentiate between self-centred and independent chuck	1
4.3 General operations 4.3.1 Sketch and describe the different operations performed on a lathe machine Like -Turning, facing, grooving, knurling, taper turning, thread cutting, parting off, Drilling, boring, reaming etc. 4.3.2 Explain the different method of taper turning with suitable sketch 4.3.3 Describe the Thread terminology & thread cutting procedure by lathe machine by calculating gear teeth 4.3.4 Explain the process of sequence for manufacturing a component	1
4.4 Operating conditions 4.3.5 Define with suitable sketch about all operating conditions like cutting speed, feed, depth of cut & MRR 4.3.6 Explain the different factors that govern cutting speed, feed & depth of cut	1
E. Drilling and Allied operations	**2**
General Learning Objective (IMO 7.04,2014, F3/3.16) P137 Understand Drilling machine construction, their classification, mechanism and different operations that performed by different Drilling machine **Sub-topic: Drilling and Allied operations** **Sub-subtopics & SLOs:** 5.1. Specifications, classification of Drilling machine, General constructions 5.2. Main parts, accessories and work holding devices and General operations	
Specific Learning Objectives: **5.1. Specifications, classification of Drilling machine, General constructions** 5.1.1 Explain the working principle of drilling machine	1

5.1.2 Describe how the drill machine is classified 5.1.3 Sketch and describe sensitive, upright and redial drilling machine 5.1.4 Explain how the drill machine is specified explain	
5.2 Main parts, accessories, work holding devices and General operations 5.2.1 Explain about the main parts of drilling machine 5.2.2 Explain the function of different work & tool holding devices like T-bolt and clamp, V-block, Angle plate, Drill jig, sleeve, socket, Tapping attachment etc. 5.2.3 Sketch and describe the different operation that performed by drilling machine (Drilling, reaming, counter boring, spot facing Tapping, Trepanning etc.) 5.2.4 Explain how to calculate Tap drill size	1
F. Shaping, Planning Machine & Operations	**2**
General Learning Objective (IMO 7.04,2014, F3/3.16) P137 Understand Shaping & Planning machine construction, their classification, mechanism and different operations that performed by different Shaping & Planning machine Sub-topic: Shaping, Planning Machine & Operations **Sub-subtopics & SLOs:** 6.1 Specification, classification of Shaping and Planning machine, General constructions and mechanism 6.2 Main parts and Holding devices and General operations	
Specific Learning Objectives: **6.1 Specification, classification of Shaping and Planning machine, General constructions and mechanism** 6.1.1 Explain how to classify and specify the shaper and planner 6.1.2 Explain the difference between shaper and planer 6.1.3 Sketch and describe the quick return mechanism of standard shaper	1
6.2. Main parts and Holding devices and General operations 6.2.1 Explain about the main parts of shaping & planning machine 6.2.2 Explain the different holding devices normally used to hold the work piece 6.2.3 Explain what are the operation performed by shaping & planning machine	1
G. Milling machine and Operations	**2**
General Learning Objective (IMO 7.04,2014, F3/3.16) P137 Understanding of milling machine construction, their classification, mechanism and different operations that performed by milling machine, Involute geometry of spur gear teeth, multiple gauging instruments **Sub-topic: Milling machine and Operations** **Sub-subtopics & SLOs:** 7.1 Classifications, Specification of Milling Machine, General construction (Main parts, accessories & holding devices) 7.2 General operations, Milling processes and Involute geometry of spur gear teeth, multiple gauging instruments	
Specific Learning Objectives: **7.1 Classifications, Specification of Milling Machine, General construction (Main parts, accessories & holding devices)** 7.1.1 Describe about principal part of milling machine (Base, column, knee, table etc.) 7.1.2 Explain how the all work & tool holding devices are normally used on milling machine. 7.1.3 Describe the function of Dividing head	1
7.2 General operations, Milling processes and Involute geometry of spur gear teeth, multiple gauging instruments. 7.2.1 Sketch and describe the face milling, end milling, straddle milling, form & gang milling etc. 7.2.2 Sketch and describe up and down milling process 7.2.3 Explain the difference between conventional and climb milling processes	1
H. Abrasive machining Processes	**2**

General Learning Objective (IMO 7.04,2014, F3/3.16) P136 Understand the different finishing processes, Abrasive machining processes, grinding wheel specification, construction & characteristics. Fine finishing operations like lapping, honing, buffing etc. **Sub-topic:** Abrasive machining processes **Sub-subtopics & SLOs:** 8.1 Introduction of abrasives & abrasive machining processes, Grinding Machine construction and classifications 8.2 Grinding wheel, construction. process of making grinding wheel, characteristics and selection, Fine finishing operations like lapping, honing, polishing and buffing	
Specific Learning Objectives: **8.1 Introduction of abrasives & abrasive machining processes, Grinding Machine construction and classifications** 8.1.1 Describe the types of abrasives and abrasive machining processes 8.1.2 Describe the classification & construction of grinding machine 8.1.3 Explain centreless grinding processes 8.1.4 Explain the precautions that to be taken while working on grinding machine 8.1.5 Explain about Emery, corundum, carborundum etc.	1
8.2 Grinding wheel, construction. process of making grinding wheel, characteristics and selection, Fine finishing operations like lapping, honing, polishing and buffing 8.2.1 Describe Grinding wheel construction. process of making grinding wheel, characteristics and selection 8.2.2 Explain the fine finishing operations like lapping, honing, polishing and buffing	1
I. Measurement and Quality in Manufacturing	**4**
General Learning Objective (IMO 7.04,2014, F3/3.16) P141 Understand the measuring and inspection process to find out the accuracy of product **Sub-topic: Measurement and Quality in Manufacturing** **Sub-subtopics & SLOs:** 9.1 Principle of Metrology, Quality, Inspection 9.2 Interchangeability, Limit, fits and tolerance 9.3 Measuring and Inspection Instrument 9.4 Optical methods of measurement 9.5 Jigs and Fixtures standardization	
Specific Learning Objectives: 9.1.1 Define The terms quality, inspection and metrology 9.1.2 Explain how is measurement different from inspection	1
9.2 Interchangeability, Limit, fits and tolerance 9.2.1 Explain the term interchangeability and what is the importance of interchangeability in production 9.2.2 Define limit, fit and tolerance. Explain the classifications of fit	1
9.3 Measuring and Inspection Instrument 9.3.1 Explain the classification of measuring instrument 9.3.2 Sketch and describe the different direct, indirect and precession measuring instrument. 9.3.3 Explain the term gauge and importance of gauge in mass production 9.3.4 Sketch and describe the limit gauge	1
9.4 Optical methods of measurement 9.4.1 Sketch and describe the application of auto-collimator, optical flat etc.	1
J. Joining processes	**5**

General Learning Objective (IMO 7.04,2014, F3/3.16) P (137-141) Understand the various aspects of permanent material joining processes like welding, soldering, brazing. **Sub-topic: Joining processes** **Sub-subtopics & SLOs:** 10.1 Advantages of joining processes, Classification of joining process 10.2 Welding process, Safety requirements during welding, Pre welding requirements types of welding joints, Welding techniques 10.3 Arc welding, AC and Dc source of electricity, Gas welding, Resistance welding 10.4 TIG, MIG, Submerged, Thermit welding 10.5 Welding defects 10.6 Brazing and Soldering	
Specific Learning Objectives: **10.1 Advantages of joining processes, Classification of joining process** 10.1.1 Explain the advantages of permanent joining processes namely welding, brazing and soldering 10.1.2 Compare joining and adhesive 10.1.3 Explain the classification of welding processes based on heat source	1
10.2 Welding process, Safety requirements during welding, Pre welding requirements types of welding joints, welding techniques 10.2.1 Explain the terminologies related to Welding processes. 10.2.2 Explain the role of pre welding requirements in getting sound weld 10.2.3 Explain the type of welding joints, lap, butt, Tee, corner etc. and their usage 10.2.4 Explain the welding techniques leftward and rightward welding, usage	1
10.3 Arc welding, Gas welding Resistance welding 10.3.1 Describe arc welding setup 10.3.2 Describe initiation of arc, source of electric current for arc (AC and DC), common tools used 10.3.3 Describe gas welding setup 10.3.4 Describe gases used for welding, their advantages, types of flames, use of different flames 10.3.5 Describe storage of acetylene and oxygen gases 10.3.5 Describe precautions during welding both arc and gas welding 10.3.6 Describe use of Electrodes, types of electrodes, function of electrode coating, storage of electrodes	1
10.4 TIG, MIG, Submerged, Thermit welding 10.4.1 Explain requirement of inert gas envelope and provision of inert gas 10.4.2 Explain TIG welding setup, operation and usage 10.4.3 Explain MIG welding setup, operation and usage 10.4.4. Explain submerged arc welding setup, operation and usage 10.4.5 Explain thermit welding setup, operation and usage 10.4.6 Explain comparison of these welding techniques and specific usage	1
10.5 Welding defects, Brazing and Soldering 10.5.1 Describe surface welding defects, causes and remedies 10.5.2 Describe subsurface defects, causes and remedies 10.5.3 Describe defects in the body of welding joint 10.5.4 Describe brazing, setup required, steps in brazing, different spelters / brazing fillers and their usage 10.5.5 Describe soldering, steps involved in soldering, types of soldering, different solders in use, soft soldering, hard soldering 10.5.6 Describe use of flux, common fluxes in soldering/ brazing	1

Subject Name/Code: Maritime Awareness/106

Instructional hours:

Lecture	: 30 hours
Total contact hours	: 30 hours
Credits	: 2

Teaching Methods

The course shall be conducted in classroom/online lectures and self-learning modes.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Sea Trading- Vol 1 (The Ships)- William V. Packard.
2. Sea Transport. – Patrick M. Alderton.

Reference:

1. Glossary of maritime Technology – N.S. Swindells.
2. Ship Construction – D. J. Eyres.
3. Basic seamanship, Marine Engineering & human relation for seafarers, P. P. Chugani.

Table of Topics

Section	Topics	Hours (L)
A1-A2	**Basis of International Trade** **Subtopics**: Discussion on International Trade, Factor Condition	1
B1-B2	**International Trade** **Subtopics:** Different mode of transportation & their Merits & De merits, World Sea borne trade & Major cargo Movement	3
C1-C7	**Map Work** **Subtopics:** Location of seas & oceans, Location of gulfs & straits, Indian port & their cargo, Important ports of the world, Important trade routes, Location of major ports for coal, Iron ore & crude oil, Location of major bunkering ports	5
D1-D3	**Geographical Features affecting Shipping** **Subtopics:** Factors affecting Sea transport, Time zone & International Date lines, Concept of load lines	2
E1- E3	**Ports & Related Activity** **Subtopics:** Definitions (Harbour, Berth, Jetty, SBM etc.), Shipyard & scrapyard, Canals- Suez &Panama	3
F1- F5	**Organization & personnel connected with shipping** **Subtopics:** IMO, DGS, MMD, Shipping Master, FOSMA	2
G1 –G2	**Familiarization with Ship Terms** **Subtopic:** Ship Sketch & important Parts, Familiarization of Ship Terms	3
H1 –H2	**Familiarization with ship Types** **Subtopic:** Introduction to ship Types, Plan View of Oil Tanker	6
I1-I3	**Familiarization with ship Construction** **Subtopic:** Principal Dimension of the ship, Ship Terms, Various Structural Member	3
J1-J3	**Ship Manning & Organization** **Sub Topic:** Organization charts, Descriptions of duties of ship staff, Watch Keeping System	2
	Total	**30**

Learning Objectives	L
A Basis of International Trade	1
General Learning Objective Understanding of the Basic Concept on International Trade **A1 Sub-topic: International Trade** **Sub-subtopics& SLOs** 1.1 Discussion on International Trade 1.2 Factor Condition	
Specific Learning Objectives: **1.1 Discussion on International Trade** 1.1.1 Explain the importance of shipping for the International Trade	
Specific Learning Objectives: **1.2 Factor condition** 1.2.1 Describe different factors which lead to international trade	
B International Trade	3
General Learning Objective: Understand the importance of international trade, Different modes of the transportation & significance of the shipping for the international trade **B1Sub-topic: Different mode of transportation & their merits & De merits** **Sub-sub topics & SLOs** 1.1 Air transportation & their Merits & De Merits 1.2 Road transportation & their Merits & De Merits 1.3 Sea Transportation & their Merits & De merits	
Specific Learning Objectives: **1.1 Air Transportation & their Merits & De merits** 1.1.1 Describe Air transportation 1.1.2 Describe merits of air transportation 1.1.3 Describe the De merits of air transportation	
Specific Learning Objectives: **1.2 Road Transportation & their Merits & De merits** 1.2.1 Describe Road Transportation 1.2.2 Describe merits of Road transportation 1.2.3 Describe the De merits of Road transportation	
Specific Learning Objectives: **1.3 Sea Transportation & their Merits & De merits** 1.3.1 Describe sea Transportation 1.3.2 Describe merits of sea transportation 1.3.3 Describe the De merits of sea transportation	
B2 Sub Topic: Sea borne trade & Major Cargo movement **Sub-sub topics & SLOs** 2.1 Development of Sea Borne Trade 2.2 Major cargo transported through sea trade	
Specific Learning Objectives: **2.1 Development of sea borne trade** 2.1.1 Describe the development in sea borne trade	
Specific Learning Objectives: **2.2Major Cargo transported through sea trade** 2.2.1 Describe the different types of cargo which is possible to be transported by sea	
C Map work	

General Learning Objective: Understand & Mapped the location of various ports, oceans, seas, Major ports in India on the world map **C1 Sub topic: Location of seas & oceans** **Sub-sub topics & SLOs** **1.1** Location of seas **1.2** Location of oceans	
Specific Learning Objectives: **1.1 Location of sea** 1.1.1 Mark location of the seas on the world Map	
Specific Learning Objectives: **1.2 Location of oceans** 1.2.1 Mark the location of the oceans on the world Map	
C2 Sub Topic: Location of Gulf & Straits **Sub-sub topics & SLOs** 2.1 Location of gulf 2.2 Location of straits	
Specific Learning Objectives: **2.1 Location of gulf** 2.1.1 Map the location of the gulf on the world map	
Specific Learning Objectives: **2.2 Location of straits** 2.2.1 Map location of the straits on the world map	
C3 Sub Topic: Indian ports & their cargo **Sub-sub topics & SLOs:** 3.1 Indian ports 3.2 Indian ports Cargo	5
Specific Learning Objectives: **3.1 Indian Ports** 3.1.1 Map all Indian ports on the India map	
Specific Learning Objectives: **3.2 Indian Port Cargo** 3.2.1 Describe different Indian port cargo & their significance because of geographical location	
C 4 Sub topic: Important ports of the World **Sub-sub topics & SLOs:** 4.1 Important World Ports	
Specific Learning Objectives: **4.1 Important World Ports** 4.1.1 Map important world ports on the world Map 4.1.2 Describe the importance of some of the Important world port	
C5 Sub topic: Important Trade Routes **Sub-sub topics & SLOs:** 5.1 Important Trade Routes for Ship	
Specific Learning Objectives: **5.1 Important Trade Routes for Ship** 5.1.1 Map the important trade routes for the ship 5.1.2 Describe the importance of the trade routes	

C6 Sub topic: Location of major Ports for Coal, Iron Ore, Crude Oil **Sub-sub topics & SLOs:** 6.1 Major ports for the coal 6.2 Major ports for the Iron ore 6.3 Major ports for the crude oil	
Specific Learning Objectives: **6.1 Major ports for the Coal** 6.1.1 Describe the Major ports for the coal	
Specific Learning Objectives: **6.2 Major ports for the Iron ore** 6.2.1 Describe the Major ports for the iron ore	
Specific Learning Objectives: **6.3 Major ports for the crude oil** 6.3.1 Describe the Major ports for the crude oil	
C7 Sub topic: Location of major bunkering ports **Sub-sub topics & SLOs** 7.1 Major Bunkering ports	
Specific Learning Objectives: **7.1 Major Bunkering ports** 7.1.1 Describe the major bunkering ports	
D Geographical features affecting shipping (IMO 7.04, 2014: F4/4.6.1.2) P 201	2
General Learning Objective: Understand various geographical features affecting shipping & various concepts on time zones, international date line **D1 Sub Topic: Factor affecting sea transport** **Sub-sub topics & SLOs** 1.1 Climate 1.2 Tides 1.3 Winds 1.4 Current	
Specific Learning Objectives: **1.1 Climate** 1.1.1 Explain how the climate condition affecting sea transport	
Specific Learning Objectives: **1.2 Tides** 1.2.1 Explain how the tides affecting sea transport	
Specific Learning Objectives: **1.3 Winds** 1.3.1 Explain how the winds affecting sea transport	
Specific Learning Objectives: **1.4 currents** 1.4.1 Explain how the current affecting sea transport	
D 2 Sub Topics: Time zones & International Date lines **Sub-sub topics & SLOs** 2.1Time zones 2.2 international Date Lines	
Specific Learning Objectives: **2.1 Time zones** 2.1.1 Describe the time changes as per time zones & understand the concept behind change in timing	
Specific Learning Objectives: **2.2 International date line** 2.2.1 Describe in brief on international date line	

D 3 Subtopic: Concept of load lines **Sub-sub topics & SLOs** 3.1Load line Marking on ship	
Specific Learning Objectives: **3.1 Load line Marking on ship** 3.1.1 Describe the load line Marking on ship 3.1.2 Describe the load line Marking significance	
E Ports & Related Activity (IMO 7.04, 2014: F4/4.6.1.3) P 201)	3
General Learning Objective: Understand in brief various terms related to ports & port activity, shipyard & scrapyard. **E1 Sub Topic: Definition** **Sub-sub topics & SLOs** 1.1 Harbour 1.2 Berth 1.3 Jetty	
Specific Learning Objectives: **1.1 Harbour** 1.1.1 Describe the definition of the harbour	
Specific Learning Objectives: **1.2 Berth** 1.2.1 Describe the definition of the Berth	
Specific Learning Objectives: **1.3 Jetty** 1.3.1 Explain the definition of the Jetty	
E 2 Sub Topic: Shipyard & Scrapyard **Sub-sub topics & SLOs** 2.1Shipyard 2.2 Scrapyard	
Specific Learning Objectives: **2.1 Shipyard** 2.1.1 Describe about the Shipyard	
Specific Learning Objectives: **2.2 Scrapyard** 2.1.1 Describe about the scrapyard	
E3 Sub Topic: Canals- Suez &Panama **Sub-sub topics & SLOs** 3.1 Suez Canal 3.2 Panama Canal	
Specific Learning Objectives: **3.1 Suez Canals** 3.1.1 Describe About the Suez Canal 3.1.2 Mark the location on the world Map	
3.2 Panama Canal 3.2.1 Describe about the Panama Canal 3.2.2 Mark the location on the world Map	
F Organizations & personnel connected with shipping (IMO 7.04, 2014:F4/4.6.1.1) P 200)	2
General Learning objective: Understand different organization & personnel connected to Shipping Industry & their Importance **F1. Sub Topic: Shipping Organization**	

Sub-Sub Topic & SLOs 1.1 IMO 1.2 DGS 1.3 MMD 1.4 Shipping Master 1.5 FOSMA	
Specific Learning Objectives: **1.1 IMO** 1.1.1 Describe about IMO organization	
Specific Learning Objectives: **1.2 DGS** 1.2.1 Describe about DGS organization	
Specific Learning Objectives: **1.3 MMD** 1.3.1 Describe about MMD organization	
Specific Learning Objectives: **1.4 Shipping Master** 1.4.1 Describe about Shipping Master	
Specific Learning Objectives: **1.5 FOSMA** 1.5.1 Describe about FOSMA	
G Familiarization of ship terms (IMO 7.04, 2014:F4/4.2.2.3) P 193)	
G. General Learning Objective: Understand various terms related to ship so that students will Identify the various spaces in the ship & know the function of important parts **G1. Sub Topic: Ship Sketch & important Parts** **Sub-Sub Topic & SLOs** 1.1 Longitudinal Sketch 1.2 Transverse Sketch	3
Specific Learning Objectives: **1.1 Longitudinal Sketch** 1.1.1. Sketch longitudinal section of the ship 1.1.2. Identify major parts in the Longitudinal section of the Ship 1.1.3. Describe the function of major parts	
Specific Learning Objectives: **1.2 Transverse Sketch** 1.2.1. Sketch Transverse section of the ship 1.2.2. Identify major parts in the Transverse section of the Ship 1.2.3. Describe the function of major parts in the transverse section of the ship	
G2 Sub Topic: Familiarization of ship Terms **Sub-Sub Topics & SLOS** 2.1 Ballasting 2.2 Double Bottom 2.3 Trim & List	
Specific Learning Objectives: **2.1 Ballasting** 2.1.1 Explain about the Ballasting 2.1.2 Describe the importance of ballasting	
Specific Learning Objectives: **2.2 Double Bottom** 2.2.1 Describe about the Double bottom 2.2.2 Describe the importance of Double Bottom	
Specific Learning Objectives: **2.3 Trim & List** 2.3.1 Describe about the Trim & List 2.3.2 Describe the importance of Trim & List	

H Familiarization with ship types (IMO 7.04, 2014: F4/4.2.2.1) P 191)	6
General Learning Objective: Understand different types of Cargo ship & their general arrangements **H 1 Sub Topics: Introduction to ship types (IMO 7.04, 2014: F4/4.2.2.1) P 191)** **Sub-Sub Topics & SLOs** **1.1** General Cargo ship **1.2** Oil Tanker	
Specific Learning Objectives: **1.1 General Cargo ship** 1.1.1 Sketch the General cargo ship's longitudinal view 1.2.1 label various parts like cargo holds, tween deck, engine room location, peak tank, Double bottom tanks, hatchways, Position of bulkheads &Crane	
Specific Learning Objectives: **1.2 Oil Tanker** 1.2.1 Sketch the Oil tanker ship's longitudinal view 1.2.2 label various parts bulkheads, cargo tanks, cofferdams, engine room	
H2 Sub Topic: Plan View of tanker ship **Sub-Sub Topic & SLOS:** **2.1** Plan view of oil tanker	
Specific Learning Objectives: **2.1 Plan View of oil Tanker Ship** 2.1.1 Sketch the plan view of tanker Showing the arrangements of cargo, ballast tanks & accommodation space	
I Familiarization with ship construction	3
General Learning Objective: Understand Principal Dimensions of the ship & various terms related to ship construction and use for calculations etc. **I 1 Sub Topic: Principal Dimensions of the Ship (IMO 7.04,2014: F4/4.2.2.1) P 192)** **Sub-Sub Topics & SLOS:** 1.1 Length Overall 1.2 Forward Perpendiculars 1.3 Length on waterline 1.4 Base line 1.5 Moulded Depth 1.6 Moulded Beam 1.7 Moulded Draft 1.8 Extreme Depth 1.9 Beam 1.10 Draft	
Specific Learning Objectives: **1.1 Length overall** 1.1.1 Define Length Overall 1.1.2 Show Length overall on simple sketch	
Specific Learning Objectives: **1.2 Forward Perpendiculars** 1.2.1 Define Forward Perpendiculars 1.2.2 Show Forward Perpendiculars on simple sketch	
Specific Learning Objectives: **1.3 Length on waterline** 1.3.1 Define Length on waterline 1.3.2 Show Length on waterline simple sketch	
Specific Learning Objectives: **1.4 Base Line**	

1.4.1 Define base line 1.4.2 Show base line on simple sketch	
Specific Learning Objectives: **1.5 Moulded Depth** 1.5.1 Define Moulded Depth 1.5.2 Show Moulded Depth on simple sketch	
Specific Learning Objectives: **1.6 Moulded Beam** 1.6.1 Define Moulded beam 1.6.2 Show Moulded Beam on simple sketch	
Specific Learning Objectives: **1.7 Moulded Draft** 1.7.1 Define Moulded Draft 1.7.2 Show Moulded Draft on simple sketch	
Specific Learning Objectives: **1.8 Extreme Depth** 1.8.1 Define Extreme Depth 1.8.2 Display Extreme Depth on simple sketch	
Specific Learning Objectives: **1.9 Beam** 1.9.1 Define Beam 1.9.2 Show Beam on simple sketch	
Specific Learning Objectives: **1.10 Draft** 1.10.1 Draft 1.10.2 Show Draft on simple sketch	
I2 Sub topic: Ship Terms (IMO 7.04,2014: F4/4.2.2.1) P 191) **Sub-Sub Topics & SLOs** 2.1Camber 2.2 Rise of floor 2.3 Tumblehome 2.4 Flare 2.5 sheer 2.6 Rake 2.7 Parallel Middle body 2.8 Entrance 2.9 Run	
Specific Learning Objectives: (IMO 7.04,2014: F4/4.2.2.1) P 191) **2.1 Camber** 2.1.1 Define camber 2.1.2 Show camber on simple sketch 2.1.3 Describe the importance of the camber	
Specific Learning Objectives: **2.2 Rise of floor** 2.2.1 Define Rise of floor 2.2.2 Show Rise of floor on simple sketch 2.2.3 Describe the importance of the Rise of floor	
Specific Learning Objectives: **2.3 Tumblehome** 2.3.1 Define Tumblehome 2.3.2 Exhibit Tumblehome on simple sketch 2.3.3 Describe the importance of the Tumblehome	
Specific Learning Objectives: **2.4 Flare** 2.4.1 Define Flare 2.4.2 Show Flare on simple sketch 2.4.3 Describe the importance of the Flare	
Specific Learning Objectives: **2.5 Sheer**	

2.5.1 Define Sheer 2.5.2 Show sheer on simple sketch 2.5.3 Describe the importance of the Sheer	
Specific Learning Objectives: **2.6 Rake** **2**.6.1 Define Rake 2.6.2 Show Rake on simple sketch 2.6.3 Describe the importance of the Rake	
Specific Learning Objectives: **2.7 Parallel Middle Body** 2.7.1 Define Parallel Middle Body 2.7.2 Show Parallel Middle Body on simple sketch 2.7.3 Describe the importance of Parallel Middle Body	
Specific Learning Objectives: **2.8 Entrance** 2.8.1 Define Entrance 2.8.2 Show Entrance on simple sketch 2.8.3 Describe the importance of Entrance	
Specific Learning Objectives: **2.9 Run** 2.9.1 Define Run 2.9.2 Show Run on simple sketch 2.9.3 Describe the importance of Run	
I3 Sub Topic: Various Structural Members (IMO 7.04,2014: F3/3.1.1) P 276) **Sub-Sub topic & SLOs** 3.1 Shell; 3.2 Deck; 3.3 Tank top; 3.4 Bulkheads 3.5 Stiffeners; 3.6 Pillars; 3.7 Bulwarks 3.8 Rudder; 3.9 Propeller; 3.10 Hull; 3.11 Sounding Pipe 3.12 Air pipe; 3.13 Ventilator	
Specific Learning Objectives: **3.1 Shell** 3.1.1 Describe about shell & Shell material	
Specific Learning Objectives: **3.2 Deck** 3.2.1 Describe about Deck & Deck materials	
Specific Learning Objectives: **3.3 Tank Top** 3.3.1 Describe about Tank top 3.3.2 Identify tank top in the diagram	
Specific Learning Objectives: **3.4 Bulkheads** 3.4.1 Describe about Bulkhead & Bulkhead Materials	
Specific Learning Objectives: **3.5 Stiffeners** 3.5.1 Describe about Stiffeners & Stiffeners Materials	
Specific Learning Objectives: **3.6 Pillars** **3**.6.1 Describe about Pillars & its Materials	
Specific Learning Objectives: **3.7 Bulwarks** 3.7.1 Describe about Bulwarks & its importance	
Specific Learning Objectives: **3.8 Rudder** 3.8.1 Describe about Rudder & its importance	
Specific Learning Objectives: **3.9 propeller** 3.9.1 Describe about Propeller & its importance	
Specific Learning Objectives: **3.10 Hull** 3.10.1 Describe about Hull & Hull Materials	

Specific Learning Objectives: **3.11 Sounding Pipe** 3.11.1 Describe about Sounding Pipe 3.11.2 Describe the importance of the sounding pipe	
Specific Learning Objectives: **3.12 Air Pipe** 3.12.1 Describe about Air pipe 3.12.2 Describe the importance of the Air pipe	
Specific Learning Objectives: **3.13 Ventilators** 3.13.1 Describe about Ventilators	
J Ship Manning & Organizations	
General Learning Objective: Understand organization, Duties of ship staff & Watchkeeping system on board ship **J1 Sub Topic: Organization Charts** **Sub-Sub Topic & SLOs** 1.1 Deck Department Chart 1.2 Engine Department Chart	
Specific Learning Objectives: **1.1 Deck Department Chart** 1.1.1 Make deck department chart 1.2.1 Describe the general role of the person mentioned in the Chart	
Specific Learning Objectives: **1.2 Engine Department Chart** 1.2.1 Make Engine department chart 1.2.2 Describe the general role of the person mentioned in the Chart	
J2 Sub Topic: Description of duties of ship staff (IMO 7.04,2014: F1/1.1.1) P 27) **Sub-Sub Topic & SLOs** 2.1 Engine Staff 2.2 Deck Staff	2
Specific Learning Objectives: **2.1 Engine Staff** 2.1.1 Describe the Duties & responsibilities of an engine staff	
Specific Learning Objectives: **2.2 Deck Staff** 2.2.1 Describe the Duties & responsibilities of the deck staff	
J3 Sub topic: Watch keeping system (IMO 7.04,2014: F1/1.1.1) P 27) **Sub-Sub Topic & SLOs** 3.1 Watch keeping at sea 3.2 Watch keeping at harbour	
Specific Learning Objectives: **3.1 Watch keeping at sea** 3.1.1 Describe watch keeping system & timings at sea	
Specific Learning Objectives: **3.2 Watch keeping at harbour** 3.2.1 Describe watch keeping system & timings at harbour	

Subject Name/Code: English and Communication /107

Instructional Hours:

Lecture	: 45 hours
Total Contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom lectures, case study analysis, writing assignments and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Rizvi, M Ashraf. Effective Technical Communication. 2nd ed. McGraw Hill, 2017.
2. Kumar, Sanjay, and Pushp Lata. Communication Skills: A Workbook. Oxford University Press, 2018.

Reference:

1. English and Human Factors (IMU/BNA-017). Chennai: Indian Maritime University.
2. Furber, Holden et al. Maritime India. Oxford University Press, 2004.
3. Kumar, Sanjay, and Pushp Lata. English for Effective Communication. Oxford University Press, 2014.
4. M. Swan, Practical English usage, 4th ed. New York: Oxford University Press, 2016.
5. Raman, Meenakshi, and Sangeeta Sharma. Fundamentals of Technical Communication. Oxford University Press, 2015.
6. Sridharan, K. Maritime History of India. Ministry of Information and Broadcasting, 1982.

Table of Topics

Section	Topics	Hours (L)
A	**Fundamentals of Communication** **Subtopics:** Communication: Concept, Process, Levels, Flow, Styles, Verbal and Non-verbal Communication, General and Technical Communication, Effective Communication, and Barriers to communication	9
B	**Grammar and its usage on board** **Subtopics:** Types of sentences, Conditionals, Modal verbs, Prepositions, Subject-verb agreement, Tense, Voice, Articles, Determiners, Imperatives, Common errors in English	8
C	**Listening Skills** **Subtopics:** Listening: Concept, Process and types of listening, Listening vs Hearing, Barriers to effective listening	4
D	**Reading Skills** **Subtopics:** Reading Process, Reading different kinds of texts (User Manuals, Manufacturer's Manuals, Engineering Publications), Reading speed, Reading types	6
E	**Writing Skills** **Subtopics:** Writing Process, Letter/Email Writing, Résumé Writing, Report Writing, Meeting related communication, Paragraph/Essay writing on maritime-related topics, Job Requirements, Functions and responsibilities on board	18
	Total	**45**

Learning Objectives	**L**
A - Fundamentals of Communication	
General Learning Objective: Understand various aspects of communication process **Subtopics & SLOs:** 1.1 Communication: Concept, Process, Levels, Flow, and Styles 1.2 Verbal and Non-verbal Communication 1.3 Technical Communication, Effective Communication, and Barriers to communication	
Specific Learning Objectives: **1.1 Communication: Concept, Process, Levels, Flow, and Styles** 1.1.1 Define the concept of communication 1.1.2 Explain the process of communication with a diagram 1.1.3 Draw a diagram of the communication process 1.1.4 Explain the levels of communication- i.e., Extra-personal, Intrapersonal, Interpersonal, and Organizational communication 1.1.5 Describe and compare different communication styles, i.e., Passive, Aggressive, Passive-aggressive, and Assertive 1.1.6 Draw the diagrams of the flow of communication- Downward, Upward, Horizontal, and Diagonal Communication 1.1.7 Outline the main features of different flows of communication	3
Specific Learning Objectives: 1.2 **Verbal and Non-verbal Communication** 1.2.1 Describe and Compare Verbal and Non-verbal Communication 1.2.2 Explain the following terms: Paralinguistics, Proxemics and Chronemics 1.2.3 List the features of non-verbal communication	3

Specific Learning Objectives: **1.3 Technical Communication, Effective Communication and Barriers to communication** 1.3.1 Compare General and Technical Communication 1.3.2 Outline the main features of technical communication 1.3.3 Explain the importance of visual aids in technical communication 1.3.4 List the factors that would help you decide whether communication has succeeded or failed 1.3.5 Classify and explain communication barriers under the following categories: Linguistic, Psychological, Cultural, Physical, and Organizational Barriers 1.3.6 Match the situations with the categories of communication barriers	3
B - Grammar and its usage on board	
General Learning Objective: Use the English Language effectively in spoken and written forms **Subtopics & SLOs:** 1.1 Types of sentences, Conditionals, Modal verbs, Prepositions, Subject-verb agreement, Active/Passive voice, Determiners, Imperatives, Common errors in English	
Specific Learning Objectives: **1.1 Types of sentences, Conditionals, Modal verbs, Prepositions, Subject-verb agreement, Tense, Voice, Articles, Common errors in English** 1.1.1 Ask for and give personal data using correct sentence structures 1.1.2 Find the error(s) in the sentence/paragraph 1.1.3 Underline the error(s) in the sentence/paragraph and rewrite 1.1.4 Transform the sentence (tense, voice, Subject-verb agreement)	8
C - Listening Skills	
General Learning Objective: Understand listening skills, comprehend a verbal message and respond appropriately **Subtopics & SLOs:** 1.1 Listening: Concept, Process, importance, and types 1.2 Listening vs Hearing, Barriers to effective listening	
Specific Learning Objectives: **1.1 Listening: Concept, Process, importance, and types** 1.1.1 Define and explain the concept and process of listening 1.1.2 Discuss the importance of listening 1.1.3 Match the types of listening with given situations 1.1.4 Name and explain types of listening- Empathetic, Appreciative, Evaluative, Comprehensive/attentive listening	2
Specific Learning Objectives: **1.2 Listening vs Hearing, Barriers to effective listening** 1.2.1 Compare listening and hearing 1.2.2 List the factors that would help you decide whether listening has succeeded or failed 1.2.3 Explain barriers to effective listening 1.2.4 Describe the ways to overcome listening barriers	2
D - Reading Skills	
General Learning Objective: Comprehend a written document and respond appropriately **Subtopics & SLOs:** 1.1 Reading: Process, reading different kinds of texts (User Manuals, Manufacturer's Manuals, Engineering Publications), Reading speed 1.2 Reading types (clarify with activities): Prediction, Scanning, Skimming, and Intensive reading	
Specific Learning Objectives: **1.1 Reading: Process, reading different kinds of texts, Reading speed** 1.1.1 Define the concept of reading 1.1.2 Explain the process of reading	2

1.1.3 Describe different kinds of texts. (User Manuals, Manufacturer's Manuals, Engineering Publications) 1.1.4 Explain the importance of reading speed	
Specific Learning Objectives: **1.2 Reading types (clarify with activities): Prediction, Scanning, Skimming, and Intensive reading** 1.2.1 Describe different types of reading 1.2.2 Match the types of reading with the situations 1.2.3 Read the passages and answer the questions- related to dealing with emergency situations on board by receiving or sending commands, processing cargo, safety, and passenger information 1.2.4 Reading different kinds of texts (User Manuals, Manufacturer's Manuals, Engineering Publications)	4
E - Writing Skills	
General Learning Objective: Understand various components of business writing skills **Subtopics & SLOs:** 1.1 Writing Process 1.2 Letter/Email Writing 1.3 Résumé writing 1.4 Report Writing (Factual Report, Routine Report), Meeting related communication 1.5 Paragraph/Essay writing 1.6 Job Requirements, Functions and responsibilities on board	
Specific Learning Objectives: **1.1 Writing Process** 1.1.1 Describe ABC (Accuracy, Brevity and Clarity) of writing skills. 1.1.2 Identify, organize and list the points/ideas related to a given topic in a logical sequence	2
Specific Learning Objectives: **1.2 Letter/Email Writing** 1.2.1 Explain the 7 C's of letter writing 1.2.2 Describe different parts of a formal letter/email 1.2.3 List the steps to write a letter 1.2.4 Compare letter writing layouts/styles- Full Block, Modified Block, and Semi Block 1.2.5 Write a letter/email – asking for information, giving information, making arrangements, giving recommendations, etc.	3
Specific Learning Objectives: **1.3 Résumé writing** 1.3.1 Outline the objectives of writing a cover letter 1.3.2 Describe the structure (various parts) of a résumé 1.3.3 Prepare a cover letter and a résumé	2
Specific Learning Objectives: **1.4 Report Writing (Factual Report, Routine Report), Meeting related communication** 1.4.1 Discuss the structure of a report. (Factual Report / Routine Report) 1.4.2 Prepare a factual/routine report on the given topic/situation 1.4.3 Write a report (Incident Report, Accident Report, and Visit Report) on the given incident 1.4.4 Prepare notice, agenda and minutes of a meeting	3
Specific Learning Objectives: **1.5 Paragraph/ Essay Writing:** 1.5.1 Explain how to draft a paragraph? 1.5.2 Write a paragraph/an essay related to the following topics: a) Indian Maritime History: Pre-independence and Post-independence b) Significance of National Maritime Day of India c) The Sagarmala Project d) Ports of India e) Role of shipping on national economic development f) Maritime Training in India	2

Specific Learning Objectives: 1.6 **Job Requirements, Functions and responsibilities on board** 1.6.1 Describe the nature of the job at sea 1.6.2 Explain demands of the career – technical, practical, physical, emotional and psychological 1.6.3 List Personal traits that will assist in effective functioning on board 1.6.4 List the essentials of personal hygiene 1.6.5 Explain the importance of Physical fitness, health and personal hygiene on board 1.6.6 Write a note on the travel arrangements for joining a ship 1.6.7 List the functions of Fleet Personnel Department, Technical Management Department, Commercial Management Department, Safety & Quality Management Department, and Designated Person Ashore 1.6.8 Sketch shipboard organizational chart 1.6.9 Explain the functions of the Deck Department, Engine Department, and Saloon Department 1.6.10 List/Describe the functions and responsibilities of shipboard staff: Master, Chief Officer, Second Officer, Third Officer, Deck Cadet, Bosun, Chief Engineer Officer, Second Engineer Officer, Third Engineer Officer, and Electro-Technical Officer 1.6.11 Explain cadets' role on board and expectations from them	6

Subject Name/Code: Essence of Indian Traditional Knowledge/108

Instructional hours:

Lecture	: 30 hours
Total contact hours	: 30 hours
Credits	: Nil Credit; Mandatory

Teaching Methods

The course shall be conducted in a combination of classroom lectures and self-learning.

Assessment Methods Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Relates to STCW Function: Marine Engineering at Operational/Management Level.

Recommended Text:

1. S. C. Chatterjee & D. M. Datta (1984): An Introduction to Indian Philosophy.
2. V. N. Jha: Language, Thought and Reality.
3. Rear Admiral Sreedharan - A Maritime History of India-2nd Edition.

Reference:

1. R. Nagaswamy (2002), Foundations of Indian Art, Tamil Arts Academy, 2002.
2. Rig Veda Hymn 1, Hymn 2 Translation by Ralph T H Griffith.
3. Vijnanan and Saraswati - Yog Vijayan, Yoga Niketan trust, Rishikesh, 1998.
4. L. N. Rangarajan, Kautilya: The Arthashastra, Penguin Books India (P) Limited.
5. Rear Admiral Sreedharan - India's Maritime Heritage.

Table of Topics

Section	Topics	Hours (L)
A	Basic structure of Indian Knowledge System **Subtopics:** Names of 4 Vedas, Upa-Vedas, 6 Vedangas	2
B	Modern Science and Indian Knowledge System **Subtopics:** Principle of Identity, Principle of Contradiction, Principle of Excluded Middle	3
C	Foundation of Yoga **Subtopics:** Yoga in different texts - Veda, Upanishad, Geeta, Ayurveda, Patanjali yoga sutra, Tantra	4
D	Fundamentals of Human Biology & Yoga **Subtopics:** General information, Different parts, Structure, Function and Effect of yogic practices	4
E	Evolution of India through its Languages **Subtopics:** The Language Families of India	4
F	Kautilya – The Arthashastra **Subtopics:** The Kautilyan State and Society	3
G	Formation of Indian Sub-Continent & Early Maritime Settlements **Subtopics:** The evolution of India	1
H	Early and Medieval India's Maritime linkage **Subtopics:** Different kingdoms that were spread over India	2
I	Colonial threats in Indian water and indigenous resistance **Subtopics:** Resistance movement against colonialism	2
J	Industrial effects on the Marine Industry of India **Subtopics:** Industrial Revolution & British Imperialism; Sail to steam and diesel ships; Ship Construction	2
K	Indian Maritime Power in Evolution **Subtopics:** Growth of Indian Navy	1
L	Emerging Maritime Rise **Subtopics:** The rise of Indian Maritime power and dominance	2
	Total	**30**

Learning Objectives	**L**
A Basic structure of Indian Knowledge System	
GLO: Understand the basic structure of Indian Knowledge System **Sub Topic: Basic Structure of Indian Knowledge System** **Specific Learning Objectives:** Explain the following briefly: 1.1. Difference between 'Shruti' and 'Smriti' 1.2. Names of 4 Vedas 1.3. Names of 4 Upa Vedas 1.4. Names of 6 Vedangas 1.5. Hymn 1 of Book 1 Of Rig Veda 1.6. Hymn 2 of Book 1 of Rig Veda	2
B Modern Science and Indian Knowledge System	
GLO: Understand the Indian traditional knowledge system **Sub Topic: Indian Knowledge System: Yoga** **Specific Learning Objectives:** Explain the following briefly: 1.1 Principle of Identity 1.2 Principle of Contradiction 1.3 Principle of Excluded Middle	3
C Foundation of Yoga	
GLO: Understand the basics of Yoga	4

Specific Learning Objectives: Explain the following briefly: 1.1 Origin of Yoga 1.2 Definition and Meaning of Yoga 1.3 Aims and Objectives, Historical Development of Yoga 1.4 Relevance of Yoga in modern age and scope 1.5 Misconceptions about Yoga 1.6 Life sketch and their contribution to Yoga 1.7 Yoga in different text -Veda, Upanishad, Geeta, Ayurveda, Patanjali yoga sutra, Tantra 1.8 Maharshi Patanjali 1.9 Maharshi Yagyavalakya 1.10 Swami Vivekanand 1.11 Maharshi Ramana 1.12 Sri Aurobindo	
D Fundamentals of Human Biology & Yoga	
GLO: Understand the relationship between human body & yoga **Specific Learning Objectives:** Explain the following briefly: 1.1 Human Body- Meaning and its Importance in Yoga 1.2 Definition of Anatomy and Physiology 1.3 Cell: Structure & Function 1.4 General information, Different parts, Structure, Function and Effect of yogic practices 1.5 Tissues: Types, Structure & Function. 1.6 Musculo-Skeletal System 1.7 Digestive system 1.8 Excretory system 1.9 Respiratory System 1.10 Circulatory system 1.11 Nervous System 1.12 Endocrinal system	4
E Evolution of India through its Languages	
GLO: Understand the evolution of Indian Languages and their origin etc. **Specific Learning Objectives:** Explain the following briefly: 1.1 The Language Families of India 1.2 The Indo-Aryan Languages 1.3 The Dravidian Languages 1.4 The Austric Family 1.5 The Tibeto-Burman Languages 1.6 Other Languages 1.7 The Writing Systems 1.8 The Indus Valley Script 1.9 The Brahmi Script 1.10 The Kharosthi Script 1.11 Modern-day Writing Systems	4
F Kautilya and Arthashastra	
GLO: Understand the structure of Kautilya's principles etc. **Specific Learning Objectives:** Explain the following briefly: 1.1 The Kautilyan State and Society 1.2 The Country 1.3 The Kautilyan Society 1.4 Aryans and Non-Aryans 1.5 The Varna System	3
G Formation of Indian Sub-Continent & Early Maritime Settlements	
GLO: Understand the evolution of India **Specific Learning Objectives:** Explain the following briefly: 1.1 History of ancient super continental breakup	1

1.2 India and evolution of South Asia	
H Early and Medieval India's Maritime linkage	
GLO: Understand the different kingdoms that were spread over India **Specific Learning Objectives:** Explain the following briefly: 1.1 Harappan Saraswati Civilisation 1.2 Lothal dock 1.3 Kalinga – Bangla Region. 1.4 The Pallavas 1.5 Chola's Pioneer naval expeditions 1.6 Rome-Muziris connect 1.7 Medieval Malabar Hub	2
I Colonial threats in Indian water and indigenous resistance	
GLO: Understand the resistance movement against colonialism **Specific Learning Objectives:** Discuss the following briefly: 1.1 Kunjali Marrakkar 1.2 Marthanda Varma and the battle of Colachel 1.3 Rise of Maratha Armar 1.4 Kanhoji Angre 1.5 Rani Abbakka 1.6 Indian Freedom Fighters from other regions of India	2
J Industrial effects on the Marine Industry of India	
GLO: Understand the effect of industrialisation **Specific Learning Objectives:** Discuss the following briefly: 1.1 Industrial Revolution 1.2 Impact of British imperialism 1.3 Transition of sail to steamships; diesel ships 1.4 Shipbuilding Legacy; ship construction	2
K Indian Maritime Power in Evolution	
GLO: Understand the growth of Indian Navy **Specific Learning Objectives:** Discuss the following briefly: 1.1 Bombay and Bengal Marines 1.2 Indian Naval Contribution in World Wars	1
L Emerging Maritime Rise	
GLO: Understand the rise of Indian Maritime power and dominance **Specific Learning Objectives:** Discuss the following briefly: 1.1 Early Post-Independent Years 1.2 Goa Liberation 1.3 Naval Transformation 1.4 Indigenisation of shipbuilding capacities 1.5 Modernisation of Maritime policies 1.6 HADR operations (Humanitarian Assistance Disaster Relief)	2

Subject Name/Code: Constitution of India and Merchant Shipping Act/109

Instructional hours:

Lecture	: 15 hours
Total Contact hours	: 15 hours
Credits	: Nil Credit; Mandatory

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, group discussion, individual/group presentation, writing assignments and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. D. Basu, Introduction to the Constitution of India, 25th ed. Gurgaon: Lexis Nexis, 2021.

Reference:

1. A Singh and K. Murari, Constitutional Government and Democracy in India, 1st ed. Noida: Pearson Education, 2019.
2. Dgshipping.gov.in. n.d. THE MERCHANT SHIPPING ACT, 1958. [online] Available at: <https://www.dgshipping.gov.in/Content/MerchantShippingAct.aspx> [Accessed 8 June 2021].
3. M. Laxmikanth, Indian Polity, 6th ed. Chennai: McGraw Hill, 2020.
4. P. Mellalli, Constitution of India, Professional Ethics and Human Rights, 1st ed. New Delhi: SAGE Texts, 2015.
5. S. Kashyap, Constitution of India - A handbook for students, 1st ed. New Delhi: Vitasta Publishing Pvt. Ltd., 2019.

Table of Topics

Section	Topics	Hours (L)
A	**Introduction to Indian Constitution** **Subtopics:** (i) Introduction to Government of India Act 1919, Government of India Act 1935, and Indian Independence Act of 1947, (ii) Framing of Indian Constitution	3
B	**Union, State and Local Governments** **Subtopics:** Working of the union, state and local governments	3
C	**Rights and Duties** **Subtopics:** Fundamental Rights, Fundamental Duties, and Directive Principles	3
D	**Select Statutory Institutions** **Subtopics:** Importance of select statutory institutions of India, viz. Election Commission of India, National Human Rights Commission and National Commission for Women	3
E	**The Merchant Shipping Act, 1958** **Subtopics:** Select Provisions of the Merchant Shipping Act- Establishment and functions of National Shipping Board, Process of registration of Indian Ships, Certificates of Officers. Provisions related to seamen, Functions of National Welfare Board for Seafarers	3
	Total	**15**

Learning Objectives	L
A: Introduction to Indian Constitution	
General Learning Objective: Understand the background and the main features of the Constitution of India **Subtopics & SLOs:** Explain the following: 1.1 Evolution of the Indian Constitution: Government of India Act 1919, Government of India Act 1935 and Indian Independence Act of 1947 1.2 Framing of Indian Constitution 1.3 Fundamental features of the Indian Constitution	
Specific Learning Objectives: Explain the following: **1.1 Evolution of the Indian Constitution: Government of India Act 1919, Government of India Act 1935 and Indian Independence Act of 1947** 1.1.1 Outline the historical background of the Indian Constitution 1.1.2 List the main features of the Government of India Act 1919, the Government of India Act 1935 and the Indian Independence Act of 1947 1.1.3 Explain whether democratic societies need a constitution 1.1.4 Explain how a constitution is different from ordinary law	1
Specific Learning Objectives: Explain the following: **1.2 Framing of Indian constitution** 1.2.1 Explain the role of the Constituent Assembly 1.2.2 List the functions of the Constituent Assembly	1
Specific Learning Objectives: Explain the following: **1.3 Fundamental features of the Indian Constitution** 1.3.1 Interpret the Preamble of the Constitution of India	1

1.3.2 Summarize the salient features of the Constitution of India 1.3.3 Outline the making of the 1950 Constitution 1.3.4 Explain whether the Preamble helps us interpret the constitution	
B: Union, State and Local Governments	
General Learning Objective: Understand the working of the union, state and local governments **Subtopics & SLOs:** 1.1 Union Government 1.2 State Government 1.3 Local Government	
Specific Learning Objectives: **1.1 Union Government** 1.1.1 Outline the functions of the Union Executive 1.1.2 Explain the role of the President and the Vice President in India 1.1.3 Describe the function of the Indian Parliament? 1.1.4 Explain the role of the Judiciary in maintaining the sanctity of the Constitution of India	1
Specific Learning Objectives: **1.2 State Government** 1.2.1 Outline the functions of the State Governments 1.2.2 Explain the role of the Governor in a state 1.2.3 Describe the functions of the Legislative Assembly and Legislative Council	1
Specific Learning Objectives: **1.3 Local Government** 1.3.1 Explain the role of Panchayat Raj Institutions in India 1.3.2 Show how the Urban Governments function	1
C: Rights and Duties	
General Learning Objective: Understand the fundamental rights and duties under the Constitution **Subtopics & SLOs:** 1.1 Fundamental Rights and their limitations 1.2 Fundamental Duties and their significance 1.3 Directive Principles	
Specific Learning Objectives: **1.1 Fundamental Rights and their limitations** 1.1.1 List the Fundamental Rights 1.1.2 Explain the limitations of the Fundamental Rights? 1.1.3 Explain who will protect these rights when they are violated?	1
Specific Learning Objectives: **1.2 Fundamental Duties and their significance** 1.2.1 List the Fundamental Duties 1.2.2 Describe the limitations of the Fundamental Duties 1.2.3 Explain the criticism of Fundamental Duties	1
Specific Learning Objectives: **1.3 Directive Principles** 1.3.1 Describe the importance and relevance of Directive Principles of State Policy 1.3.2 Explain the conflict between Fundamental Rights and Directive Principles of State Policy (DPSPs)	1
D: Select Statutory Institutions	
General Learning Objective: Understand the importance of select statutory institutions of India	

Subtopics & SLOs: 1.1 Election Commission of India 1.2 National Human Rights Commission 1.3 National Commission for Women	
Specific Learning Objectives: **1.1 Election Commission of India** 1.1.1 List the functions of Election Commission of India 1.1.2 Explain the powers of the Election Commission? 1.1.3 Explain the Electoral Process in India	1
Specific Learning Objectives: **1.2 National Human Rights Commission** 1.2.1 Elaborate Human Rights and Values 1.2.2 Describe the role of the National Human Rights Commission of India 1.2.3 List the main features of the Protection of Human Rights (Amendment) Act, 2019	1
Specific Learning Objectives: **1.3 National Commission for Women** 1.3.1 Describe the constitution of the National Commission for Women 1.3.2 Explain the functions of the Commission 1.3.3 Outline the main features of the National Commission for Women (Procedure) Regulations, 2016 for Dealing with Complaints in NRI Cell	1

E Merchant Shipping Act **General Learning Objective:** Understand the importance of MS Act **Subtopics & SLOs:** Explain the following: 1.1 Evolution of the Act and significance (Select Provisions) 1.2 Importance to Shipping and alignment with International Rules/Conventions 1.3 Changes to MS Act	
Specific Learning Objectives **1.1 Evolution of the Act and significance** 1.1.1 State Enactment period etc. 1.1.2 Describe the framework of the Merchant Shipping Act 1.1.2 List the important Elements and their Functions (National Shipping Board; National Welfare Board for Seafarers etc.) 1.1.3 Explain Registration of Ships, Certification/Welfare of Seafarers etc. 1.1.4 Explain the provisions related to seamen- Classification of Seamen, Engagement of Seamen, Discharge of Seamen, Payment of Wages, Health and Accommodation, etc. **Specific Learning Objectives** **1.2 Importance to Shipping and alignment with International Rules/Conventions** 1.2.1 Describe Safety, Load line, Stability aspects 1.2.2 Explain importance of Collision, Pollution Responsibilities (International Oil Pollution Compensation Fund etc.) **Specific Learning Objectives** **1.3 Changes to MS Act** 1.3.1 Explain why changes are needed 1.3.2 Explain efforts taken by GoI/MoPSW/DGS	3

Subject Name/Code: Physics Laboratory (P)/110

Instructional Hours:

Practical	: 30 hours
Total Contact hours	: 30 hours
Credits	: 1

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. A textbook of Engineering Mechanics by R.S. Khurmi.
2. A textbook of Engineering Mechanics by Dr. R. K. Bansal.

Reference:

1. Engineering Mechanics Statics and Dynamics by Rajasekaran S and Sankarasubramanian G.
2. Electrical Technology volume 1 by B. L. Theraja.
3. Applied Mechanics, J. Hannah and M.J. Hiller, Longman,1998, ISBN:9780582256323.

Table of Topics

Section	Topics	Hours
A1	Electrical Practical Exercises: Biot-Savart's law, Coulomb's force, Energy Band Gap of a Semiconductor, Kirchhoff's Laws, B-H curve, Hall voltage	14
B1	Mechanics Practical Exercises	16
	Total	**30**

Learning Objectives	P
A. Electrical Practical Exercises	**14**
General Learning Objective Understand different basic laws used in electrical and magnetic systems **A1. Sub-Topics: Basic Magnetic and Electrical Laws.** **Sub-Sub-topics** 1.1 Biot Savart's Law 1.2 Coulomb's force law 1.3 Energy Band Gap of a Semiconductor 1.4 Kirchhoff's Laws 1.5 B-H curve 1.6 Hall effect	14
Specific Learning Objectives: **1.1 Biot Savart's Law** 1.1.1. Explain Biot Savart's Law 1.1.2. Study the magnetic field for a straight conductor 1.1.3. Study the magnetic field along the axis of a current carrying circular loop according to Biot-Savart law 1.1.4. Predict the strength of the magnetic field at the centre of the current carrying circular loops	2
Specific Learning Objectives: **1.2 Coulomb's force law** 1.2.1 Explain Coulomb's Law 1.2.2 Determine the factors which affect the electrostatic force, between two charges, q1 and q2 1.2.3 Determine the value of Coulomb's Constant, k	2
1.3 Energy Band Gap of a Semiconductor 1.3.1 Explain Band gap energy and its formula for a P-N junction diode 1.3.2 Calculate Band gap energy using the formula and value of current at different temperatures	2
1.4 Kirchhoff's Laws 1.4.1 Explain Kirchhoff's current law 1.4.2 Explain Kirchhoff's voltage law 1.4.3 Verify KCL using electrical circuit 1.4.4 Verify KCL using electrical circuit	2
1.5 B-H curve 1.5.1 Explain B-H curve for magnetic materials 1.5.2 Plot the graph of B Vs H	4
1.6 Hall effect 1.6.1 Explain Hall Voltage and effect 1.6.2 Determine the Hall voltage in a sample of doped germanium is studied for Constant magnetic field and temperature and varying control current 1.6.3 Determine the Hall voltage in a sample of doped germanium is studied for Constant control current and temperature and varying magnetic field	2

1.6.4 Determine the Hall voltage in a sample of doped germanium is studied for Constant magnetic field and control current and varying temperature	
B. Mechanics Practical Exercises	**16**
General Learning Objective **Understand the basic concepts used in mechanics and their applications** B1. **Sub-Topic: Fundamentals Laws of mechanics and their applications** **Sub-Sub Topics** 1.1 Triangle Law of Forces 1.2 Polygon Law of Forces 1.3 Analysis of forces in Derrick crane 1.4 Analysis of forces in shear leg apparatus 1.5 Support reactions of a loaded beam 1.6 Moment of Inertia and radius of Gyration of flywheel 1.7 Coefficient of friction between leather and metal	16
Specific Learning Objectives: **1.1 Triangle Law of forces** 1.1.1 Explain triangle law of forces 1.1.2 Verify the triangle law of forces	2
Specific Learning Objectives: **1.2 Polygon Law of forces** 1.2.1 Explain polygon law of forces 1.2.2 Verify the polygon law of forces	2
Specific Learning Objectives: **1.3 Analysis of forces in Derrick crane** 1.3.1 Explain features of a Derrick crane 1.3.2 Experimentally determine the magnitude and nature of forces acting on the different members of Derrick crane with varying loads. 1.3.3 Theoretically determine the magnitude and nature of forces acting on the different members of Derrick crane using equilibrium equations or Lami's theorem	2
Specific Learning Objectives: **1.4 Analysis of forces in shear leg apparatus** 1.4.1 Explain features of a shear leg apparatus 1.4.2 Experimentally determine the magnitude and nature of forces acting on the different members of shear leg 1.4.3 Theoretically determine the magnitude and nature of forces acting on the different members of shear leg using equilibrium equations (Vector analysis)	2
Specific Learning Objectives: **1.5 Support reactions of a loaded beam** 1.5.1 Explain Moment and Principle of moment 1.5.2 Explain different types of Beams and their applications 1.5.3 Study types of support and support reactions 1.5.4 Experimental and theoretical determination of support reactions in simply supported beam 1.5.5 Experimental and theoretical determination of support reactions in Bell Crank Lever	4
Specific Learning Objectives: **1.6 Moment of Inertia and radius of Gyration of flywheel** 1.6.1 Flywheel: Explain concept, design and applications 1.6.2 Explain the concept of moment of inertia 1.6.3 Define radius of Gyration 1.6.4 Determination of moment of Inertia and radius of gyration	2
Specific Learning Objectives: **1.7 Coefficient of friction between leather and metal** 1.7.1 Explain Coulomb's Law of dry friction 1.7.2 Experimentally Calculate the coefficient of friction between leather and metal by using inclined plane apparatus	2

Subject Name/Code: Workshop Technology (P)/111

Instructional hours:

Practical	: 60 hours
Total contact hours	: 60 hours
Credits	: 2

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. Workshop Technology V [I] , S.K. Hajra Chaudhary. Media promoters & publishers Pvt. Ltd.
2. Workshop Technology V[II] , S.K. Hajra Chaudhary. Media promoters & publishers Pvt. Ltd.

Reference:

1. A Text Book of Workshop Technology, R.S. Khurmi & J.K. Gupta. S. Chand& company Pvt. Ltd.
2. Workshop Technology, W.A.J. Chapman Vol I & Vol II, Published by Routledge (1972).
3. Elements of Manufacturing processes, B.S. Nagendra Parashar& R.K Mittal. PHI Learning Pvt. Ltd.
4. Workshop Practical Manual.

Table of Topics

Section	Topics	Hours (P)
A1-A2	**Safety Measures** **Sub-Topics:** Safe working practices, Introduction to workshop machines and Personal protective equipment and Risk hazards in workshop while performing practical and Identification and checks of safety equipment / guards	4
B1-B4	**Common Workshop Tools** **Sub-Topics:** Bench and Fitting hand and measuring Tools, Carpentry Shop, Smithy Shop and Power operated hand Tools	20
C1-C3	**Lathe machine and operations** Sub-Topics: Introduction, function, classification & specification of lathe machine, Main parts and accessories and General operations	12
D1-D2	**Drilling and Allied operations** **Sub-Topics:** Drill Machine's Parts and accessories and Demonstrate drilling procedure	2
E1-E2	**Shaping Machine & Operations** **Sub-Topics:** Specification, classification of Shaping machine, General constructions, mechanism and General operations	4
F1-F2	**Milling machine and Operations** **Sub-Topics:** Milling Machine, General construction, Main parts& accessories and General operations and Milling processes	2
G1-G2	**Abrasive machining Processes** **Sub-Topics:** Grinder Machine and its parts, Safe working practices and checks while operating grinding machine and Demonstrate Pedestal and Hand Grinding machine operation	4
H1-H3	**Joining Processes** **Sub-Topics:** Electric Arc Welding process and techniques and Oxy Acetylene Gas Welding/Cutting, Inspection of Arc and Gas welding	12
	Total	**60**

Learning Objectives	P
A. Safety measures	**4**
General Learning Objective (IMO 7.04,2014, F3/3.15 P135 and 7.02D3/3.3 P144-146) Increase safety awareness and develop the safety culture in the student while working on the shop floor / equipment **Sub-topic: Safety measures** **Sub-subtopics & SLOs** 1.1 Safe working practices, Introduction to workshop machines and Personal protective equipment 1.2 Risk hazards in workshop while performing practical and Identification and checks of safety equipment / guards	
Specific Learning Objectives: **1.1 Safe working practice, Introduction to workshop machines and Personal protective equipment.** 1.1.1 Explain the safe working practices to be followed while in workshop area / equipment 1.1.2 Explain importance of PPE 1.1.3 Explain the various hazards of shop floor / equipment and protection for each 1.1.4 Explain safety instructions and operating instructions of each work place and equipment	2
1.2 Risk hazards in workshop while performing practical and Identification and checks of safety equipment / guards. 1.2.1 Explain the importance of safety Guards and Safety Devices provided in each equipment / work place 1.2.2 Demonstrate safe working practices while performing work in workshop/ equipment 1.2.3. Describe familiarization to workshop equipment	2
B. Common Workshop Tools	**20**
General Learning Objective (IMO 7.04,2014, F3/3.16) P136 Understand use of various hand operated and power operated/ assisted tools **Sub-topic:** **Common Workshop Tools** **Sub-subtopics & SLOs** 2.1.1 Bench and Fitting Tools 2.1.2 Carpentry Shop 2.1.3 Smithy Shop 2.1.4 Power operated hand Tools	
Specific Learning Objectives: **2.1.1 Bench Fitting hand and measuring Tools** 2.1.1.1 Explain and demonstrate uses of common fasteners, spanners and wrenches 2.1.1.2 Explain and demonstrate application of different work holding devices like Bench vice, Hand vice, pipe & leg vice, pin vice and v-block with clamp, Magnetic V Block 2.1.1.3 Explain and demonstrate application of different Striking tools (Ball-peen, cross-peen, straight-peen, Double-headed and soft hammer) 2.1.1.4 Explain and demonstrate application of cutting tools (Chisels, files, scraper and Hacksaw) 2.1.1.5 Explain and demonstrate uses of Measuring Tools i.e., Vernier Calliper, Micrometer, Dial Gauge, feeler gauge, Thread Pitch Gauge, Ring Gauge, Plug Gauge, Radius Gauge etc. 2.1.1.6 Explain and demonstrate different marking tools (surface plate, scriber, punches, angle plate, Try-square, combination set, Trammel, Straight edge, Vernier height gauge etc.) 2.1.1.7 Demonstrate making of an open fitting task using hack sawing, and filing operation Sketch and describe about Twist drill nomenclature and angle 2.1.1.8 Explain Drill machine and its parts. Demonstrate Speed setting of drill machine	12

2.1.1.9 Demonstrate a close fitting task using hack sawing, chain drilling , chipping and filing operation	
2.1.2 Carpentry Work 2.1.2.1 Demonstrate use of Marking and measuring tools (Marking gauge, mortise gauge, fold rule, Try square, Mitre square, pattern Maker scale, calliper and sprit level etc.) 2.1.2.2 Demonstrate use of cutting tools (Saw, chisels and Gouging tools etc.) 2.1.2.3 Demonstrate use of tools (Jack plane, smoothing plane etc.) 2.1.2.4 Demonstrate use of Job holding device and boring tools 2.1.2.5 Demonstrate making of Dove Tail Joint, Lap Joint	3
2.1.3 Smithy and Foundry work 2.1.3.1Explain and demonstrate use of smithy tools (Anvil, swage block, hammers, tongs, chisel, fullers, flatters, punches & drift etc.) 2.1.3.2 Demonstrate making of a job consisting of drawing down, hot bending and making square head	3
2.1.4 Power Operated Hand Tools 2.1.4.1 Demonstrate safe working practices while operating Power hand tools 2.1.4.1 Demonstrate grinding/ buffing operation using hand grinder 2.1.4.1 Demonstrate use of pneumatic tools	2
C. Lathe machine and operations	**12**
General Learning Objective (IMO 7.04,2014, F3/3.16) P137 Understand Lathe machine construction, their classification, mechanism and different operations that are performed by different lathe **Sub-topic: Lathe machine and operations** **Sub-subtopics & SLOs** 3.1 Introduction, function, classification & specification of lathe machine 3.2 Main parts and accessories 3.3 General operations	
Specific Learning Objectives: 3.1 Introduction, function, classification and Specifications of lathe machine 3.1.1 Demonstrate safe working practices while working on lathe machine	2
3.2 Main parts and accessories. **3.2.1** Identify and explain different parts and accessories of lathe machine (Head stock, tail stock, carriage, chuck, face plate etc.)	2
3.3 General operations 3.3.1 Demonstrate various operations which are carried out on lathe machine (facing, Turning, Drilling, Taper turning step turning, thread cutting chamfering, knurling etc.). 3.3.2 Demonstrate making of a job on lathe performing different lathe operations as specified	8
D. Drilling and Allied operations	**2**
General Learning Objective (IMO 7.04,2014, F3/3.16) P137 Understand Drilling machine construction, their classification, mechanism and different operations that are performed by different Drilling machines **Sub-topic: Drilling machine and operations** **Sub-subtopics & SLOs** 4.1. Drill Machine's Parts and accessories 4.2 Demonstrate drilling, boring, reaming procedures	
Specific Learning Objectives:	1

4.1. Drill Machine's Parts and accessories 4.1.1 Demonstrate safe working practices while working on lathe machine 4.1.2 Identify and explain different parts and accessories of Drilling machine	
4.2 Demonstrate drilling procedure 4.2.1 Demonstrate making of a job on Drilling performing different Drilling, reaming operations as specified	1
E. Shaping Machine & Operations	**4**
General Learning Objective (IMO 7.04,2014, F3/3.16) P137 Understand Shaping & Planning machine construction, their classification, mechanism and different operations that are performed by different Shaping & Planning machine **Sub-topic: Shaping Machine & Operations** **Sub-subtopics & SLOs** 5.1 Specification, classification of Shaping machine, General constructions and mechanism 5.2 General operations	
Specific Learning Objectives: **5.1 Specification, classification of Shaping machine, General constructions and mechanism** 5.1.1 Explain and demonstrate safe working practices while working on a Shaping Machine 5.1.2 Identify and explain the different parts of shaping Machine	1
5.2 General operations 5.2.1 Demonstrate shaping machine operation bevelling/ planning operation 5.2.2 Demonstrate making of a job on Shaper performing different shaping operations as specified	3
F. Milling machine and Operations	**2**
General Learning Objective (IMO 7.04,2014, F3/3.16) P137 Understanding Milling machine construction, their classification, mechanism and different operations that are performed by different milling machine **Sub-topic: Milling machine and Operations** **Sub-subtopics & SLOs** 6.1 Milling Machine, General construction, Main parts& accessories 6.2 General operations and Milling processes	
Specific Learning Objectives: 6.1 Milling Machine general construction, Main parts& accessories 6.1.1 Demonstrate safe working practices on Milling machine 6.2.2 Identify different Main parts and accessories of milling machine 6.2.3 Identify different tools of milling machine	1
6.2 General operations and Milling processes 6.2.1 Demonstrate making a job such as hexagon / key way/spur gear cutting operation on milling machine	1
G. Abrasive machining Processes	**4**
General Learning Objective (IMO 7.04,2014, F3/3.16) P136 Understanding Bench and hand machine construction, their mechanism and different operations that are performed by different Bench & hand grinding machine **Sub-topic: Abrasive machining Processes** **Sub-subtopics & SLOs** 7.1 Grinder Machine and its parts, Safe working practices and checks while operating grinding machine. 7.2 Demonstrate Pedestal and Hand Grinding machine operation	
Specific Learning Objectives: 7.1 Grinder Machine and its parts, Safe working practices and checks while operating grinding machine.	2

7.1.1 Demonstrate the safe working practices on Grinding machine 7.1.2 Identify different parts of the drilling machine	
7.2 Demonstrate Pedestal and Hand Grinding machine operation 7.2.1 Demonstrate making a job like tool grinding rough surface grinding, Buffing & polishing etc.	2
H. Joining processes	**12**
General Learning Objective (IMO 7.04,2014, F3/3.16) P (137-141) Understand the various aspects of permanent material joining processes like welding, soldering, brazing **Sub-topic:** Joining processes (Electric Arc Welding - Gas Welding / Cutting- Soldering & Brazing) **Sub-subtopics & SLOs** 8.1 Electric Arc Welding process, techniques and Inspection 8.2 Oxy Acetylene Gas Welding/ Cutting and Inspection 8.3 Soldering & Brazing	
Specific Learning Objectives: 8.1 Electric Arc Welding process and techniques 8.1.1 Demonstrate safe working practices while performing welding, Safety instruction Hot work permit and operating instruction of the welding machine 8.1.2 Demonstrate the connecting of welding machine and preparation for welding. Straight Polarity and Reverse polarity 8.1.3 Demonstrate Arc striking and arc stabilizing 8.1. 4 Demonstrate weld acceptable bead making for a satisfactory weld 8.1.5 Demonstrate Lap Joint weld, T Weld, and Butt Weld 8.1.6 Demonstrate V Weld 8.1.7 Explain common defect in arc welding and their remedial action 8.1.8 Demonstrate TIG/ MIG welding process 8.1.9 Demonstrate Brazing and soldering operation	6
8.2 Oxy Acetylene Gas Welding/ Cutting 8.2.1 Demonstrate safe working practices while performing Oxyacetylene welding/ cutting, Safety instruction Hot work permit and operating instruction of the oxyacetylene system 8.2.2 Demonstrate connecting oxyacetylene system and preparing for operation 8.2.3 Identify different components and accessories of oxyacetylene system and explain their applications 8.2.4 Demonstrate different flame setting and explain their uses 8.2.5 Demonstrate Fusion welding with out and with filler 8.2.6 Demonstrate gas cutting of a 10mm thick plate straight and circular and Inspection process	4
8.3 Soldering & Brazing 8.3.1 Demonstrate how to make a soft and hard soldering 8.3.2 Explain the process of brazing	2

Subject Name/Code: Marine Engineering Graphics (P)/112

Instructional hours:

Practical	: 45 hours
Total contact hours	: 45 hours
Credits	: 1.5

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. N.D. Bhatt, 'Engineering Drawing' Charotar Publishing House.

Reference:

1. Simmonds, C.H. and Maguire D.E. progressive engineering drawing for T.E.C students, London, Hodder and Stoughton Ltd,1983(ISBN03-40-26196-x-0) out of print 1999.
2. M. B. Shah and B.C. Rana, 'Engineering Drawing ', Pearson Education.

Table of Topics

Section	Topics	Hours (P)
A	Types of drawings	2
B	Line work	2
C	Pictorial Projection	6
D	Development	6
E	Dimensioning	4
F	Engineering drawing practice	25
	Total	**45**

Learning Objectives	P
General Learning Objective Understand about good draftsman-ship, curves used in the engineering practice and projection of solids **A Types of drawings** **Specific Learning Objectives: (IMO 7.04,2014: A1/3.2.6.) COMPETENCE 3.2.** **Sub-topics & SLOs** 1.1 Explain the purpose of the general arrangement 1.2 Explain the purpose of the assembly drawings 1.3 Explain the purpose of component drawings 1.4 Explain the use of collective single-part drawings 1.5 Explain the use of pictorial drawings 1.6 List the standard/ routine information and references commonly given on drawings	2
General Learning Objective Draw and illustrate various projections of engineering drawings **B Line work** **Sub-topics & SLOs** 1.1 Relate examples of lines to applications and vice-versa 1.2 Draw tangents as required in practice 1.3 Demonstrate what is meant by: first-angle projection third-angle projection and sketch the correct symbol for both cases using given examples 1.4 Complete first and third-angle projections with missing lines missing views simple plotted curves 1.5 Prepare a sketch given simple components and provides sufficient dimensions for their manufacture 1.6 Draw a third-angle projection with hidden detail 1.7 Explain the use of auxiliary projection	2
General Learning Objective Draw and illustrate various isometric views of few basic engineering components **C Pictorial projection** **Sub-topics & SLOs** 1.1 Draw isometric projections of simple solids 1.2 Draw orthographic projections of simple solids 1. Axis perpendicular to a plane 2. axis parallel to both planes 3. axis parallel to one plane and inclined to the other 4. axis inclined to both planes 1.3 Generate sectional views in orthographic projection	6

General Learning Objective Draw and illustrate various projections of regular geometric shapes **D Development** **Sub-topics & SLOs** 1.1 Draw the development of a 90° intersection of circular trunking 1.2 Draw the development of a cone 1.3 Draw the development of a square pyramid 1.4 Draw the development of a square-to-round transition piece 1.5 Develop the surface of prisms 1.6 Draw pyramids and cones and the curves of intersection of cylinders to cylinders, cylinders to cones and other solids	6
General Learning Objective Demonstrate insertion of various dimensions following conventional methods **E Dimensioning** **Sub-topics & SLOs** 1.1 Draughtsman ship 1.2 Lettering, dimensioning 1.3 Types of lines and correct use of drawing instruments 1.4 Construction of geometrical figures specially showing joining of straight lines and Curves, dimensions a simple component, applying all correct standards 1.5 Explain the advantage of datum dimensioning	4
General Learning Objective Demonstrate by drawings sectional views, an understanding of engineering drawing **F Engineering drawing practice** **Sub-topics & SLOs** 1.1 Sections in two parallel planes 1.2 Revolved sections 1.3 Thin sections 1.4 Part sections 1.5 Half sections 1.6 Hidden detail 1.7 Conic sections construction of ellipse, 1.8 Parabola and hyperbola by various methods 1.9 Drawing of spirals 1.10 Involutes 1.11 Cycloids 1.12 Epi and hypocycloids 1.13 Helixes 1.14 Detailed drawings of helical springs of round and rectangular sections; Square thread formation in proper helical form	25

Subject Name/Code: English and Communication Lab (P)/113

Instructional Hours:

Practical (P)	: 45 hours
Total Contact hours	: 45 hours
Credits	: 1.5

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Practical Internal Assessment	: 50%
Practical External Assessment	: 50%

Recommended Text:

1. Rizvi, M Ashraf. Effective Technical Communication. 2^{nd} ed. McGraw Hill, 2017.
2. Kumar, Sanjay, and Pushp Lata. Communication Skills: A Workbook. Oxford University Press, 2018.

Reference:

1. Balasubramanian, T. English Phonetics for Indian Students. Laxmi Publications, 2018.
2. IMO Standard Marine Communication Phrases. International Maritime Organization, 2002.
3. Jones, Daniel. Cambridge English Pronouncing Dictionary. Cambridge University Press, 2012.
4. Koneru, Aruna. Professional Speaking Skills. Oxford University Press, 2015.
5. Kumar, Sanjay, and Pushp Lata. English for Effective Communication. Oxford University Press, 2014.
6. M. Swan, Practical English usage, 4th ed. New York: Oxford University Press, 2016.

Table of Topics

Section	Topics	Hours (P)
	Practical	
A	**Introduction to English Phonology** **Subtopics -** Speech Sounds, Consonant Clusters, Word Stress, Intonation, Sentence Stress	6
B	**Introduction to Maritime English** **Subtopics -** Maritime English, Standard Marine Communication Phrases (SMCP)	9
C	**Developing Vocabulary** **Subtopic -** Adjectives of nationality, Verbs describing routine operations on board; Phrases connected with Watchkeeping duties, Adjectives indicating preferences, Basic galley equipment, Cooking utensils, adjectives describing physical appearance and personality, phrases for greeting and introducing people; nouns connected with planning, idioms	6
D	**Developing Listening Skills** **Subtopic -** Listening training: speeches of people of different backgrounds and regions, preferably native speakers of English, Maritime communication Listening exercises: listening for general content, listening to fill up the information, Intensive listening, listening for specific information.	6
E	**Developing Speaking Skills** **Subtopics -** Speaking activities in various contexts, Making a Presentation, Facing a job Interview, Group Communication	18
	Total	**45**

Learning Objectives	**P**
A - Introduction to English Phonology	
General Learning Objectives Understand and use the sounds in English effectively **Subtopics & SLO:** 1.1 Speech Sounds- Vowels and Consonants 1.2 Consonant Clusters, Word Stress, Intonation, Sentence Stress	
Specific Learning Objectives: 1.1 Speech Sounds- Vowels and Consonants 1.1.1 Describe the term 'phonology' and its application in communication 1.1.2 List the speech sounds with one example of each 1.1.3 Differentiate between Consonant, Monophthong, and Diphthong with examples 1.1.4 Identify commonly mispronounced sounds/words and rectify 1.1.5 Identify the different accents and record the sounds in your own voice in the language lab	3
Specific Learning Objectives: 1.2 Consonant Clusters, Word Stress, Intonation, Sentence Stress 1.2.1 Describe the following terms with examples: Syllable, Consonant clusters, Word stress, Intonation, and Sentence Stress 1.2.2 Transcribe the phonetics into words and vice versa 1.2.3 Listen to the recorded speech and repeat 1.2.4 Understand the different accents and repeat 1.2.5 Read a paragraph loudly and record your own voice in the language lab 1.2.6 Listen and make language corrections	3
B - Introduction to Maritime English	
General Learning Objectives Understand and use SMCP effectively in maritime communication **Subtopics & SLO:** 1.1 Maritime English	

1.2 Standard Marine Communication Phrases (SMCP):	
Specific Learning Objectives: 1.1 Maritime English 1.1.1 Recall, describe and identify the fundamentals of maritime English 1.1.2 Compare General English and Maritime English 1.1.3 Define the terms related to maritime English 1.1.4 Locate parts of a ship and describe their functions 1.1.5 Identify parts of the ship in a drawing	3
Specific Learning Objectives: 1.2 Standard Marine Communication Phrases (SMCP): 1.2.1 Explain the importance of SMCP in maritime practice 1.2.2 Identify and use SMCP related to procedure, spelling, message markers, responses, urgency/safety signals, corrections, readiness, repetition etc. 1.2.3 List the spelling of letters, Message Markers, Distress, Urgency and Safety Signals. 1.2.4 Identify and use SMCP terms related to numbers, positions, bearing, courses, distances, speed, times, geographical names, ambiguous words, omission of 'may, might, should, could etc. 1.2.5 List and describe the Ambiguous words in SMCP 1.2.6 Use SMCP using a walky-talky device	6
C - Developing Vocabulary	
General Learning Objectives Understand and use a wide range of vocabulary in day-to-day conversations as well as in the maritime sector **Subtopics & SLO:** **1.1** Adjectives of nationality, Verbs describing routine operations on board; Phrases connected with engine room duties, Adjectives indicating preferences, Basic galley equipment, Cooking utensils, adjectives describing physical appearance and personality, phrases for greeting and introducing people; nouns connected with planning, idioms	
Specific Learning Objectives: 1.1 Adjectives of nationality, Verbs describing routine operations on board; Phrases connected with engine room duties, Adjectives indicating preferences, Basic galley equipment, Cooking utensils, adjectives describing physical appearance and personality, phrases for greeting and introducing people; nouns connected with planning, idioms 1.1.1 Use the techniques of improving vocabulary. 1.1.2 Find the error(s) in the sentence/paragraph. 1.1.3 Underline the error(s) in the sentence/paragraph and rewrite. 1.1.4 Select the correct option. 1.1.5 Select the wrong pair from the given pairs. 1.1.6 Fill the gap(s) in the sentence/paragraph. (Cloze test) 1.1.7 Match Part-A with Part-B in the given exercises	6
D - Developing Listening Skills	
General Learning Objectives Understand spoken English of speakers from different nationalities and work-related instructions on board **Subtopics & SLO:** 1.1 Listening training: speeches of people of different backgrounds and regions, preferably native speakers of English, Maritime communication 1.2 Listening exercises: listening for general content, listening to fill up the information, Intensive listening, listening for specific information	
Specific Learning Objectives: 1.1 Listening training: speeches of people of different backgrounds and regions, preferably native speakers of English, Maritime communication 1.1.1 Listen to a speech and analyse it. (Tone, diction, and pronunciation) 1.1.2 Compare the speeches made by the speakers of different backgrounds and regions.	3
Specific Learning Objectives: 1.2 Listening exercises: listening for general content, listening to fill up the information, Intensive listening, listening for specific information	

1.2.1 Listen to an audio/video clip and answer the questions 1.2.2 Understand orders from the bridge 1.2.3 Identify VHF communications regarding distress, urgency, safety and bunkering operations 1.2.4 Listen to an audio/video clip for different purposes (for general content, filling up the information, intensive listening, specific information, etc.)	3
E - Developing Speaking Skills	
General Learning Objectives Understand and express confidently in English language in various professional situations **Subtopics & SLO:** 1.1 Speaking activities in various contexts: Describing objects/situations/people, Agreeing and Disagreeing, Extempore Speeches 1.2 Making a Presentation: individual and group presentation, Content Structuring, Preparation & Planning 1.3 Facing a job Interview 1.4 Group Communication: Group Discussion (GD), Role Play	
1.1 Speaking activities in various contexts: Describing objects/situations/people, Agreeing and Disagreeing, Extempore Speeches 1.1.1 Describe and discuss an object, a situation, a person 1.1.2 Describe the purpose of a safety device 1.1.3 Narrate engine failure/accident reports 1.1.4 Narrate a past voyage or marine accident 1.1.5 Describe the functions of engines and propulsion systems 1.1.6 Describe personal likes, dislikes and leisure time on board 1.1.7 Make a speech on a given topic- Making Requests and Seeking Permissions, Giving Directions and Guidelines	3
1.2 Making a Presentation: individual and group presentation, Content Structuring, Preparation & Planning 1.2.1 Explain the importance of body language in a presentation 1.2.2 Plan and Make a group presentation on a given topic 1.2.3 Conduct and participate in a webinar for your class	6
1.3 Facing a job Interview 1.3.1 Explain the process for an interview 1.3.2 List the frequently asked questions in a job interview and answer them 1.3.3 Organize and participate in a mock interview	3
1.4 Group Communication: Group Discussion (GD), Role Play 1.4.1 Define Group Discussion and explain its objectives. 1.4.2 Describe the types of Group Discussion- Issue-based, Abstract, Role Play, and Case Study 1.4.3 Participate in group discussion activities 1.4.4 Compare Group Discussions and debates 1.4.5 Participate in role-play activities 1.4.6 Conduct an online meeting/seminar	6

SEMESTER 2

Subject Name/Code: Mathematics 2/201

Instructional hours:

Lecture	: 45 hours
Tutorial	: 15 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a classroom/on line lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. AICTE Model Course: Prerequisite for Mechanical/Electrical Engineering UG Programmes.

Recommended Text:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Edition, 2010.

Reference:

1. Dennis G. Zill and Warren S. Wright, Advanced Engineering Mathematics, Fourth Edition, Jones & Bartlett, 2011.
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint,2002.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw Hill, New Delhi,2008.
5. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint,2010.
6. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint,2008.

Table of Topics

Section	Topics	Hours (L:T)
A1-A2	**Differential equations** **Sub-Topics/SLOs:** Ordinary differential equation of first order and its applications, Linear differential equation and its application, Partial differential equation and its order.	20:3
B1	**Transforms** **Sub-Topics:** Laplace transforms, Inverse Laplace transforms and its application to differential equations	10:5
C1	**Series** **Sub-Topics**: Fourier series, even, odd half range Fourier series and Wave form	10:5
D1	**Complex Analysis** **Sub-Topics:** Complex variable function, complex integrations, series of complex functions	5:2
	Total	**45:15**

Learning Objectives	**L:T**
A. Understand the mathematical techniques which represent technical situations and solve problems based on differential equations	
1 Differential Equations **General Learning Objective** Understand and use Differential Equations for solving problems **Sub-Topics/SLOs** **1.1** Ordinary Differential Equations of First Order **1.2** Applications of Differential Equations of First Order **1.3** Linear Differential Equations **1.4** Applications of Linear Differential Equations	
Specific Learning Objectives **1.1 Ordinary Differential Equations of First Order** 1.1.1 Define differential equation, ordinary differential equations, partial differential equation, the order, degree and solution 1.1.2 Explain formation of differential equation for family of curves. 1.1.3 Find the solution of differential equations using variable separable method. 1.1.4 Find the solution of differential equations using reducible to variable separable method. 1.1.5 Define Linear differential equations of the first order (Leibnitz's linear equation), Integrating factor 1.1.6 Find the solution using linear differential equations. 1.1.7 Find the solution of differential equations using exact differential equation method	20:3
Specific Learning Objectives **1.2 Applications of Differential Equations of First Order** 1.2.1 Define Orthogonal Trajectories and its geometric interpretation for families of curves 1.2.2 State Condition for the given curve to be self-orthogonal 1.2.3 Explain procedure for finding the orthogonal trajectory of the curve (Cartesian and polar form) 1.2.4 Use different method of differential equation to solve problem based on simple electric circuit, law of cooling and heat flow	
Specific Learning Objectives **1.3 Linear Differential Equations**	

1.3.1 Define nth order LDE, operator D, Auxiliary equation (AE), inverse operator D^{-1}
1.3.2 Explain rules for finding the complementary Function (CF) of the given LDE based on nature of roots of AE
1.3.3 Explain rules for finding the PI of the LDE where $X = e^{ax}$; X=sin(ax+b) or cos(ax+b); X is polynomial; $X= e^{ax}$ V is a function of x
1.3.4 Solve the given LDE using the rules of CF and PI
1.3.5 Explain Method of variation of parameters
1.3.6 Explain Method of undetermined coefficient
1.3.7 Solve the given Differential equation using other two methods of finding PI
1.3.8 Define equations reducible to linear equations with constant coefficients
1.3.9 Define Cauchy's homogeneous linear equation, Define Legendre's linear equation
1.3.10 Solve the given Cauchy's homogeneous linear equation
1.3.11 Solve the given Legendre's linear equation
1.3.12 Define simultaneous linear equations with constant coefficients
1.3.13 Solve the simultaneous equations

Specific Learning Objectives

1.4 Applications of Linear Differential Equations.

1.4.1 Explain the method of finding deflection of beams
1.4.2 Define strut and column
1.4.3 Obtain the deflection of beam

A2 Partial Differential Equations

General Learning Objective

Understand the ways in which Partial Differential Equations are formed and investigate the solutions of special types of PDE by problem solving

Sub-Topics/SLOs

2.1 Partial Differential Equations
2.2 Applications of Partial Differential Equations

Specific Learning Objectives

2.1 Partial Differential Equations

2.1.1 Define Partial Differential Equations, formation of PDE
2.1.2 Derive the partial differential equation (by eliminating the constants)
2.1.3 Understand the solution of PDE solvable by direct integration
2.1.4 Solve the given PDE

Specific Learning Objectives

2.2 Applications of Partial Differential equations

2.2.1 Explain the method of separation of variable
2.2.2 Solve the given equation by method separation of variable
2.2.3 Define vibrations of a stretched string-wave equation
2.2.4 Solve completely the equation representing the vibrations of string
2.2.5 Solve the given 1-D heat equation
2.2.6 Solve the 2-D heat flow –Laplace equation

B. Learn about Laplace transform, its origin and use in engineering problems

B1 Laplace Transforms

General Learning Objective

Understand easy and effective means for the solution of many problems arising in engineering using Laplace transform

Sub-Topics/SLOs

1.1. Laplace transforms
1.2 Inverse Laplace transforms
1.3 Applications to Differential equation

10:5

Specific Learning Objectives

1.1 **Laplace Transforms**

1.1.1 Define Laplace Transform 1.1.2 Apply the definition of LT to transforms of elementary functions 1.1.3 Solve problems by using Laplace transform of standard functions 1.1.4 Describe different properties (linearity, shifting, transforms of derivatives and integrals, multiplication by tn, division by t) of Laplace Transforms 1.1.5 Find the LT of given function using different properties 1.1.6 Evaluate the integrals by LT	
Specific Learning Objectives 1.2 **Inverse Laplace Transforms (ILT)** 1.2.1 Determine the Inverse LT of standard function 1.2.2 Use the method of Partial fraction to find the ILT of given function 1.2.3 Describe different properties (linearity, shifting, transforms of derivatives and integrals, multiplication by s^n, division by s) of Inverse Laplace Transforms 1.2.4 Find the Inverse Laplace transform of given function using different properties 1.2.5 State Convolution theorem 1.2.6 Apply convolution theorem to evaluate the Inverse function	
Specific Learning Objectives 1.3**Application to Differential equation.** 1.3.1 State the working procedure to solve a linear differential equation with constant coefficients by transform method 1.3.2 Solve by using the method of transform the differential equation 1.3.3 Define Unit step function 1.3.4 Express the function in terms of unit step faction and find its LT	
C. Learn about the concept of Fourier series and its applicability	
C1 Fourier series **General Learning Objective** Understand and express a function in a series of sines and cosines, which is useful in conduction of heat, electro-dynamics and acoustics **Sub-topics and SLO** 1.1 Fourier Series 1.2 Fourier Series for Even and Odd functions 1.3 Half range series 1.4 Typical wave-form	
Specific Learning Objectives **1.1 Fourier series** 1.1.1 Define Periodic function, Orthogonal function 1.1.2 State Dirichlet's conditions for Fourier Series expansion 1.1.3 State Euler's formulae 1.1.4 State Fourier Series in different interval (**$\alpha < x < \alpha+2\pi$**) 1.1.5 Find the Fourier Series for the function in the interval $0 < x < 2\pi$. 1.1.6 Define functions having points of discontinuity 1.1.7 Find the F. S. expansion of given function having points of discontinuity. 1.1.8 State Fourier series for functions having arbitrary period (change of interval) 1.1.9 Expand F.S. In different interval (change of interval) for given function	10:5
Specific Learning Objectives **1.2 Fourier series for Even and Odd functions** 1.2.1 Define Even and Odd functions, Expansion of even and odd function. 1.2.2 Find F.S for given even/odd function	
Specific Learning Objectives **1.3 Half range series**	

1.3.1 Define Sine series and Cosine series 1.3.2 Express the function as a half-range sine /cosine series	
Specific Learning Objectives **1.4Typical wave form** 1.4.1 Define square waveform, square-toothed waveform, Saw-toothed waveform, Modified saw-toothed waveform, Triangular waveform, Half-wave rectifier, Full wave rectifier 1.4.2 Find F.S expansion for square, rectangular wave form	
D Learn the techniques of complex variable function and the series of complex function	5:2
D1 Calculus of Complex Functions/Complex Analysis **General Learning Objective** Understand complex functions, which are useful in the study of fluid mechanics, thermodynamics and electric fields **Sub topics and SLO** 1.1 Basics of Complex number 1.2 Complex variable function f(z) 1.3 Complex integration 1.4 Series of complex terms	
Specific Learning Objectives **1.1 Basics of Complex number** 1.1.1 Define Geometrical &Polar representation of complex number 1.1.2 State properties of complex number and De-Moivre's theorem 1.1.3 Use De-Moivre's theorem to simplify the given expression	
Specific Learning Objectives **1.2 Complex variable function f(z)** 1.2.1 Define complex variable function, analytic function, singular point, Derivative of f(z), Harmonic function 1.2.2 State Cauchy- Riemann equations 1.2.3 Use Cauchy Riemann equations to check whether the given function is Analytic or not 1.2.4 Explain the construction of Analytic function: Milne-Thomson method 1.2.5 Use Milne-Thomson method to construct the analytics function whose real/imaginary part is given	
Specific Learning Objectives **1.3 Complex Integration** 1.3.1 Define zeros and Pole (singular point) of analytic function 1.3.2 State Cauchy's integral theorem and integral formula, Cauchy's Residue theorem 1.3.3 Evaluate the given integral by using Cauchy's integral theorem/ Cauchy's Residue theorem 1.3.4 Determine the poles of the function and residue at each pole and hence evaluate the integral	
Specific Learning Objectives **1.4 Series of complex terms** 1.4.1 State Taylor's series 1.4.2 Find Expansion of f(z) using Taylor's series 1.4.3 State Laurent's series 1.4.4 Expand the function f(z) in Laurent's series	

Subject Name/Code: Basic Electrical Engineering/202

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted with classroom/online lectures and self–learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. A Textbook of Electrical Technology: Part 1 - Basic Electrical Engineering in S. I. Units (Volume - 1) (English, Paperback, Theraja A. K.); Publisher S. Chand; ISBN: 9788121924405.
2. Electrical and Electronic Technology, Hilley John, Brown Keith and Smith Lan Mckenzie, Pearson Education.
3. Electronic Devices and Circuit Theory, Boylestad and Nashelsky, Pearson Education.

Reference:

1. Basic Electrical Engineering V.N Mittle, Arvind Mittal, 2nd Edition; Publisher: McGraw Hill Education – Europe; ISBN: 9780070593572.

Table of Topics

Section	Topics	Hours (L)
A1	Basic Laws in Electrical Theory and Concepts of Circuits **Sub-Topics:** Ohm's law, Kirchhoff's law, Electrical Circuit, impedance and inductance	15
B1	Fundamentals of Alternating Current **Sub-Topics:** Alternating Current, Electromagnetic Induction, Work, Energy and Power	26
C1	Testing and Measuring Equipment **Sub-Topics:** Insulation tester, Continuity tester, Multi-tester, Clamp meter	4
	Total	**45**

Learning Objectives	L
A – Basic Laws in Electrical Theory and Concepts of Circuits **General Learning Objectives** • Understand the importance of basic laws in electricity • Understand the function of a basic electrical circuit **Topic 1. Basic Laws in Electrical Theory and Concepts of Circuits** **Sub-Topics:** 1.1 Ohm's law 1.2 Kirchhoff's law 1.3 Electrical circuit 1.4 Impedance and inductance	
A1 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1) 2.1.1.1 **1.1 Ohm's law** 1.1.1 Describe the effect of resistors in a circuit and use the symbol R 1.1.2 Define name and uses of the symbol Ω 1.1.3 Define the unit of resistance 1.1.4 Define Ohm's law 1.1.5 Define Ohm's law to find current, voltage and resistance in simple problems 1.1.6 Describe how the current through and the voltage across resisters are affected in series and in parallel circuits	1
1.2 Kirchhoff's law 1.2.1 State and applies Kirchhoff's: voltage law current law 1.2.2 Calculate the current flowing and the voltage drop across resistors in simple circuits	1

1.2.3 Construct and use a Wheatstone Bridge 1.2.4 Calculate the total (or equivalent) resistance of a parallel circuit, given the voltage and total current. 1.2.5 Calculate the total resistance given the values of resistances in a parallel circuit 1.2.6 Compare the effect of adding a further resistance to: - a parallel circuit - a series circuit 1.2.7 Explain how the objective affects the e.m.f and the terminal potential difference of a supply, demonstrating the effect by calculations and by experiment 1.2.8 Explain the effect of internal resistance in the supply source 1.2.9 Determine current flows, resistance values and voltages in: - series circuits and parallel circuits by calculation	2
1.3 Electrical circuit 1.3.1 State that current can flow in a closed circuit 1.3.2 Explain why some materials are: - conductors - insulators - and Name commonly used materials in each group	1
1.3.3 Name the different sources of electricity and Explain their effect when connected to a conductor 1.3.4 Explain potential difference and electromotive force, stating the units and the symbols used 1.3.5 Explain the current flow, stating its symbol (I) 1.3.6 State that current strength is measured in amperes, represented by A 1.3.7 State that a steady current flowing in a single direction is called a direct current (D.C.) 1.3.8 State that when the direction of flow of a current is continually reversing it is called an altering current (A.C.) 1.3.9 State that in modern ships the main supply is usually A.C. but that D.C. has many uses	2
1.3.10 Describe what is meant by static electricity 1.3.11 Describe electrostatic charging and the principles of overcoming potential hazards	1
1.4 Impedance and inductance 1.4.1 Explain what is meant by 'impedance' and use of the correct symbol 1.4.2 Compare impedance of an A.C. circuit with resistance of a D.C. circuit 1.4.3 State the relationship between impedance, voltage and current	1
1.4.4 Compare the effect in an A.C. circuit and in a D.C. circuit: - of a simple resistance - the same resistance wound in form of a coil - the same coiled resistance, into which an iron core is inserted 1.4.5 Describe what is meant by 'reactance' and use of the correct symbol 1.4.6 Sketch the impedance triangle, indicating R,X,Z and the phase angle (ϕ) 1.4.7 State that the cosine of the phase angle is called the power factor 1.4.8 Calculate impedances and power factors, given the resistance and reactance of coils	1
1.4.9 Explain the effect of changing current and its associated magnetic flux on the induced e.m.f.	1
1.4.10 Explain why, in a circuit containing only reactance, there is a difference in phase of 90° between the applied voltage and the current 1.4.11 Sketch graphs showing the variation of current, applied voltage and back e.m.f. over one cycle when an A.C. is applied to: - a circuit containing only pure resistance - a choke having inductance only	1

1.4.12 Superimpose a curve representing the power dissipated in both cases in the above objective 1.4.13 State the value of the power factor in both cases in the above objective	
1.4.14 State that, in practice, an inductor will always have a resistance 1.4.15 Sketch a phasor diagram for a circuit containing an inductance which has resistance, indicating the resultant applied voltage and the phase angle 1.4.16 State that in cases such as those in the above objective, i.e., in inductive circuits, the current always lags the applied voltage 1.4.17 State that shipboard installations produce power demand with a lagging power factor 1.4.18 Explain the effect of varying power factor on the power consumed 1.4.19 State that power = V x I x R/Z or V x I x COSϕ	1
1.4.20 Solve simple problems concerning power, current, resistance, impedance, reactance and power factor and verifies the solutions, using laboratory equipment	2
B - Fundamentals of Alternating Current **General Learning Objectives** • Understand the fundamentals of Alternating Current • Know the importance of electromagnetic induction in today's machinery and systems and the laws governing it • Know how to calculate Work, Energy and Power **Topic: Fundamentals of Alternating Current** **Sub-Topics:** 1.1 Alternating Current 1.2 Electromagnetic Induction 1.3 Work, Energy and Power	
B1 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1) **1.1 Alternating Current** 1.1.1 Explain how alternating current is produced in a simple loop rotating in a magnetic field	2
1.1.2 Relate the position of the loop in the above objective to the voltage wave form for one cycle at 90° intervals of rotation by means of a Sketch	2

1.1.3 Explain the relationship between: - instantaneous voltage - conductor velocity - the sine of the displaced angle θ 1.1.4 Sketch the wave form of an A.C. voltage	2
1.1.5 Show diagrammatically a simple circuit for a three-phase supply from an alternator	2
1.1.6 Develop the expression $e = Blv$ to produce $e = E_{max} \sin\theta$, where e is the instantaneous voltage, E_{max}, is the maximum voltage and θ is the displaced angle	1
1.1.7 Project the vertical components of a rotating vector to draw one complete cycle of a sine wave	1
1.1.8 State that the rotating vector is called a phasor 1.1.9 Use a triangle produced from the above objective, confirms that $\frac{e}{E_{max}} = \sin\theta$ 1.1.10 Superimpose degrees and radians on the sine wave drawn in the above objective	2
1.1.11 Use the correct symbols and conventions for: - rotation - angular velocity - periodic time - frequency - peak value - amplitude	2
1.1.12 Deduce the expression $e = E_{max} \sin\theta\ 2\pi ft$ 1.1.13 Calculate instantaneous voltages, given the unknown quantities 1.1.14 Explain what is meant by phase difference between voltage and current values	2
1.1.15 Explain why root mean square (r.m.s.) values are used 1.1.16 Calculate r.m.s. value, given a series of values of instantaneous voltage or current for a hall cycle 1.1.17 State that the r.m.s value for a sine wave is 0.707 of the peak value	2
1.2 Electromagnetic Induction 1.2.1 Describe the principles of electromagnetic induction and State its main applications 1.2.2 Explain how the following factors affect the induced voltage: - flux density - number of turns in the coil - conductor/flux cutting rate	2
1.2.3 Explain Faraday's law of electromagnetic induction 1.2.4 Explain Lenz's law 1.2.5 Explain in simple terms the principle of static induction, to include mutual conduction and self-induction	2
1.3 Work, Energy and Power 1.3.1 Explain the difference between work, energy and power, giving the units and symbols commonly used 1.3.2 State that work = current $\times$ time $\times$ voltage, giving the units used 1.3.3 Do simple calculations to determine energy and work	2
1.3.4 Define power, giving the units and symbols used; from the above objective, derive the expression power = voltage $\times$ current (P=VI), giving the units used 1.3.5 Use the equations from above objectives, derive $P = I^2 R$ and $P = \frac{V^2}{R}$	2
C - Testing and Measuring Equipment	

General Learning Objectives • Understand the construction and operation of the testers • Know how to safely use the test equipment • Know how to deduce faults in basic equipment and machinery, using these testers **Topic: Construction and Operation of Electrical Testing and Measuring Equipment)** **Sub-Topics** 1.1 Insulation tester 1.2 Continuity tester 1.3 Multi-tester 1.4 Clamp meter	
C1 Specific Learning Objectives: (IMO 7.04,2014: 2.2.4	
1.1 Insulation tester 1.1.1 State the operation principles of an insulation tester 1.1.2 State the precautions when using an insulation tester 1.1.3 State the range of voltages used for testing ships' equipment	2
1.2 Continuity tester 1.2.1 State the operation principles of a continuity tester 1.2.2 State the precautions when using a continuity tester	
1.3 Multi-tester 1.3.1 State the operation principles of a multi-tester 1.3.2 State the precautions when using a multi-tester	
1.4 Clamp meter 1.4.1 State the operation principles of a clamp meter 1.4.2 State the precaution when using a clamp meter	2

Subject Name/Code: Basic Electronics/203

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, practical in workshops and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

Pre-requisites: Basic elementary knowledge of Physics, Electricity, Magnetism and Semiconductors.

Recommended Text:

1. Electrical and Electronic Technology; Hilley John, Brown Keith and Smith Lan Mckenzie; Pearson Education.
2. Electronic Devices and Circuit Theory; Boylestad and Nashelsky; Pearson Education.

Reference:

1. Practical Marine Electrical Knowledge; Dennis T. Hall; London, Witherby & Co. (ISBN: 1 85609 182 1).
2. Digital Electronics: Principles and Application; Roger L Tokheim; McGraw Hill; ISBN: 978-0078309823.
3. Marine Control Practice; D. A. Taylor and Billis; Butterworth Heinemann; ISBN: 978-0408013130.
4. Kraal, E.G.R., Basic Electrotechnology for Engineers. 3rd ed. London, Thomas Reed Publications Ltd, 1985 (ISBN 0-900335-96-3).
5. Basic Electronics (Solid State) In Multi Colour Edition Paperback – 1 December 2006 S Chand.
6. Power Electronics: Devices, Circuits and Applications; Fourth Edition; 2017 Pearson Education.
7. Microprocessor Architecture, Programming and Applications with the 8085 6/e Paperback; 2013 Penram International Publishing.

Table of Topics

Section	Topics	Hours (L)
A	Basic Electronics	8
B	Basic electronic circuit element	8
C	Power Electronics	2
D	Operational amplifier	4
E	Digital techniques	10
F	Electronic measuring and test instruments	2
G	Microprocessor and microcontroller	6
H	Voltage regulators and multivibrator	2
I	Flowchart for automatic and control systems	1
J	Electronic control equipment	2
Total		**45**

Learning Objectives	L
General Learning Objective **(IMO 7.04,2014: 2.1.2,.2.2.6, IMO 7.02,2014: 2.1(1.2),2.2.2,4.3)** Understand the principles of basic electronics devices and electronic control equipment; use the devices and Manage Troubleshooting	
A Basic Electronics **Specific Learning Objectives:** – Understand the semiconductor physics of the intrinsic, p and n materials. 1.1 **Semiconductor theory** 1.1.1 Electron theory **(IMO 7.04,2014: 2.1.2)** 1.1.2 Explain what a semiconductor is 1.1.3 Bonds in Semiconductors 1.1.4 Crystal structure of semiconductor 1.1.5 Commonly Used Semiconductors 1.1.6 Energy Band Description of Semiconductors 1.1.7 Effect of Temperature on Semiconductors 1.1.8 Hole Current 1.1.9 Intrinsic Semiconductor 1.1.10 Extrinsic Semiconductor 1.1.11 n-type Semiconductor 1.1.12 p-type Semiconductor 1.1.13 Charge on n-type and p-type Semiconductors 1.1.14 Majority and Minority Carriers 1.1.15 Diffusion and Drift current 1.1.16 Mobility 1.1.17 Explain photoelectric effect (IMO 7.02,2014: 2.1(1.2) 1.1.18 Explain thermoelectric effect (IMO 7.02,2014: 2.1(1.2) 1.1.19 Explain Hall effect (IMO 7.02,2014: 2.1(1.2)	**8** 2
Specific Learning Objectives: –Understand the characteristics of the p-n junction, the diode and some special function diodes and their application in electronic circuits. 1.2 **Semiconductor diode (IMO 7.02,2014: 2.1(1.2)** 1.2.1 PN Junction 1.2.2 Properties of PN-Junction	2

1.2.3 Applying D.C. Voltage across PN- Junction or Biasing PN- Junction 1.2.4 Current Flow in a Forward Biased PN-Junction 1.2.5 Volt-Ampere Characteristics of PN Junction 1.2.6 Important Terms forward break over voltage, knee voltage, reverse breakdown voltage related from datasheet of diode. 1.2.7 Resistance of Crystal Diode 1.2.8 Crystal Diode Equivalent Circuits	
1.3 **Rectifier and filters** **Specific Learning Objectives:** – Understand the Basics of Half wave, Full wave and bridge rectifiers. Effect of different filters on output of rectifier. 1.3.1 Define Rectifier, Rectification 1.3.2 Define Crystal Diode Rectifiers 1.3.3 Define Half-Wave Rectifier 1.3.4 Define Full-Wave Rectifier 1.3.5 Define Full-Wave Bridge Rectifier 1.3.6 Define Efficiency of Full-Wave Rectifier 1.3.7 Define Nature of Rectifier Output 1.3.8 Define Comparison of Rectifiers 1.3.9 Define types of Filter Circuits or smoothing circuits (C, L, LC, CLC filter) (IMO 7.02,2014: 2.1(1.2)	2
Specific Learning Objectives: – Understand the characteristics of the special function diodes and their application in electronic circuits. 1.4 **Special purpose diode and applications** 1.4.1 Explain Zener Diode 1.4.2 Explain Zener Diode as Voltage Stabilisation circuit 1.4.3 Explain Breakdown mechanisms in Zener diode 1.4.4 Explain Light-Emitting Diode (LED) 1.4.5 Explain LED Voltage and Current characteristic 1.4.6 Explain Advantages of LED 1.4.7 Explain Multicolour LEDs 1.4.8 Explain Applications of LEDs 1.4.9 Explain Photo-diode 1.4.10 Explain Photo-diode operation 1.4.11 Explain Characteristics of Photo-diode 1.4.12 Explain Applications of photo-diodes 1.4.13 Explain Diode as clipping circuit for pulse shaping application (IMO 7.02,2014: 2.1(1.2) 1.4.14 Diode as clamping circuit (IMO 7.02,2014: 2.1(1.2)	2
B Basic electronic circuit element (IMO 7.04,2014: 2.1.2) **Specific Learning Objectives:** – Understand the Fundamentals of BJT, Construction, Principles of operation and Characteristic curves in different configurations of transistors. 1.1. Explain a Transistor 1.2 Explain Type of transistor and Symbols 1.3 Explain BJT bipolar junction transistor operation (IMO 7.02,2014: 2.1(1.2) 1.4 Explain Transistor Connections 1.5 Explain Characteristics of Common Base connection (IMO 7.02,2014: 2.1(1.2) 1.6 Explain Connection Common emitter (IMO 7.02,2014: 2.1(1.2) 1.7 Explain Common Collector Connection (IMO 7.02,2014: 2.1(1.2) 1.8 Explain Commonly Used Transistor Connection (IMO 7.02,2014: 2.1(1.2) 1.9 Explain Transistor DC Load Line Analysis (IMO 7.02,2014: 2.1(1.2)	**8** 2
Specific Learning Objectives: – Understand the Biasing and stabilization techniques for BJT. **2.1** Transistor biasing **(IMO 7.02,2014: 2.1(1.2)** 2.1.1 Describe Transistor Biasing 2.1.2 Describe Inherent Variations of Transistor 2.1.3 Describe Parameters of Stabilisation circuits (IMO 7.02,2014: 2.1(1.2)	2

2.1.4 Describe Essentials of a Transistor Biasing Circuit 2.1.5 Describe Stability Factor 2.1.6 Describe Methods of Transistor Biasing 2.1.7 Describe Base Resistor Method 2.1.8 Describe Emitter Bias Circuit 2.1.9 Describe Emitter Bias Biasing with Collector Feedback 2.1.10 Describe Resistor Voltage Divider Bias method	
2.2 Amplification (IMO 7.02,2014: 2.1(1.2) 2.2.1 Explain Single Stage Transistor Amplifier CE configuration 2.2.2 Explain Input/Output Phase Relationships 2.2.3 Explain Role of Capacitors in Transistor Amplifiers 2.2.4 Explain Voltage Gain 2.2.5 Explain frequency response of CE amplifier 2.2.6 Explain Multistage Transistor Amplifier 2.2.7 Explain Properties of dB Gain 2.2.8 Explain RC Coupled Transistor Amplifier 2.2.9 Explain Transformer-Coupled Amplifier 2.2.10 Explain Direct-Coupled Amplifier 2.2.11 Explain Compare of Different Types of Coupling 2.2.12 Explain the switching action of transistor	2
Specific Learning Objectives: – Understand the Fundamentals of FET, MOSFET Construction Principles, operation and Characteristic curves. **2.3 JFET and MOSFET (IMO 7.02,2014: 2.1(1.2)** 2.3.1 Explain JFET 2.3.2 Explain Construction of N-channel JFET 2.3.3 Explain Working and characteristic of N-channel JFET 2.3.4 Explain Parameters of JFET 2.3.5 Explain P-channel JFET 2.3.6 Explain Applications of JFET 2.3.7 Explain MOSFET 2.3.8 Explain Construction of N-channel MOSFET 2.3.9 Explain Operation, characteristics and parameters of N-channel MOSFET 2.3.10 Explain P-channel MOSFET 2.3.11 Explain Enhancement MOSFET. 2.3.12 Explain Construction of N-channel Enhancement MOSFET 2.3.13 Explain Operation, characteristics Enhancement MOSFET 2.3.14 Explain P-channel Enhancement MOSFET 2.3.15 Explain Advantages, disadvantages, applications 2.3.16 Explain UJT **(IMO 7.02,2014: 2.1(1.2)** 2.3.17 Explain Construction of UJT 2.3.18 Explain Operation, characteristics of UJT 2.3.19 Explain Application	2
C Power Electronics (IMO 7.02,2014: 2.1(1.2) **Specific Learning Objectives:** – Understand the basic theory of power semiconductor devices and passive components, their practical applications in power electronics. 1.1 Explain Thyristor (IMO 7.02,2014: 2.1(1.2) 1.2 Explain SCR construction (IMO 7.02,2014: 2.1(1.2) 1.3 Explain Modes of operation and characteristics of SCR (IMO 7.02,2014: 2.1(1.2) 1.4 Explain SCR ratings 1.5 Explain UJT triggering circuit 1.6 Explain Protection circuits for dv/dt and di/dt (snubber circuit) 1.7 Explain Commutation circuit 1.8 Explain GTO construction, working, characteristic, applications 1.9 Explain DIAC construction, working, characteristic, applications 1.10 Explain TRIAC construction, working, characteristic, applications 1.11 Explain IGBT construction, working, characteristic, applications	**2** 2
D Operational amplifier (IMO 7.02,2014: 2.1(1.2) **Specific Learning Objectives:** – Understand the Concept of operational amplifier, Study of IC741, operation of various applications of OPAMP circuits. 1.1 Explain Differential amplifier theory	**4** 2

1.2 Explain Block diagram of Op-Amp 1.3 Explain Op-Amp symbol and terminals 1.4 Explain Op-Amp IC 741, features of IC 741, Pin configuration of IC 741 (IMO 7.02,2014: 2.1(1.2) 1.5 Explain Parameters of ideal and practical Op-Amp (differential gain, common mode gain, common mode rejection ratio, power supply rejection ratio, slew rate) (IMO 7.02,2014: 2.1(1.2) 1.6 Explain Open loop and close loop configuration of Op-Amp 1.7 Explain Concept of zero input current and virtual ground 1.8 Explain circuit configuration of operational amplifier as Inverting amplifier 1.9 Explain Non inverting amplifier	
1.1.10 Explain Op-Amp IC application as adder 1.1.11 Explain Op-Amp IC application as subtractor 1.1.12 Explain Op-Amp IC application as integrator 1.1.13 Explain Op-Amp IC application as differentiator 1.1.14 Explain Comparator circuit using Op-Amp 1.1.15 Explain Schmitt trigger circuit using Op-Amp 1.1.16 Explain Instrumentation amplifier using Op-Amp (IMO 7.02,2014: 2.1(1.2) 1.1.17 Explain Applications of Instrumentation amplifier 1.1.18 Explain Voltage to current converter using Op-Amp 1.1.19 Explain Current to voltage converter using Op-Amp (IMO 7.02,2014: 2.1(1.2) 1.1.20 Explain construction, working of Op-Amp as multivibrator (IMO 7.02,2014: 2.1(1.2)	2
E Digital techniques (IMO 7.02,2014:4.3) **Specific Learning Objectives: –** Understand the Concept of digital logic levels, understand digital electronics circuits and their applications, perform the analysis and design various digital electronic circuits. 1.1 Explain Number system (decimal, binary, octal, hexadecimal) 1.2 Explain Boolean algebra (IMO 7.02,2014:4.3) 1.3 Explain De Morgan's theorem 1.4 Explain Code conversion 1.5 Explain BCD code 1.6 Explain Grey code (conversion of binary to grey, conversion of grey to binary) 1.7 Explain Design of binary to grey code converter 1.8 Explain Design of grey binary code converter 1.9 Explain Basic Logic gates and derived logic gates (symbol and truth table) (IMO 7.02,2014:4.3) 1.10 Explain Universal gates (IMO 7.02,2014:4.3) 1.11 Explain Sum of product (SOP)and Product of Sum (POS) form 1.12 Explain Minterm and Maxterm 1.13 Explain Minimization technique using K-map (up to 4 variables with don't care conditions)	**10** 2
2.1 Explain Design of half adder circuit 2.2 Explain Design of full adder circuit 2.3 Explain Design of comparator 2.4 Explain Introduction to Flip-Flops (IMO 7.02,2014:4.3) 2.5 Explain NAND Gate Latch/ NOR Gate Latch 2.6 Explain RS latch 2.7 Explain Concept of clock and triggering (level triggering and edge triggering) 2.8 Explain RS flip flop (symbol, truth table) 2.9 Explain JK flip flop (symbol, truth table) 2.10 Explain Mater slave JK flip flop (symbol, truth table) 2.11 Explain D flip flop (symbol, truth table) 2.12 Explain T flip flop (symbol, truth table) 2.13 Explain Introduction to multiplexer 2.14 Explain Multiplexer tree 2.15 Explain Applications of multiplexer 2.16 Explain Introduction to De multiplexer 2.17 Explain De Multiplexer Tree 2.18 Explain Applications of De multiplexer	2

3.1 Explain Introduction to decoder (IMO 7.02,2014:4.3) 3.2 Explain Design of 2X4 decoder 3.3 Explain Applications of decoder 3.4 Explain Introduction to encoder (IMO 7.02,2014:4.3) 3.5 Explain Design of priority encoder 3.6 Explain Application of encoder 3.7 Explain Introduction to register (IMO 7.02,2014:4.3) 3.8 Explain Types of register (SISO, SIPO, SIPO, PIPO) 3.9 Explain Applications of registers 3.10 Explain Introduction to counter (IMO 7.02,2014:4.3) 3.11 Explain Types of counters (synchronous counter, asynchronous counter) 3.12 Explain Design of ripple counter (UP counter) with truth table 3.13 Explain Design of ripple counter (Down counter) with truth table 3.14 Explain Design of ring counter with truth table 3.15 Explain Design of Johnson's counter with truth table	2
4.1 Explain Introduction to ADC (IMO 7.02,2014:4.3) 4.2 Explain Parameters of ADC (resolution, full scale voltage, accuracy) 4.3 Explain Types of ADC 4.4 Explain Block diagram, operation of counter type ADC 4.5 Explain Block diagram, operation of single slope type ADC 4.6 Explain Block diagram, operation of Dual slope type ADC 4.7 Explain Applications of ADC 4.8 Explain Introduction to DAC (IMO 7.02,2014:4.3) 4.9 Explain Resolution of DAC 4.10 Explain Types of DAC (IMO 7.02,2014:4.3) 4.11 Explain Design of binary weighted DAC 4.12 Explain Design of R-2R type of DAC 4.13 Explain Applications of DAC 4.14 Explain Introduction to memories (IMO 7.02,2014:4.3) 4.15 Explain Types of memories (RAM, ROM-PROM, EPROM, EEPROM, UVPROM) 4.16 Explain Compare RAM and ROM 4.17 Explain Compare Static RAM and Dynamic RAM 4.18 Explain what is a CPU (Central Processing Unit) 4.19 Define and explain Working [with Block Diagram]	2
IC and LSI (IMO 7.02,2014: 2.1(1.2) 5.1 Define Integrated Circuit (IC) 5.2 Describe advantages of IC 5.3 Describe classification of integrated circuit on number of circuit elements 5.4 Define Large Scale Integrated Circuit (LSI) as circuit elements 5.5 Describe the structures of IC 5.6 Describe briefly the functions of the following types of IC: ➢ Transistor-Transistor Logic (TTL) ➢ Emitter-Coupled Logic (ECL) ➢ Complementary Metal-Oxide Semiconductor (CMOS)	2
F Electronic measuring and test instruments **Specific Learning Objectives: –** Understand the construction and design of measuring devices and circuits, measuring instruments and their proper applications. 1.1 Explain the principle and working of Cathode Ray Oscilloscope. (IMO 7.02,2014: 2.1(1.2) 1.2 How CRO is used to measure voltage, frequency and phase difference. (IMO 7.02,2014: 2.1(1.2) 1.3 Explain the principle and working of Digital voltmeter. 1.4 Explain the principle and working of Frequency meter 1.5 Explain the principle and working of Digital Multimeter (DMM) (IMO 7.02,2014: 2.1(1.2) 1.6 Explain what a Q meter is and what are its applications. 1.7 Explain what IC tester is and how it is used to find faulty IC. (IMO 7.02,2014: 2.1(1.2)	**2** 2
G Microprocessor & Microcontroller (IMO 7.02,2014:4.3)	**6**

Specific Learning Objectives: – Understand the architecture and operation of typical microprocessors and microcontrollers, programming and interfacing of microprocessors and microcontrollers. 1.1 Introduction to the concepts of microprocessors, microcontrollers 1.2 Differentiate between microprocessor and microcontroller 1.3 Describe Evolutions of Microprocessor 1.4 Describe Features of 8085 Microprocessor 1.5 Describe applications of microprocessor on ship 1.6 Explain Block Diagram of 8085 Microprocessor 1.7 Explain GPIO or Pin Diagram of 8085 Microprocessor (IMO 7.02,2014:4.3) 1.8 Explain Address Bus & Multiplexed Address / Data Bus 1.9 Explain Control and status signals 1.10 Explain Power-supply and clock frequency 1.11 Explain Externally initiated signals including Interrupts 1.12 Explain Serial I/O Ports 1.13 Explain Input /output devices (switch, relay, solenoid, LED,)	2
2.1 Describe 8085 BUS organization and 8085 registers 2.2 Describe Microprocessor operations: Microprocessor initiated Operations, Internal data operations, Externally Initiated operations 2.3 Describe Microprocessor Communication & Bus Timings 2.4 Describe De-multiplexing the Bus AD7 to AD0 2.5 Describe Generating Control Signals	2
3.1 Explain Memory & I/O Interfacing (IMO 7.02,2014:4.3) 3.2 Explain Address Decoding & Memory Addresses 3.3 Explain Comparison of Memory Mapped I/O & Peripheral I/O 3.4 Explain Instruction Formats: Single Byte, Tow Bytes & Three Bytes Instructions 3.5 Explain DATA Transfer Operations, Arithmetic Operations, Logic Operations, Branch Operations, Stack, I/O& Machine Control Instructions, Looping, Counting and Indexing 3.6 Explain tack and Subroutines 3.7 Explain with block diagram how microprocessor is used in surveillance and data recording application 3.8 Explain Simple programs for addition, subtraction, block transfer etc. (IMO 7.02,2014:4.3)	2
H Voltage regulators and multivibrator: (IMO 7.02,2014: 2.1(1.2) **Specific Learning Objectives: –** Understand the importance and use of regulated power supply and multivibrators to do various tasks required in industry. 1.1 Explain Block diagram of regulated power supply 1.2 Explain the need of regulator **(IMO 7.04,2014: 2.1.2)** 1.3 Explain Transistor as Series regulator 1.4 Explain Transistor as shunt regulator 1.5 Explain Voltage regulator IC LM 723 1.6 Explain three terminal regulators 78xx and 79xx series 1.7 Explain Line and load regulation 1.8 Explain Concept of multivibrator (**IMO 7.04,2014: 2.1.2)** 1.9 Explain Types of multivibrators 1.10 Explain IC 555 – block diagram 1.11 Explain IC 555 – PIN diagram 1.12 Explain Design of a stable multivibrator circuits using IC555 1.13 Explain Design of monostable multivibrator circuits using IC555 1.14 Explain Design of bi stable multivibrator circuits using IC555 1.15 Explain Numerical	**2** 2
I Flowchart for automatic and control systems (IMO 7.04,2014: 2.1.2) **Specific Learning Objectives: –** Understand the basics of flowchart and process to break down tasks or subsystem to create a flowchart of system or process. 1.1 Explain the following: electrical diagrams, block diagram, system diagram, circuit diagram, wiring diagram 1.2 Define flowchart 1.3 Define Symbols and their purpose when used in flow chart 1.4 Define Types of flow chart 1.5 Define Advantages of flow chart	**1** 1

J Electronic control equipment (IMO 7.04,2014: 2.1.2) **Specific Learning Objectives: –** Understand the basic working and use of Basic Electronic control equipment like PLC, relay, PID and their application on ship. 1.1 Explain Function of Relay (IMO 7.04,2014: 2.1.2) 1.2 Draw and Explain basic parts of relay with Operation (IMO 7.04,2014: 2.1.2) 1.3 Explain Relay Terminology 1.4 Explain Classification of Relays 1.5 Explain Advantages of Relay 1.6 Explain the need and benefits of PLC in automation. 1.7 Differentiate Relay based system & PLC control system 1.8 Explain block diagram of PLC as a control equipment (IMO 7.04,2014: 2.1.2) 1.9 Explain Integrated Automation Control and Monitoring System (IACMS)with block diagram (IMO 7.04,2014: 2.1.2) 1.10 Explain applications and advantages of IACMS 1.11 Explain a controller is 1.12 Explain why controller is required 1.13 Explain types of controllers 1.14 Explain by basic block diagram PID controller operation. (IMO 7.04,2014: 2.1.2) 1.15 Explain applications of PID controller on ship	**2** 2

Subject Name/Code: Engineering Mechanics/204

Instructional hours:

Lecture	: 45 hours
Tutorial	: 15 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

Pre-requisites: Class 12 Physics, Maths.

Recommended Text:

1. Applied Mechanics, I B Prasad, Khanna Publishers.
2. A textbook of Engineering Mechanics by R.S Khurmi.
3. A textbook of Engineering Mechanics by Dr. R. K Bansal.

Reference:

1. Reed Volume 2: Applied Mechanics for Engineers; By William Embleton; Revised by J.T. Gunn; Publisher Sunderland Tyne and Wear) Thomas Reed.1983: ISBN0900335874.
2. Applied Mechanics, J. Hannah and M.J. Hiller, Longman,1998, ISBN:9780582256323.
3. Engineering Mechanics Statics and Dynamics by Rajasekaran S and Sankarasubramanian G.

Table of Topics

Section	Topics	Hours (L:T)
A	**Introduction to Engineering Mechanics** **Subtopics:** Introduction, statics, dynamics, kinematics, kinetics, importance, applications.	2:0
B	**Truss and Frames** **Subtopics:** Introduction, truss, elements of a truss, types of trusses, assumptions for truss analysis, methods of analysis of truss, method of joints, method of sections, frames, method of analysis of frame.	8:3
C	**Properties of Lines, Surfaces and Physical Bodies** **Subtopics:** Centroid, centre of mass and centre of gravity, analytical expressions of centroids, centroids of lines and curves, centroids of composite shapes, Pappus-Guldinus theorems, second moment of area, radius of gyration, perpendicular axis theorem for second moment of area, parallel axis theorem, moment of inertia of composite sections.	12:3
D	**Lifting Machines** **Subtopics:** Introduction, importance, mechanical advantage, velocity ratio, efficiency, reversible machines, irreversible machines, law of machines.	4:2
E	**Kinematics and kinetics of linear motion** **Subtopics:** kinematic parameters in linear motion, displacement, velocity, acceleration, time relationships, equations of linear motion with constant acceleration and variable acceleration, relative velocity, De Alembert's principle of dynamic equilibrium.	8:2
F	**Kinematics of curvilinear motion** **Subtopics:** kinematic parameters in curvilinear motion, normal, tangential and total acceleration, projectile motion analysis.	4:2
G	**Introduction to mechanical vibrations and Simple Harmonic Motion** **Subtopics:** Basic parameters of SHM, beats, resonance, simple pendulum, compound pendulum, spring mass systems, shaft rotor system, single degree of freedom undamped and damped free vibrations.	7:3
	Total	**45:15**

Learning Objectives	L:T
A. Introduction to Engineering Mechanics	2:0
General Learning Objective: Understand the meaning of Engineering Mechanics, its classification, importance and applications. **Sub-topic: Definition, classification and applications. (IMO 7.04, Appendix IV,2014)** **Sub-subtopics & SLOs** 1.3 Definition of mechanics and classification 1.4 Importance of mechanics and applications	
Specific learning objectives: **1.3 Definition of mechanics and classification** 1.3.1 Define Engineering Mechanics 1.3.2 Define statics and dynamics 1.3.3 Define kinematics and kinetics	1:0
Specific learning objectives: **1.4 Importance of mechanics and applications** 1.4.1 Explain importance of mechanics 1.4.2 Explain various applications of mechanics	1:0
B. Truss and Frames	8:3
General Learning Objective: Understand the meaning of truss and frames and its analysis. **Sub-topic: Truss, frames, methods of analysis. (IMO 7.04, Appendix IV,2014)** **B. Sub-subtopics & SLOs** 1.1 Definition of truss and its classification 1.2 Assumptions in truss analysis 1.3 Methods of truss analysis 1.4 Definition of frame **1.5** Method of frame analysis	
Specific learning objectives: 1.1 **Definition of truss and its classification** 1.1.1 Explain the meaning of truss 1.1.2 Explain the various truss elements 1.1.3 State various types of trusses	1:0
Specific learning objectives: 1.2 **Assumptions in truss analysis** 1.2.1 state the various assumptions in truss analysis 1.2.2 Explain its applications in truss analysis	1:0
Specific learning objectives: 1.3 **Methods of truss analysis** 1.3.1 Explain method of joints 1.3.2 Numerical analysis by method of joints 1.3.3 Explain method of sections 1.3.4 Numerical analysis by method of sections	3:2
Specific learning objectives: 1.4 **Definition of frames** 1.4.1 Define frame 1.4.2 Difference between truss and frames	1:0
Specific learning objectives: 1.5 Method of frame analysis 1.5.1 Explain method of members 1.5.2 Numerical analysis by method of members	2:1
C. Properties of Lines, Surfaces and Physical Bodies	12:3
General Learning Objective: Understand the importance of centroids and centre of gravity of curves, areas and composite shapes and methods of finding centroids and moment of inertia of various standard and composite shapes.	

C. Sub-topic: Importance and meaning of centroids and moment of inertia, methods of finding centroids and moment of inertia (IMO 7.04, Appendix IV,2014) **Sub-subtopics & SLOs** 1.6 Centroids, centre of mass and centre of gravity 1.7 Methods of finding centroids of curves and areas 1.8 Pappus Guldinus theorems 1.9 Second moment of area and radius of gyration 1.10 Perpendicular axis and parallel axis theorems 1.11 Method of finding moment of inertia	
Specific learning objectives: 1.1 **Centroids, centre of mass and centre of gravity.** 1.1.1 Explain meaning of centroid, centre of mass and centre of gravity 1.1.2 State difference between centroid, centre of mass and centre of gravity	1:0
Specific learning objectives: 1.2 **Methods of finding centroid of curves and areas.** 1.2.1 Integration method of finding centroid of area bounded under curves and centroid of standard areas 1.2.2 Numerical analysis by integration method 1.2.3 Explain analytical method of finding centroid of composite shapes 1.2.4 Numerical analysis on centroid of composite shapes	3:1
Specific learning objectives: 1.3 **Pappus Guldinus theorems** 1.3.1 State Pappus Theorem-I and theorem-II. 1.3.2 Numerical analysis by application of Pappus theorems	1:0
Specific Learning Objectives: 1.4 **Second moment of area and radius of gyration** 1.4.1 Explain meaning and importance of second moment of area 1.4.2 Define the radius of gyration and its relation with moment of inertia 1.4.3 Numerical analysis on radius of gyration	2:1
Specific Learning Objectives: 1.5 Perpendicular axis theorem and parallel axis theorems. 1.5.1 Statement and proof of Perpendicular axis theorem 1.5.2 Statement and proof of Parallel axis theorem. 1.5.3 Explain the application of both theorems to find moment of inertia.	2:0
Specific Learning Objectives: 1.6 **Method of finding moment of inertia.** 1.6.1 Explain Integration method of finding moment of inertia of standard areas 1.6.2 Explain analytical method of finding moment of inertia of areas 1.6.3 Numerical analysis on moment of inertia of composite sections	3:1
D. Lifting Machines	4: 2
General Learning Objective: Understand the meaning, importance and applications of various types of lifting machines. **D. Sub-topic: Definition, terms involved, types of machines and law of machine** **Sub-subtopics & SLOs (IMO 7.02)** **1.4.** Definition of lifting machine and terminology. **1.5.** Types of lifting machines. **1.6.** Law of machines	
Specific Learning Objectives: 1.1 **Definition of lifting machine and terminology.** 1.1.1 Define lifting machine	1:1

1.1.2 Define mechanical advantage, velocity ratio, efficiency 1.1.3 Explain input work, output work, ideal machine, actual machine	
Specific Learning Objectives: 1.1 **Types of lifting machines** 1.1.1 Explain reversible machines and irreversible machines 1.1.2 Explain construction and working of simple wheel and axle and differential wheel and axle and derive VR 1.1.3 Explain construction and working of single purchase winch crab and double purchase winch crab and derive VR 1.1.4 Explain construction and working of pulley systems and derive VR 1.1.5 Explain construction and working of screw jack and derive VR and efficiency	2:1
Specific Learning Objectives: 1.1 **Law of machines** 1.1.1 Explain law of machines 1.1.2 Numerical analysis on law of machine	1:0
E. Kinematics and kinetics of linear motion	8:2
General Learning Objective: Understand the kinematic parameters, kinematic analysis, kinetic analysis and dynamic equilibrium of particles and rigid bodies in linear motion. **E. Sub-topic: Kinematic parameters, equations of linear motion with constant and variable acceleration, kinetic analysis, De Alembert's principle.** **Sub-subtopics & SLOs (IMO 7.04, Appendix IV,2014)** 1.1 Kinematic parameters in linear motion 1.2 Equations of linear motion with constant acceleration 1.3 Equations of linear motion with variable acceleration 1.4 Kinetic analysis and dynamic equilibrium	
Specific Learning Objectives: 1.1 Kinematic parameters in linear motion. 1.1.1 Define displacement, velocity, acceleration 1.1.2 Explain uniform velocity, variable velocity, uniform acceleration, variable acceleration 1.1.3 Explain significance of Displacement-Time plot, Velocity-Time plot, Acceleration-Time plot	2:1
Specific Learning Objectives: 1.2 Equations of linear motion with constant acceleration 1.2.1 Derivations of linear motion equations with constant acceleration 1.2.2 Numerical analysis on constant acceleration	2:0
Specific Learning Objectives: 1.3 Equations of linear motion with variable acceleration 1.3.1 Derivations of linear motion equations with variable acceleration 1.3.2 Numerical analysis on linear motion with variable acceleration	2:0
Specific Learning Objectives: 1.4 Kinetic analysis and dynamic equilibrium 1.4.1 Explain kinetics of linear motion 1.4.2 Explain dynamic equilibrium of rigid bodies 1.4.3 State De Alembert's principle of motion 1.4.4 Numerical analysis on kinetic analysis	2:1
F. Kinematics of Curvilinear Motion	4: 2
General Learning Objective: Understand the kinematic parameters, normal acceleration, tangential acceleration in curvilinear motion and projectile motion analysis. **F. Sub-topic: Kinematic parameters in curvilinear motion, total acceleration analysis and projectile motion. (IMO 7.04, Appendix IV,2014)** **Sub-subtopics & SLOs** 1.1 Curvilinear motion kinematics 1.2 Projectile motion	

Specific Learning Objectives: 1.1 Curvilinear motion kinematics 1.1.1 Define curvilinear motion 1.1.2 Explain normal acceleration, tangential acceleration and total acceleration 1.1.3 Numerical analysis on curvilinear motion kinematics	2: 1
Specific Learning Objectives: 1.2 Projectile motion 1.2.1 Define projectile motion, its parameters and applications 1.2.2 Derive expressions for range, maximum range, time of flight, maximum height attained, trajectory equation, equivalent velocity 1.2.3 Numerical analysis on projectile motion in different applications	2: 1
G. Simple Harmonic Motion	7:3
General Learning Objective: Understand the meaning and applications of simple harmonic motion, beats phenomena, resonance, amplitude, frequency and time period analysis in simple pendulum, compound pendulum, spring mass system and shaft rotor system. **G. Sub-topic: Basic parameters of SHM, beats, resonance, simple pendulum, compound pendulum, spring mass system, shaft rotor system. (IMO 7.04, Appendix IV,2014)** **Sub-subtopics & SLOs** 1.1 Basic parameters of SHM, beats and resonance. 1.2 Simple and compound pendulum. 1.3 Spring mass system. 1.4 Shaft rotor system. 1.5 Undamped and damped vibrations	
Specific Learning Objectives: 1.1 Basic parameters of SHM, beats and resonance. 1.1.1 Define periodic motion (SHM), explain various applications. 1.1.2 Explain amplitude, frequency, time period, maximum velocity, maximum acceleration 1.1.3 Explain phenomena of beats, resonance 1.1.4 Numerical analysis	1:1
Specific Learning Objectives: 1.2 Simple and compound pendulum. 1.2.1 Explain periodic motion in simple pendulum and derive expression of time period 1.2.2 Explain periodic motion in compound pendulum and derive expression of time period 1.2.3 Numerical analysis	2:1
Specific Learning Objectives: 1.3 Spring mass system and shaft rotor system 1.3.1 Derivation of governing equation for spring mass system 1.3.2 Determination of natural frequency for springs in series and parallel configuration 1.3.3 Derivation of governing equation for shaft rotor system. 1.3.4 Numerical analysis	2:1
Specific Learning Objectives: 1.4 Single degree of freedom undamped and damped free vibrations 1.4.1 Define degree of freedom, what are SDOF vibrations 1.4.2 SDOF undamped free vibrations analysis 1.4.3 SDOF damped free vibrations analysis 1.4.4 Numerical analysis	2:0

Subject: Name/Code: Basic Thermodynamics/205

Instructional hours:

Lecture	: 45 hours
Tutorial	: 15 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

Pre-requisites: 10, + 1 and +2 scheme (MPC Group)

Recommended Text:

1. Basic Thermodynamics, P K Nag; McGraw Hill.
2. Çengel, Y. A., Boles. (2014). Thermodynamics: An Engineering Approach. India: McGraw Hill Education.

Reference:

1. Bailey, M. B., Boettner, D.D., Moran, M.J., Shapiro, H.N. (2011). Fundamentals of Engineering Thermodynamics. United Kingdom: Wiley.
2. Sonntag, R.E., Borgnakke, C. (2018). Borgnakke's Fundamentals of Thermodynamics. United State: Wiley.
3. Harrington (Editor) Marine Engineering. (1992). United State: Society of Naval Architects and Marine Engineers. (For Tutorials, this book may be used).

Books that can be referred to on internet (Free sources):

1. Keenan, J.H., Hatsopoulos, G.N. (1965). Principles of general thermodynamics. United Kingdom: Wiley. - www.archive.org
2. Karamchandani, C.J., Patel, R.C.(1963).Elements of Heat Engines.(n.p.):Acharya Book Depot [1962-63, vol 1 - - http://thermodynamicsheatengines.com/downloads.html

Table of Topics

Section	Topics	Hours (L:T)
A	Application Areas of Thermodynamics in Maritime Industry	1: 1
B	Basic Concepts	6: 2
C	Energy, Energy Transfer and General Energy Analysis	4: 2
D	Properties of Pure Substances	8: 2
E	Energy Analysis of Closed Systems	8: 2
F	Mass and Energy Analysis of Control Volumes	6: 2
G	The Second Law of Thermodynamics	6: 2
H	Entropy	4: 0
I	Exergy	2: 2
Total		**45: 15**

Learning Objectives	**L: T**
General Learning Objective: Understand fundamental principles, conservation laws and rate processes of the physical sciences, Laws of Nature, Fundamental engineering knowledge and systematic analysis of systems, processes, engines, machinery, energy, energy conversion, power plant	
A Application Areas of Thermodynamics in Maritime Industry (IMO 7.02,2014: F1/1.2.1.1) (IMO 7.04,2014: 1.1.1, 1.1.3, 3.1) **Specific Learning Objectives:** 1. Explain how thermodynamic fundamentals help in understanding engines, pumps, compressors, air conditioning / refrigeration plants, heat transfer / exchangers, fuel estimation etc. 2. Demonstrate how theory and practical applications complement each other 3. Demonstrate why it is important for a practising marine engineer to know the fundamentals of thermodynamics (Note: Suggested tutorial from 'Marine Engineering' by Harrington)	1: 1
B Basic Concepts: (IMO 7.02,2014: F1/1.2.1.1) (IMO 7.04,2014: 1.1.1, 1.1.3, 3.1) **Specific Learning Objectives:** 1. Identify the unique vocabulary associated with thermodynamics through the precise definition of basic concepts to form a sound foundation for the development of the principles of thermodynamics 2. Review the metric SI and the English unit systems that will be used throughout the text 3. Explain the basic concepts of thermodynamics such as system, state, state postulate, equilibrium, process, and cycle 4. Discuss properties of a system and Define density, specific gravity, and specific weight 5. Review concepts of temperature, temperature scales, pressure, and absolute and gauge pressure. Introduce an intuitive, systematic problem-solving technique 6. Explain the following: - Systems and control volumes - Properties of a system - State and Equilibrium - Processes and cycles - Temperature and the Zeroth Law of Thermodynamics - Pressure and measurement devices	6: 2

C Energy, Energy Transfer and General Energy Analysis **(IMO 7.02,2014: F1/1.2.1.1) (IMO 7.04,2014: 1.1.1, 1.1.3, 3.1)** **Specific Learning Objectives:** 1. Explain the concept of energy and Define its various forms 2. Discuss the nature of internal energy Define the concept of heat and the terminology associated with energy transfer by heat 3. Define the concept of work, including electrical work and several forms of mechanical work 4. Introduce the first law of thermodynamics, energy balances and mechanisms of energy transfer to or from a system 5. Determine that a fluid flowing across a control surface of a control volume carries energy across the control surface in addition to any energy transfer across the control surface that may be in the form of heat and/or work 6. Define energy conversion efficiencies 7. Discuss the implications of energy conversion on the environment 8. Explain the following: - Forms of Energy - Energy Transfer by Heat - Energy Transfer by Work - Mechanical forms of work - The First Law of Thermodynamics - Energy conversion Efficiencies - Energy and Environment	4: 2
D Properties of Pure Substances: IMO 7.02,2014: F1/1.2.1.1) (IMO 7.04,2014: 1.1.1, 1.1.3, 3.1) **Specific Learning Objectives:** 1. Explain the concept of a pure substance Discuss the physics of phase change processes 2. Illustrate the P-v, T-v, and P-T property diagrams and P-v-T surfaces of pure substances 3. Demonstrate the procedures for determining thermodynamic properties of pure substances from tables of property data 4. Describe the hypothetical substance 'ideal gas' and the ideal-gas equation of state 5. Apply the ideal-gas equation of state in the solution of typical problems 6. Introduce the compressibility factor, which accounts for the deviation of real gases from ideal-gas behaviour 7. Present some of the best-known equations of state 8. Explain the following: - Pure substance - Phases of a pure substance - Phase change processes of pure substances - Property diagrams for phase change processes, Pvt Surfaces - Property Tables - The ideal gas equation of state - Compressibility factor – a measure of deviation from ideal gas behaviour - Other equations of state – Vander Waal's Equation, Virial Equation	8: 2
E Energy Analysis of Closed Systems: (IMO 7.02,2014: F1/1.2.1.1) (IMO 7.04,2014: 1.1.1, 1.1.3, 3.1) **Specific Learning Objectives:** 1. Examine the moving boundary work or P dV work commonly encountered in reciprocating devices such as automotive engines and compressors 2. Identify the first law of thermodynamics as simply a statement of the conservation of energy principle for closed (fixed-mass) systems 3. Develop the general energy balance applied to closed systems 4. Define the specific heat at constant volume and the specific heat at constant pressure Relate the specific heats to the calculation of the changes in internal energy and enthalpy of ideal gases 5. Describe incompressible substances and determine the changes in their internal energy and enthalpy 6. Solve energy balance problems for closed (fixed-mass) systems that involve heat and work interactions for general pure substances, ideal gases, and incompressible substances	8: 2

7. Explain the following: - Moving boundary work - Energy balance for closed systems - Internal energy, enthalpy and specific heats of ideal gases - Internal energy, enthalpy and specific heats of solids and liquids	
F Mass and Energy Analysis of Control Volumes **(IMO 7.02,2014: F1/1.2.1.1) (IMO 7.04,2014: 1.1.1, 1.1.3, 3.1)** **Specific Learning Objectives:** 1. Develop the conservation of mass principle 2. Apply the conservation of mass principle to various systems including steady- and unsteady-flow control volumes 3. Apply the first law of thermodynamics as the statement of the conservation of energy principle to control volumes, Identify the energy carried by a fluid stream crossing a control surface as the sum of internal energy, flow work, kinetic energy, and potential energy of the fluid and to relate the combination of the internal energy and the flow work to the property enthalpy 4. Solve energy balance problems for common steady-flow devices such as nozzles, compressors, turbines, throttling valves, mixing chambers, and heat exchangers 5. Apply the energy balance to general unsteady flow processes with particular emphasis on the uniform- flow process as the model for commonly encountered charging and discharging processes 6. Explain the following: - Conservation of Mass - Flow work and the energy of a flowing fluid - Energy analysis of steady flow systems - Steady flow engineering devices - Energy analysis of unsteady flow processes	6: 2
G The Second Law of Thermodynamics **(IMO 7.02,2014: F1/1.2.1.1) (IMO 7.04,2014: 1.1.1, 1.1.3, 3.1)** **Specific Learning Objectives:** 1. State the second law of thermodynamics Identify valid processes as those that satisfy both the first and second laws of thermodynamics 2. Discuss thermal energy reservoirs, reversible and irreversible processes, heat engines, refrigerators, and heat pumps 3. Describe the Kelvin–Planck and Clausius statements of the second law of thermodynamics 4. Discuss the concepts of perpetual-motion machines 5. Apply the second law of thermodynamics to cycles and cyclic devices 6. Apply the second law to develop the absolute thermodynamic temperature scale 7. Describe the Carnot cycle 8. Examine the Carnot principles, idealized Carnot heat engines, refrigerators, and heat pumps 9. Determine the expressions for the thermal efficiencies and coefficients of performance for reversible heat engines, heat pumps, and refrigerators 10. Explain the following: - Introduction to the second law - Thermal energy reservoirs - Heat Engines - Refrigerators and Heat pumps - Perpetual motion machines - Reversible and irreversible processes - The Carnot Cycle - The Carnot principles - The Thermodynamic temperature scales - The Carnot heat engine - The Carnot refrigerator and heat pump	6: 2
H Entropy: MO 7.02,2014: F1/1.2.1.1) (IMO 7.04,2014: 1.1.1, 1.1.3, 3.1) **Specific Learning Objectives:** 1. Apply the second law of thermodynamics to processes 2. Define a new property called entropy to quantify the second-law effects	4: 0

<table>
<tr>
<td>3. Establish the increase of entropy principle
4. Calculate the entropy changes that take place during processes for pure substances, incompressible substances, and ideal gases
5. Examine a special class of idealized processes, called isentropic processes, and develop the property relations for these processes
6. Derive the reversible steady-flow work relations
7. Develop the isentropic efficiencies for various steady-flow devices
8. Introduce and apply the entropy balance to various systems
9. Explain the following:
- Entropy
- The increase of entropy principle
- Entropy change of pure substances
- Isentropic processes
- Property diagrams involving entropy
- TDS Relationships
- Entropy change of liquids and solids
- The entropy changes of ideal gases
- Reversible steady flow work
- Minimizing compressor work
- Isentropic efficiencies of steady flow devices
- Entropy balance</td>
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<tr>
<td>I Exergy: (IMO 7.02,2014: F1/1.2.1.1) (IMO 7.04,2014: 1.1.1, 1.1.3, 3.1)

Specific Learning Objectives:
1. Examine the performance of engineering devices in light of the second law of thermodynamics
2. Define exergy, which is the maximum useful work that could be obtained from the system at a given state in a specified environment
3. Define reversible work, which is the maximum useful work that can be obtained as a system undergoes a process between two specified states
4. Define the exergy destruction, which is the wasted work potential during a process as a result of irreversibility. Define the second-law efficiency
5. Develop the exergy balance relation
6. Apply exergy balance to closed systems and control volumes
7. Explain the following:
- Exergy: work potential of energy
- Reversible work and irreversibility
- Second law efficiency
- Exergy changes of a system
- Exergy transfer by heat, work and mass
- The decrease of exergy principle and exergy destruction
- Exergy balance: Closed systems
- Exergy balance: Control Volumes</td>
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Subject Name/Code: Marine Electrical Power Generation and Distribution/206

Instructional hours :
Lecture : 15 hours
Tutorial : 15 hours
Total contact hours : 30 hours

Credits : 2

Teaching Methods
The course shall be conducted with classroom/online lectures and tutorials.

Assessment Methods: **Refer to IMU Guidelines prior start of the Session for actual allocations.**
Class Assessments (Written tests/MCQs/Projects/Assignments) : 30%
Final Exam : 70%

Additional Information on Subject:

Prerequisite for this Subject: Class 12 Physics, Maths.

Recommended Text:

1. A Textbook of Electrical Technology: - AC and DC Machines (Volume - 2) (English, Paperback, Theraja A. K.); Publisher S. Chand; ISBN:
2. Marine Electrical Technology 11th Edition; By Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN: 9789352139514.

Reference:

1. Ship's Electrical Systems: Drawings; Yard Finished plans/As-built Plans; OEM Manuals.

Table of Topics

Section	Topics	Hours (L: T)
1	Power Generation on board Ships	8: 8
2	AC Distribution Systems	5: 5
3	Electrical Circuits	2: 2
Total		**15: 15**

Learning Objectives	L: T
Section 1 Power Generation on board Ships	
General Learning Objectives Understand how power is generated on the ship.	L: T
(IMO 7.04,2014: 2.1.1) **2.1 OPERATIONAL, ELECTRONIC AND CONTROL SYSTEMS** **2.1.1 BASIC ELECTRICAL ENGINEERING** **1.3 Generators** **Sub topic: Power Generation on board Ships** **Specific Learning Objectives:** Explain the following: 1. Specification of electric power for shipboard installations 2. The use of electrical power on ship, why we generate electric power, how we generate the electric power and its various uses 3. The diesel-electric power generator and various configurations that are found on ships 4. Turbo-electric power generation, shaft power generator, emergency generators, shore power supply and batteries 5. Configurations of electric power generation plant for electric propulsion ships, Medium Voltage / High Voltage installation (MV/HV) 6. Various conditions of ships operation and power requirement, covering - - Sea going ballast condition – normal sailing - Sea going ballast condition with cargo / ballast operations - Seagoing laden voyage - Sea going laden voyage with cargo / ballast operations - Manoeuvring in / out of power or restricted areas - Port discharging - Power loading 7. Power distribution system – How electric power is distributed and specification of power distribution systems for MV / HV - Main Switchboard – MV / HV - Cargo Switchboards - Group Starter Panels - Transformers - Lighting distribution panel - Remote starter panels / Local starter panels - Back-up and redundancy arrangement – Emergency power	8:8

8. Emergency power generation and distribution, its location
9. Power failure and restoration

Additional Objectives:

1 A.C. generators

1.1 Use Fleming's hand rules to determine the directions of magnetic field, motion and current

1.2 On an actual machine, or by using given diagram that shows the arrangement of a simple generator, identify and explain the function of:

- the armature
- slip rings
- brushes and springs
- field poles
- field coils

1.3 Sketch a graph showing the variation of e.m.f. when a simple loop generator coil is rotated between poles

1.4 State the range of voltage and frequency at which ship's electrical power is generated

1.5 State that the A.C. voltages normally given are root mean square values and that all equipment is rated in these terms

1.6 State that the peak values are 2 times larger than r.m.s values

1.7 Describe in simple terms an A.C. generator with three-phase windings, stating the phase difference

1.8 Sketch a schematic arrangement of a three-phase alternator with star connection

1.9 In the terminal box of a stator field winding, identify the outlets of the three phases and the common neutral connection

1.10 Explain how excitation of the rotor is produced and supplied

1.11 Describe how a generator is cooled

1.12 List the parts of a generator fitted with temperature alarms

1.13 Explain why heaters are fitted to a generator

Additional Objectives:

2 D.C. Generators

2.1 Sketch, in diagrammatic form, the basic circuit for a D. C. generator on a given drawing or an actual generator, identify the field poles, yoke, shoe, files windings and interpoles

2.2 Describe the differences in appearance of shunt coils and series coils

2.3 On a given drawing or an actual generator, identify the windings, commutator, commutator insulation, laminations, clamping arrangement, ventilation holes, coil-retaining arrangements, brushes, tails, brush loading arrangement and bearings and name the two types of windings used on armatures

2.4 On an actual machine or by using a given diagram that shows the arrangement of a simple direct-current generator, identify and explain the function of:

- the armature
- the commutator
- brushes and springs
- field poles and field coils

Additional Objectives:

(IMO 7.02,2014: 2.1.3)

3 Three phase generators

3.1 Explain the following features of the three-phase alternator:

- construction
- salient and cylindrical rotor types
- excitation methods

3.2 Briefly explain the operation of shaft generators

Additional Objectives: **(IMO 7.02,2014: 2.1.3)** **4 Three phase transformers** 4.1 Define Construction 4.2 Define Polarity 4.3 Define Configuration in star and delta combinations 4.4 Define Open delta configuration	
Additional Objectives: **IMO 7.04,2014: 2.1.1)** **1.4 Power distribution systems** **5 Transformers** 5.1 State that transformers on ships are usually air-cooled 5.2 Show diagrammatically the connections between the main switchboard and the main distribution board through: - delta-delta transformers - delta-star transformers - delta-star transformers with an earthed neutral	
Section 2 AC Distribution Systems	
General Learning Objectives Understand the fundamentals of generic ac power distribution systems and systems adopted on board ships; Understand how power is distributed in the ship from generator to various consumers.	
(IMO 7.04,2014: 2.1.1) **2 Power distribution systems** Explain and illustrate where required: 2.1 Draw a system diagram of a typical distribution system, showing: - main generators - emergency generators - shore supply - battery charging - 440-volt supply - 220-volt supply - circuit breakers - transformers 2.2 Ship's Specific Layout Explanation with Illustrations for 1. Diesel Generator starting and group indicator control cabinet 2. Emergency Diesel Generator Control Panels 3. Emergency Generator Fuel system. 4. Main Electrical Network 5. Breaker Identification 6. Circuit-Breaker Interlock System 7. Generator Protection and Power 8. Management Unit Mechanical Interlock Procedures 9. HV Main Switchboard Control Location Flow Charts 10. 6.6kV Main Switchboards Layout 11. 6.6kV Main Switchboards Generator and Synchronising Panels 12. Emergency Generator Switchboard and Local Control Panels 13. No.1 440V Main Switchboard Distribution 14. No.2 440V Main Switchboard Distribution 15. No.1 and No.2 220V Feeder Panel Distribution including lighting distribution 16. No.1 GSP Distribution 17. No.2 GSP Distribution Local Group Starter Panel Distribution 18. Emergency Switchboard Distribution 19. No.1 High Voltage and Low Voltage Cargo Switchboard Distribution	5:5

20. No.2 High Voltage and Low Voltage Cargo Switchboard Distribution 21. Shore Connection 22. Main Alternator 23. Emergency Alternator	
Section 3 Electrical Circuits	
General Learning Objectives Understand electrical power circuits	
1 Electrical Circuits Explain and demonstrate where required: 1. Definitions – Single line or one-line diagram, schematic or elementary diagram, connection or wiring diagram, interconnection diagram, terminal diagram and other terms 2. General Information on reference standards, diagram titles, forms of diagrams, combined forms of diagram, drawing size and format, line conventions and lettering 3. Graphic symbols – representation of electrical contacts, abbreviations, layout of diagrams, grouping of parts, drawing reference number and reference location Diagram revisions, colour information 4. Various electrical components, switchgear and equipment found on ship Its function, picture and symbolic representation 5. Ships' electrical power generation / distribution – single line diagrams general and for power switch gear and industrial control 6. General information on ratings, winding connection symbols, neutral, insulated or ground connections, feeder circuits, protective relaying instruments, meters and associated switches, power circuit breaker mechanism, rations of instrument transformers 7. Schematic diagrams layout, connecting lines, junctions and crossovers, mechanical linkages 8. Schematic diagrams for power switchgear and industrial control – device ratings, rating location, current transformers, explanatory notes, wire and terminal designations, designation location, terminal designation, general layout 9. Schematic circuits – device contacts, circuit arrangements, control sources, physical relationships, course of circuit, phasing indicators and polarity indication	2:2

Subject Name/Code: Basic Electrical Engineering (P) /207

Instructional Hours

Practical	: 15 hours
Total contact hours	: 15 hours
Credits	: 0.5

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. A Textbook of Electrical Technology: Part 1 - Basic Electrical Engineering in S. I. Units (Volume - 1) (English, Paperback, Theraja A. K.); Publisher S. Chand; ISBN: 9788121924405.
2. Basic Electrical Engineering V.N Mittle, Arvind Mittal, 2nd Edition; Publisher: McGraw Hill Education – Europe; ISBN: 9780070593572.

Reference:

1. Ship's Electrical Systems: Drawings; Yard Finished plans/As-built Plans; OEM Manuals.
2. Practical Marine Electrical Knowledge; Dennis T. Hall; London, Witherby & co. (ISBN: 1 85609 182 1).

Table of Topics

Section	Topics	Hours (P)
A1	Basic Laws in Electrical Theory and Concepts of Circuits **Sub-Topics:** Ohm's law, Kirchhoff's law, impedance and inductance	5
B1	Fundamentals of Alternating Current **Sub-Topics:** Alternating Current, Electromagnetic Induction, Work, Energy and Power	6
C1	Testing and Measuring Equipment **Sub-Topics:** Insulation tester, Continuity tester, Multi-tester, Clamp meter	4
	Total	**15**

Learning Objectives	P
A Basic Laws in Electrical Theory and Concepts of Circuits **General Learning Objectives** • Understand the importance of basic laws in electricity • Understand the function of a basic electrical circuit **Topic 1. Basic Laws in Electrical Theory and Concepts of Circuits** **Sub-Topics:** 1.1 Ohm's law 1.2 Kirchhoff's law 1.3 Impedance and inductance	
A1 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1) 2.1.1.1 **1.1 Ohm's law** 1.1.1 Demonstrate the effect of resistors in a circuit 1.1.2 Apply Ohm's law to find current, voltage and resistance in simple problems 1.1.3 Demonstrate how the current through and the voltage across resisters are affected in series and in parallel circuits	1
1.2 Kirchhoff's law 1.2.1 Construct and Use a Wheatstone Bridge 1.2.2 Measure the total (or equivalent) resistance of a constructed parallel circuit, given the voltage and total current 1.2.3 Measure the total resistance, given the values of resistances in a constructed parallel circuit 1.2.4 Compare the effect of adding a further resistance to: - a parallel circuit - a series circuit 1.2.5 Demonstrate how the objective affects the e.m.f and the terminal potential difference of a supply, demonstrating the effect by calculations and by experiment 1.2.6 Demonstrate the effect of internal resistance in the supply source 1.2.7 Determine current flows, resistance values and voltages in: - series circuits and parallel circuits by calculation	1
1.3 Impedance and inductance 1.3.1 Demonstrate the effect in an A.C. circuit and in a D.C. circuit: - of a simple resistance - the same resistance wound in form of a coil - the same coiled resistance, into which an iron core is inserted	1

1.3.2 Calculate impedances and power factors, given the resistance and reactance of coils	
1.3.3 Demonstrate why, in a circuit containing only reactance, there is a difference in phase of 90° between the applied voltage and the current 1.3.4 Sketch graphs showing the variation of current, applied voltage and back e.m.f. over one cycle when an A.C. is applied to: - a circuit containing only pure resistance - a choke having inductance only 1.3.5 Superimpose a curve representing the power dissipated in both cases in the above objective 1.3.6 Calculate the value of the power factor in both cases in the above objective	1
1.3.7 Solve simple problem concerning power, current, resistance, impedance, reactance and power factor and verifies the solutions, using laboratory equipment	1
B – Fundamentals of Alternating Current **General Learning Objectives** • Understand the fundamentals of Alternating Current • Know the importance of electromagnetic induction in today's machinery and systems and the laws governing it • Know how to calculate Work, Energy and Power **Topic: Fundamentals of Alternating Current** **Sub-Topics:** 1.1 Alternating Current 1.2 Electromagnetic Induction 1.3 Work, Energy and Power	
B1 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1) **1.1 Alternating Current** 1.1.1 Demonstrate how alternating current is produced in a simple loop rotating in a magnetic field	1
1.1.2 Demonstrate the operation of a simple circuit for a three-phase supply from an alternator	1
1.2 Electromagnetic Induction 1.2.1 Demonstrate how the following factors affect the induced voltage: - flux density - number of turns in the coil - conductor/flux cutting rate	1
1.2.2 Demonstrate Faraday's law of electromagnetic induction 1.2.3 Demonstrate Lenz's law 1.2.4 Demonstrate the principle of static induction, to include mutual conduction and self-induction; cross field theory etc.	1
1.3 Work, Energy and Power 1.3.1 Demonstrate that work = current × time × voltage, giving the units used 1.3.2 Make simple calculations to determine power, energy and work	1
1.3.3 Define power, giving the units and symbols used; from the above objective, derives the expression power = voltage × current (P=VI), giving the units used 1.3.4 Using the equations from above objectives, derive $P = I^2 R$ and $P = \frac{V^2}{R}$	1

C – Testing and Measuring Equipment **General Learning Objectives** • Understand the construction and operation of the testers in the scope of this section • Know how to safely use the test equipment in the scope of this section • Know how to deduce faults in basic equipment and machinery, using these testers **Topic: Construction and Operation of Electrical Testing and Measuring Equipment** **Sub-Topics** 1.1 Insulation tester 1.2 Continuity tester 1.3 Multi-tester 1.4 Clamp meter	
C1 Specific Learning Objectives: (IMO 7.04,2014: 2.2.4 **1.1 Insulation tester** 1.1.1 Demonstrate the operation of an insulation tester 1.1.2 Demonstrate the precautions when using an insulation tester 1.1.3 Demonstrate the range of voltages used for testing ships' equipment 1.1.4 Use an insulation tester: - to check the zero reading - to check that the equipment is dead - to measure values of phase-to-phase insulation - to measure values of phase-to-earth insulation	1
1.2 Continuity tester 1.2.1 Use a continuity tester to: - check that the equipment is dead - measure the resistance of circuits 1.2.2 Enter the test readings and relevant comments on an appropriate record card 1.2.3 Demonstrate the significance of individual and comparative test readings	1
1.3 Multi-tester 1.3.1 Use digital and analogue multimeters, taking the necessary precautions, to: - check the accuracy of the meter - check for battery failure - measure resistance - measure voltage - measure current - test diodes	1
1.4 Clamp meter 1.4.1 Use a clamp meter to measure current 1.4.2 Use a live-line tester to determine whether equipment is alive or dead	1

Subject Name/Code: Basic Electronics (P)/208

Instructional hours:

Practical	: 45 hours
Total contact hours	: 45 hours
Credits	: 1.5

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. Electrical and Electronic Technology, Hilley John, Brown Keith and Smith Lan Mckenzie, Pearson Education.
2. Electronic Devices and Circuit Theory, Boylested and Nashelsky, Pearson Education.

Reference:

1. Practical Marine Electrical Knowledge; Dennis T. Hall; London, Witherby & Co. (ISBN: 1 85609 182 1).
2. Digital Electronics: Principles and Application; Roger L Tokheim; McGraw Hill; ISBN: 978-0078309823.
3. Marine Control Practice; D. A. Taylor and Billis; Butterworth Heinemann; ISBN: 978-0408013130.
4. Kraal, E.G.R., Basic Electrotechnology for Engineers. 3rd ed. London, Thomas Reed Publications Ltd, 1985 (lSBN 0-900335-96-3).
5. Basic Electronics (Solid State) In Multi Colour Edition Paperback – 1 December 2006 S Chand.
6. Power Electronics: Devices, Circuits and Applications; Fourth Edition; 2017; Pearson Education.
7. Microprocessor Architecture, Programming and Applications with the 8085; 6/e; 2013; Penram International Publishing.

Table of Topics

Section	Topics	Hours (P)
A	Basic Electronics	06
B	Basic electronic circuit element	02
C	Power Electronics	02
D	Operational amplifier	05
E	Digital techniques	06
F	Electronic measuring and test instruments	02
G	Microprocessor and microcontroller	06
H	Voltage regulators and multivibrator	04
I	Flowchart for automatic and control systems	02
J	Electrical and simple electronic diagram	02
K	Function test of electrical, electronic control equipment and safety	04
L	Electronic control equipment	04
	Total	**45**

Learning Objectives	P
General Learning Objective	
(IMO 7.04,2014: 2.1.2,.2.2.6, IMO 7.02,2014: 2.1(1.2),2.2.2,4.3)	
Understand the principles of basic electronics devices and electronic control equipment; use the devices and Manage Troubleshooting	
A Basic Electronics	
1.1 Semiconductor diode (IMO 7.02,2014: 2.1(1.2)	**6**
Specific Learning Objectives: –Understand the characteristics of the p-n junction, the diode and some special function diodes and their application in electronic circuits	
1.1.1 To plot V-I Characteristics of Silicon and Germanium P-N Junction Diodes. 2. To find cut-in voltage for Silicon and Germanium P-N Junction diodes. 3. To find static and dynamic resistances in both forward and reverse biased conditions	1
1.1.2 To plot V-I Characteristics of Zener diode	1
1.2 Rectifier and filters	
Specific Learning Objectives: – Understand the Basics of Half wave, Full wave and bridge rectifiers. To study Effect of different filters on output of rectifier practically	1
1.2.1 To study the characteristics of half wave, full wave and bridge rectifier with and without filter and calculate the ripple factor, rectification efficiency	1
Specific Learning Objectives: – Understand the characteristics of the special function diodes and these diodes' application in electronic circuits	
1.3 Special purpose diode and applications	
1.3.1 To plot V-I Characteristics of Zener diode	
1.3.2 To plot V-I Characteristics of Photo diode	2
1.3.3 To plot V-I Characteristics of diode LED	
1.3.4 To perform and observe waveforms for diode as clipper and clamper circuit	
1.3.5 To study Zener diode as voltage regulator, calculate % line regulation, calculate % load regulation	
B Basic electronic circuit element (IMO 7.04,2014: 2.1.2)	**2**
Specific Learning Objectives: – Understand the Fundamentals of BJT, study working of transistor as switch and amplifier and their practical applications on ships in electronic circuitry.	
1.1 To plot frequency response of single stage CE amplifier and calculate the bandwidth.	1
1.2 To study and perform Transistor as a switch.	1
C Power Electronics (IMO 7.02,2014: 2.1(1.2)	**2**
Specific Learning Objectives: – Understand the basic theory of power semiconductor devices and passive components, their practical applications in power electronics	1
1.1 To plot the I-V characteristics of SCR	
1.2 To study speed control of DC motor using SCR	1
D Operational amplifier (IMO 7.02,2014: 2.1(1.2)	**5**
Specific Learning Objectives: – Understand the Concept of operational amplifier, Study of IC741, operation of various applications of OPAMP circuits	
1.1 To study Op-Amp as Inverting amplifier and non-inverting amplifier	1
1.2 To study Op-Amp as adder and subtractor	2
1.3 To study Op-Amp as integrator and differentiator	2
E Digital techniques (IMO 7.02,2014:4.3)	
Specific Learning Objectives: – Understand the Concept of digital logic levels, understand digital electronics circuits and their applications, perform the analysis and design various digital electronic circuits	**6**
1.1 To verify truth table of logic gates	2
1.2 To design and verify truth table of half and full adder circuit	2
1.3 To design and verify truth table of one-bit comparator	2

F Electronic measuring and test instruments (IMO 7.02,2014: 2.1(1.2) **Specific Learning Objectives: –** Understanding the construction and design of measuring devices and circuits, how to use measuring instruments practically with proper safety procedure 1.1 To observe various waveforms on the C.R.O. and to measure amplitude and frequency of the waveforms 1.2 To measure Resistance, Voltage (AC/DC), Current (AC) and Check Continuity of a given Circuit Using digital Multi meter	**2** 1 1
G Microprocessor and Microcontroller (IMO 7.02,2014:4.3) **Specific Learning Objectives: –** Understand the architecture and operation of typical microprocessors and microcontrollers, and study programming of 8085 microprocessors, practically 1.1 Performing simple arithmetic operations of addition using 8085 Microprocessor 1.2 Performing simple arithmetic operations of subtraction using 8085 Microprocessor 1.3 To perform program of block transfer of data from one location to another location	**6** 2 2 2
H Voltage regulators and multivibrator: (IMO 7.02,2014: 2.1(1.2) **Specific Learning Objectives: –** Understand the importance and use of regulated power supply and multivibrators to do various tasks required in industry. 1.1 To perform transistor as series and shunt regulator 1.2 To perform IC 555 as a stable multivibrator	**4** 2 2
I Flowchart for automatic and control systems (IMO 7.04,2014: 2.1.2) **Specific Learning Objectives: –** Understand the basics of flowchart and to break down tasks or subsystem to create a flowchart of system or process 1.1. To draw and explain various symbol marks used in flow charts such as terminal, processing, determination, input/output, etc. 1.2 To draw and explain flow charts for automatic control system for main engine, generator control system	**2** 1 1
J Electrical and simple electronic diagram (IMO 7.04,2014: 2.2.6) Specific Learning Objectives: – Understand the importance of symbols and electronic diagram and able to trace a circuit or wiring diagram from circuit board 1.1 To draw electrical and electronic symbols used in their circuit diagrams and write the function of circuit elements presented by the symbols in the circuit diagram 1.2 To draw a given simple circuit or wiring diagrams from a given circuit board using correct letter and circuit symbols	**2** 1 1
K Function test of electrical, electronic control equipment and safety devices (IMO 7.02,2014: 2.2.2(2.1) **Specific Learning Objectives: –** Understand the importance and use of electrical, electronic control equipment and safety devices. 1.1 To Perform function test of following devices and write their applications. - function test Over Current Relay (OCR) - function test relays and magnetic contactors - function test timers - function test fuses - function test MCCB - function test ACB 1.2 To Perform function test of following devices and write their applications - function test diodes - function test Silicon Controlled Rectifier (SCR) - function test temperature, pressure and level transmitters - function test over speed protection devices - function test flame scanners - function test fire detecting system	**4** 2 2
L Electronic control equipment (IMO 7.04,2014: 2.1.2) **Specific Learning Objectives: –** Understand the basic working and use of Basic Electronic control equipment like PLC, relay, PID and their application on ship 1.1 To draw block diagram or wring diagram or flow diagram and state and explain how control equipment are utilized for the following:	**4**

- Boiler: Automatic Combustion Control (ACC), burner control, - Feed Water Control (FWC) - Steam Temperature Control (STC) - auxiliary machinery; purifier automatic control (automatic sludge discharge) - temperature/level/pressure/viscosity control	2
1.2 To draw block diagram or wring diagram or flow diagram and state and explain how control equipment are utilized for the following: - main engine: start/stop, revolution, injection timing, electronic governor and the others (auto-load, crash astern, automatic shutdown, automatic slowdown, etc.) - controllable Pitch Propeller (CPP); auto load/blade angle control - generator: generator automatic control (GAC) (auto-synchro, load sharing, primary mover start/stop sequence	2

Subject Name/Code: Marine Engineering Drawing (P)/209

Instructional hours:

Practical	: 60 hours
Total contact hours	: 60 hours
Credits	: 2

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. N.D. Bhatt, 'Engineering Drawing' Charotar Publishing House.
2. S.C. Sharma, 'Machine Drawing' Standard Publishers distributors, Delhi.
3. Reed's Vol-II, Engineering Drawing for Marine Engineers, H. G. Beck, Bloomsbury.

Reference:

1. Simmonds, C.H. and Maguire D.E. progressive engineering drawing for T.E.C students, London, Hodder and Stoughton Ltd,1983(ISBN03-40-26196-x-0) out of print 1999.
2. M. B. Shah and B.C. Rana, 'Engineering Drawing ', Pearson Education.
3. McGibbon's Pictorial Drawing Book for Marine Engineers- H. Barr & J.G. Holburn.

Table of Topics

Section	Topics	Hours (P)
A	**Introduction** **Sub-Topics:** Purpose of a general arrangement, purpose of assembly drawings, purpose of component drawings, use of collective single-part drawings; use of pictorial drawings; List the standard/routine information and references commonly given on drawings	1
B	**Tangency** **Sub-Topics:** Draw a tangent to point A on the circumference of a circle.	1
C	**Sectional Orthographic Projection** **Sub-Topic:** Placement of section views, labelling cutting planes, line precedence, rules for lines in section views, cutting plane line styles, section lining technique, **Sectional views** – creating a section view, lines used in sectional views, rules of sectioning, basic sections – full section, half section, offset section; advanced sections – aligned section, rib and web sections, broken section, removed section, revolved section, non-sectioned parts, thin sections, intersections in sections, conventional breaks and sections, assembly sections.	10
D	**Screws threads and conventional representation** **Sub-Topic:** Screw threads, threads for power transmission, drafting conventions associated with threads, multiple threads, the application of thread conventions, tapping drill.	8
E	**Thread Formation, Nuts, Bolts and Studs** **Sub-Topic:** V-threads and square thread details; Metric & BSP threads; General conventions for drawing of threads in engineering drawings; Standard bolts, studs, nuts & tapped holes; Special bolts & screws e.g., tapped bolts, collar bolts and studs, pinching screws, cheese headed and round headed screws; Various types of locking arrangements of nuts.	8
F	**Drawing layouts and simplified methods** **Sub-Topic:** Single part drawing, Collective single part drawings, assembly drawings, collective assembly drawings, design layout drawings, combined details and assembly drawings, exploded assembly drawings, simplified drawings, machine drawing, drawing scales, Scale used in geometric construction	2
G	**Worked Examples in Machine Drawing** **Sub-Topic:** Examples from Main / Auxiliaries Engine parts. Flange coupling, Non return valve, Blow off cock, Cylinder relief valve, Bilge suction strainer valve, Pedestal bearing, Pulleys, Flywheel	18
H	**Keys and keyways** **Sub-Topic:** Sunk keys, woodruff keys, dimensioning keyways (parallel keys)	2
I	**Limits and fits** **Sub-Topic:** Need for limits and fits; given various ways of indicating limits of size, Explain their meaning; Explain the meaning of: tolerance actual size, basic size, nominal size, Explain hole basis fits Explain shaft basis fit, Explain, using examples: clearance fits, transition fits, interference fits Describe, using examples, the cumulative effect of tolerances Explain what is meant by selective assembly List the factors which influence the selection of tolerances	2
J	**Welded joints** **Sub-Topic:** Symbols for different welded joints; Drawing of different types of welded joints.	4
K	**Riveted joints** **Sub-Topic:** Types of rivet heads; classification of riveted joints, Lap joint, Butt joint, Drawing of lap and butt joint	4
	Total	**60**

Learning Objectives	P
A. Introduction **General Learning Objective:** Understand the need and scope of Engineering Drawing **Sub-Topics: Types of drawing** **Sub-Topics & SLOs:** 1.1 Explain purpose of a general arrangement 1.2 Explain purpose of assembly drawings 1.3 Explain purpose of component drawings 1.4 Use of collective single-part drawings 1.5 Use of pictorial drawings 1.6 List the standard/routine information and references commonly given on drawings	1
B. Tangency **General Learning Objective:** (**IMO 7.04,2014: C3/3.2.6)** **Sub-Topics/SLOs: Tangency** 1.1 Draw a tangent to point A on the circumference of a circle.	1
C. Sectional Orthographic Projection **General Learning Objective:** (**IMO 7.04,2014: C3/3.2.6)** Understand and draw sectional orthographic projection from isometric projection **Sub-Topics: Sectional Orthographic Projection** **Sub-Topics & SLOs:** 1.1 Explain General principles 1.2 Explain Creating a section view 1.3 Explain Lines used in sectional views 1.4 Explain Rules of sectioning 1.5 Explain Basic sections – full section, half section, offset section; advanced sections – aligned section, rib and web sections, broken section, removed section, revolved section, 1.6 Explain Non-sectioned parts, thin sections, intersections in sections, conventional breaks and sections, assembly sections	10
D. Screws threads and conventional representation **General Learning Objective:** (**IMO 7.04,2014: C3/3.2.6)** Understand and draw screw threads and conventional representations **Sub-Topics: Screw threads and conventional representation** **Sub-Topics & SLOs:** 1.1 Describe Screw threads 1.2 Describe Threads for power transmission 1.3 Describe Drafting conventions associated with threads 1.4 Describe Multiple threads 1.5 Describe Application of thread conventions 1.6 Describe Tapping drill	8
E. Thread Formation, Nuts, Bolts and Studs **General Learning Objective:** (**IMO 7.04,2014: C3/3.2.6)** Understand and Identify types of nuts, bolts and draw orthographic projection using empirical relations	8

Sub-Topics: Isometric Projection **Sub-Topics & SLOs:** 1.1 Draw three views of nut, bolt and washer with proportions V-threads and square thread details 1.2 Draw & explain Metric & BSP threads 1.3 Draw & explain General conventions for drawing of threads in engineering drawings 1.4 Draw & explain Standard bolts, studs, nuts & tapped hole Special bolts & screws e.g., tapped bolts, collar bolts and studs, pinching screws, cheese headed and round headed screws 1.5 Draw & explain Various types of locking arrangements of nuts	
F. Drawing layouts and simplified methods **General Learning Objective:** (**IMO 7.04,2014: C3/3.2.6)** Understand and Identify different types of drawing layouts and simplified methods **Sub-Topics: Isometric Projection** **Sub-Topics & SLOs:** 1.1 Explain Single part drawing, Collective single part drawings 1.2 Explain assembly drawings, collective assembly drawings 1.3 Explain design layout drawings 1.4 Explain combined details and assembly drawings 1.5 Explain exploded assembly drawings, simplified drawings 1.6 Explain machine drawing, drawing scales 1.7 Explain Scale used in geometric construction	2
G. Worked Examples in Machine Drawing **General Learning Objective:** (**IMO 7.04,2014: C3/3.2.6)** Understand and draw component and assembly drawing. **Sub-Topics/SLOs:** 1.1 Draw Examples from Main / Auxiliaries Engine parts 1.2 Draw Flange coupling 1.3 Draw Non return valve 1.4 Draw Blow off cock 1.5 Draw Cylinder relief valve 1.6 Draw Bilge suction strainer valve 1.7 Draw Pedestal bearing 1.8 Draw Pulleys 1.9 Draw Flywheel	18
H. Keys and keyways **General Learning Objective:** (**IMO 7.04,2014: C3/3.2.6)** Understand to draw keys and keyways. **Sub-Topics/SLOs:** 1.1 Draw Sunk keys 1.2 Draw woodruff keys 1.3 Draw dimensioning keyways (parallel keys)	2
I. Limits and fits **General Learning Objective:** (**IMO 7.04,2014: C3/3.2.6)** Understand scope and application of limits and fits in drawing **Sub-Topics: Isometric Projection** **Sub-Topics & SLOs:**	2

1.1 Explain Need for limits and fits 1.2 Explain Various ways of indicating limits of size, their meaning 1.3 Explain Meaning of: tolerance, actual size, basic size, nominal size 1.4 Explain Hole basis fits 1.5 Explain Shaft basis fits 1.6 Explain Clearance fits 1.7 Explain Transition fits 1.8 Explain Interference fits	
J. Welded joints **General Learning Objective:** (**IMO 7.04,2014: C3/3.2.6)** Understand and Identify types of weld joints and draw welded joints. **Sub-Topics: Isometric Projection** **Sub-Topics & SLOs:** 1.1 Explain Types of welded joints 1.2 Explain Symbols for welded joints 1.3 Explain Drawing of welded joints	4
K. Riveted joints **General Learning Objective:** (**IMO 7.04,2014: C3/3.2.6)** Understand and Identify types of riveted joints and draw riveted joints **Sub-Topics: Isometric Projection** **Sub-Topics & SLOs:** Explain and demonstrate by drawing where necessary: 1.1 Identify & draw the types of rivet heads 1.2 Identify & draw Lap joint, butt joint 1.3 Identify & draw Orthographic projection of lap joint and butt joint	4

Subject Name/Code: Ship Familiarization (P)/210

Instructional hours

Practical	: 45 hours
Total contact hours	: 45 hours
Credits	: 1.5

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. Seamanship Primer: Capt. Bhandarkar.

Reference:

1. IMO 7.04 Model Course: 3.2.3 (3.14)- p147, 4.6.1 (1.3)- p199, 4.6.1 (1.4)- p209, 4.1.1- p173, 4.8- p213, 4.4.2- p197, 4.4.1- p197, 4.4.1- p197, 4.2.2- (2.4) - p194); 2014 Ed.
2. MARPOL: IMO.
3. ILO: Accidental Prevention On-board Ship at Sea and in Port.

Table of Topics

Section	Topics	Hours (P)
A 1-A4	**Seamen and their Duties:** **Sub-Topics:** Ship`s Departments, General ship knowledge, Layout and Nautical terms, Bridge equipment arrangement.	3
B 1-B6	**Navigational Light and signals:** **Sub-Topics:** Navigation lights, Colours, Locations and Visibility. Look-out, precautions in bad weather, Flags-etiquette, Morse and Semaphore signalling, Sound signals.	6
C1-C3	**Rope knots and Moorings:** **Sub-Topics:** Type of knots, Practice of knot formation, Material of ropes. Strength, Care and maintenance, use of mooring line, Heaving line, Rat guards, Canvas and its use.	6
D1-D3	**Anchors:** **Sub-Topics:** Different type of anchors, its uses, Dropping and Weighing anchor, Cable stopper.	3
E1-E5	**Navigation:** **Sub-Topics:** General knowledge of principal stars, Sextant, Navigation Compass, Echo Sounder, Log and uses, Barometer and weather classifications, G.M.T. and zonal time, wireless navigational Instruments, radar satellite-navigation.	5
F1-F7	**Lifeboat and Life rafts:** **Sub-Topics:** Construction, equipment carried, carrying capacity. Davits and its launching operation, Launching of Life rafts (Inflatable type). Embarkation into Life boat and Life raft. Survival pack, Stowage and securing arrangement. Rescue Boat, immersion suit, Thermal protective aid.	6
G1-G5	**Abandon Ship:** **Sub-Topics:** Manning of lifeboat and life raft. Muster list, Radio and alarm signals, Distress Signal (S.O.S.). Distress call time and radio frequency. Pyro-techniques.	6
H1-H3	**Survival at Sea:** **Sub-Topics:** Survival difficulties and factors equipment available, Duties of crew members, initial action on boarding, maintaining the craft.	6
I1-I4	**Introduction of MARPOL:** **Sub-Topics:** Convention and its annexes, Regulatory control towards environmental pollution at sea, Familiarization with SOLAS, STCW conventions, ISPS Code and other maritime codes and conventions, Effect of cargo on human and environment.	4
	Total	**45**

Learning Objectives	P
A. Seamen and Their Duties: **General Learning Objective** Understand the Seamen's routines and duties, ship's organisation and typical nautical terms **Sub-sub topics & SLOs** 1. Ship`s Departments 2. General ship Knowledge. 3. Layout and Nautical terms 4. Bridge & Engine Room equipment arrangement	3
Specific Learning Objectives: **1 Ship`s departments** 1.1 Name the departments on board a merchant ship 1.2 State the ranks of Officers and Ratings in the Deck & Engine Room	
Specific Learning Objectives: **2 General ship Knowledge** 2.1 Know the meaning of most commonly spoken nautical and engineering terms	

Specific Learning Objectives: **3 Layout and Nautical terms** 3.1 Define Poop-Deck, Forecastle, Bridge, Hull Bridge, Monkey island, Superstructure, Accommodation, Cargo Hold, Tanks, Cargo Handling gear cranes, Pumps, Machinery space	
Specific Learning Objectives: **4 Bridge equipment arrangement** 4.1 Define the various Bridge and Engine room equipment & machinery	
B. Navigational Light and signals **General Learning Objective** Understand the different types of Navigation lights & Signals **Sub-sub topics & SLOs** 2.1 Navigation Lights 2.2 Colours, Locations and Visibility 2.3 Look-out, precautions in bad weather 2.4 Flags-etiquette 2.5 Morse and Semaphore signalling 2.6 Sound Signals	6
Specific Learning Objectives: **2.1 Navigation Lights** 2.1.1 Draw a sketch to show the light to be shown by a ship - While vessel is Underway - While vessel is at anchorage	
Specific Learning Objectives: **2.2 Colours** 2.2.1 State the colour, Range and Visibility of various navigational light	
Specific Learning Objectives: **2.3 Look-out, precautions in bad weather** 2.3.1 Understand the importance of Look-out, precautions in bad-weather	
Specific Learning Objectives: **2.4 Flags etiquette** 2.4.1 Define a Flag employed on board 2.4.2 Define use of Flag 2.4.3 State the locations where the flags are hoisted	
Specific Learning Objectives: **2.5 Morse and Semaphore signalling** 2.5.1 Define Morse code 2.5.2 State the uses of Morse code 2.5.3 Define Semaphore	
Specific Learning Objectives: **2.6 Sound Signals** 2.6.1 Define the sound signals under various emergency situations on-board.	

C. Rope knots and Moorings **(IMO 7.04: 3.2.3 (3.14)- p147)** **General Learning Objective** Understand the different types of ropes, knots and its uses **Sub-sub topics & SLOs** 3.1 Ropes 3.2 Knots 3.3 Mooring **Specific Learning Objectives:** **3.1 Ropes** 3.1.1 Explain what are ropes 3.1.2 Explain various types of ropes 3.1.3 List the uses of the ropes 3.1.4 Explain care & maintenance of the ropes **Specific Learning Objectives:** **3.2 Knots** 3.2.1 Understand the types of knots 3.2.2 Practice knot formation **Specific Learning Objectives:** **3.3 Mooring** 3.3.1 Explain Mooring 3.3.2 Describe different types of mooring lines used to moor a ship alongside a jetty 3.3.3 Define a heaving line and its uses 3.3.4 Explain the use of rat-guard 3.3.5 Define the uses of canvases	6
D. Anchors **(IMO 7.04: 4.2.2- (2.4) - p194)** **General Learning Objective** Understand the types and uses of Anchors **Sub-sub topics & SLOs** 4.1 Anchor 4.2 Terms used for anchors 4.3 Safety **Specific Learning Objectives:** **4.1 Anchor** 4.1.1 Define the Anchor 4.1.2 State its uses 4.1.3 Define the various types of anchors **Specific Learning Objectives:** **4.2 Terms used for anchors** 4.2.1 Explain the term 'LET GO' 4.2.2 Explain the term 'Weighing Anchor' **Specific Learning Objectives:** **4.3 Safety** 4.3.1 Explain the function of a Cable Stopper	3

E. Navigation **General Learning Objective** Understand the general Knowledge of the various tools and equipment used for the navigation 5.1 General Knowledge of principal stars 5.2 Navigation equipment 5.3 Navigation: Other Aids 5.4 Time zones 5.5 Navigation instrument	5
Specific Learning Objectives: **5.1 General Knowledge of principal stars** 5.1.1 Explain the principal stars used for navigation	
Specific Learning Objectives: **5.2. Navigation equipment** 5.2.1. Explain the navigational equipment on board 5.2.2. Explain the compasses and its uses 5.2.3. Explain the echo sounder and its uses	
Specific Learning Objectives: **5.3. Navigation: Other Aids** 5.3.1 Explain the log and its uses 5.3.2 Explain the barometer and its uses	
Specific Learning Objectives: **5.4 Time zones** **5.4.1** Explain the Classification of weathers **5.4.2** Explain what is G.M.T. **5.4.3** Explain the zonal time	
Specific Learning Objectives: **5.5 Navigation instrument** 5.5.1 Explain the wireless navigation instruments 5.5.2 Explain the radar and its uses 5.5.3 Explain the satellite navigation	
F. Life boat and Life rafts (IMO 7.04: 4.4.1- p197) **General Learning Objective** Understand the Construction, carrying capacity, arrangements of the life boat & life raft on the ships **Sub-sub topics & SLOs** 1. Construction, equipment carried, carrying capacity 2. Davits and its operation 3. Launching of life raft 4. Embarkation into life boat and life raft 5. Stowage and securing 6. Rescue boat 7. Personal LSA	6
Specific Learning Objectives: **6.1 Construction, equipment carried, carrying capacity** 6.1.1 Explain the construction of the Life boat 6.1.2 State the various equipment carried on life boat 6.1.3 State carrying capacity of the life boat	
Specific Learning Objectives: **6.2 Davits and its operations** 6.2.1 Explain about the Davits 6.2.2 State the types of the Davits	

Specific Learning Objectives: **6.3 Launching of the Life rafts** 6.3.1 Explain the procedure of launching of the life rafts (Inflatable type)	
Specific Learning Objectives: **6.4 Embarkation into life boat and life raft** 6.4.1 Explain about embarkation into the life raft & lifeboat	
Specific Learning Objectives: **6.5 Stowage & securing** 6.5.1 Explain the stowage and securing arrangements on-board	
Specific Learning Objectives: **6.6 Rescue Boat** 6.6.1 Explain about Rescue boat 6.6.2 Explain about its capacity	
Specific Learning Objectives: **6.7 Personal LSA** 6.7.1 Explain about Immersion Suit and its uses 6.7.2 Explain TPA and its uses	
G. Abandon Ship (IMO 7.04: 4.4.1- p197) **General Learning Objective** Understand the emergencies and abandon ship procedures **Sub-sub topics & SLOs** 7.1 Manning of the lifeboat & life raft 7.2 Radio & Alarm signals 7.3 Muster list 7.4 Distress signals (S.O.S.) 7.5 Pyro techniques	6
Specific Learning Objectives: **7.1Manning of the lifeboat & life raft** 7.1.1 Explain about the manning of lifeboat and life raft	
Specific Learning Objectives: **7.2Radio & Alarm signals** 7.2.1 Explain about the radio & alarm signals on-board	
Specific Learning Objectives: **7.3 Muster list** 7.3.1 Explain about the Muster list	
Specific Learning Objectives: **7.4 Distress signals (S.O.S.)** 7.4.1 Explain the distress signals 7.4.2 Understand about the distress call time & radio frequency	
Specific Learning Objectives: **7.5 Pyro Techniques** 7.5.1 Explain about the Pyro Techniques.	

H. Survival at Sea (IMO 7.04: 4.4.2- p197) **General Learning Objective** Understand marine environment & survival techniques **Sub-sub topics & SLOs** 8.1 Survival Difficulties and factors 8.2 Duties of crew members 8.3 Maintaining the crafts	6
Specific Learning Objectives: 8.1 **Survival Difficulties and factors** 8.1.1 Explain the survival difficulties and factors 8.1.2 State the available equipment in survival craft	
Specific Learning Objectives: 8.2 **Duties of crew members** 8.2.1 Explain the duties of crew members 8.2.2 Explain the initial actions to be taken by crew members while boarding on survival craft	
Specific Learning Objectives: 8.3 **Maintaining the crafts** 8.3.1 Explain the maintenance to be carried out on the survival craft	
I. Introduction of MARPOL (IMO 7.04: 4.6.1 (1.3)- p199, 4.6.1 (1.4)- p209, 4.1.1- p173, 4.8- p213) **General Learning Objective** Understand marine environment & marine pollution **Sub-sub topics & SLOs** 9.1 Regulatory control towards environmental pollution at sea 9.2 Familiarisation with SOLAS 9.3 STCW conventions 9.4 ISPS code	4
Specific Learning Objectives: **9.1Regulatory control towards environmental pollution at sea** 9.1.1 Explain the regulatory control towards MARPOL 9.1.2 State various conventions & its annexes 9.1.3 Understand the effect of the cargo on human and environment	
Specific Learning Objectives: **9.2 Familiarisation with SOLAS** 9.2.1 Explain the induction of the SOLAS	
Specific Learning Objectives: **9.3 STCW conventions** 9.3.1 Explain the various conventions of STCW & its conventions	
Specific Learning Objectives: **9.4 ISPS code** 9.4.1 Explain the need of ISPS code & other maritime codes & its conventions	

Subject Name/Code: Marine Workshop (Mechanical) (P)/211

Instructional hours:

Practical	: 60 hours
Total contact hours	: 60 hours
Credits	: 2

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Practical assessment Hands-on skills	: 50%
Viva voce	: 50%

Additional Information on Subject:

1. Relates to STCW Function: Marine Engineering at Operational/Management Level.
2. Prerequisite for this Subject: Basic Workshop Knowledge.

Recommended Text:

1. Workshop Technology Vol-I, S K Hajra Choudhury, Media Promoters & Publishers.
2. Workshop Technology Vol-II, S K Hajra Choudhury, Media Promoters & Publishers.

Reference:

1. B15 - Machine Shop Tools and Operations. R. Miller, 5th Edition, 2004, Wiley publishing. ISBN 0-764-55527-8.
2. A Textbook of Welding Technology by O P Khanna.

Table of Topics

Section	Topics	Hours (P)
A	Safe Measures to be taken to ensure a safe working environment, Safe handling of Hand tools, Machine tools and Measuring Instruments	1
B	Introduction of different hand tools and machine tools, their application	1
C1 -C3	Fitting Work using different hand tools and measuring instruments.	18
D1-D4	Identification and application of different parts and mechanisms of lathe machine, Different cutting tools.	20
E1-E5	Arc & Gas Welding	20
	Total	**60**

Learning Objectives	P
A. Measures to be taken to ensure safe working environment, Safe handling of Hand tools, Machine tools and Measuring Instruments **General Learning Objective {IMO 7.04,2014/3.1.6(6.1) P-136}** Understand Safe working environment, Safe Handling of tools and measuring instruments **Subtopic & SLO** 1.1 Explain Safe working practices while working and using hand tools and machine tools 1.2 Explain Safe working practices while using measuring instruments	1
B. Introduction of different hand tools and machine tools, their application. **General Learning Objective {IMO 7.04,2014/3.1.6(6.3) P-137}** Understand uses of Different hand tools and machine tools and their application **Subtopics: Hand Tools** 1.1 Identify and demonstrate different types of Spanners, Wrenches, Screwdrivers, Nipper, Scrapers, Gear Pullers 1.2 Identify and demonstrate different Cutting Tools and Files - Hacksaws, Chisels, Files 1.3 Identify and demonstrate taps and Die 1.4 Identify and demonstrate different types of Hammers, Punches	1
C. Fitting Work using different hand tools and measuring instruments. **General Learning Objective {IMO 7.04,2014/3.1.6(6.3) (1) P-137}** Understand and select the Correct tools and measuring instruments for performing tasks **Subtopic & SLO** **1.1. Making a Square block from a cylinder block** 1.1.1 Demonstrate safe working practices while using machine tools, marking tools, dot punches and measuring instruments 1.1.2 Identify and select the right tools for carrying out hacksawing operations. 1.1.3 Cut the job as per dimension using hacksaw 1.1.4 Demonstrate correct procedures of filing and Make the desired job as per given dimension 1.1.5 Use correct files to Make a final finishing job as per dimension	6
Subtopic & SLO **1.2 Making a close-fitting task**	6

1.2.1 Demonstrate safe working practices while using machine tools, marking tools and measuring instruments 1.2.2 Identify and select the right tools for carrying out hacksawing operations. 1.2.3 Cut the job as per dimension using hacksaw 1.2.4 Demonstrate drilling and chiselling operation using correct tools	
Subtopic & SLO **1.3 Drilling Machine Operation - Use of Drill bit, Reamer** 1.3.1 Demonstrate safe working practices while using machine tools, marking tools and measuring instruments 1.3.2 Identify and select the right tools for carrying out drilling operations 1.3.3 Demonstrate and select right tools for carrying out reaming operation	6
D. Identify parts & mechanisms of lathe and understand their application, Different types of Cutting Tools Used in lathe operations **General Learning Objective {IMO 7.04,2014/3.1.6(6.3) P-137}** **Subtopics & SLO** 1.1. Safe working practices while working on lathe machine	1
Subtopics & SLO 1.2. Make a step pulley of given size as per given tolerances (facing, turning, centre drilling, drilling, step turning operation) 1.2.1 Demonstrate safe working practices while using lathe machine 1.2.2 Carry out facing operation of a given job 1.2.3 Demonstrate centre drilling and subsequent drilling operation 1.2.4 Demonstrate step turning operation as per given dimension	7
Subtopics & SLO 1.3. Explain Drilling operation on lathe and thread Cutting using tap and dies 1.3.1 Demonstrate safe working practices while using lathe machine 1.3.2 Carry out job setting on lathe machine 1.3.3 Demonstrate facing and centre drilling operation 1.3.4 Demonstrate turning operation as per given dimension 1.3.5 Demonstrate tapping and die operation using taps and dies	6
Subtopics & SLO 1.4. Milling operation – Making square shape 1.4.1 Demonstrate indexing method as per dimension on milling machine 1.4.2 Demonstrate holding of job on job holder 1.4.3 Demonstrate holding of Cutter on the tool post 1.4.4 Set the speed as per desired job	6
E Arc & Gas Welding **General Learning Objective {IMO 7.04,2014/3.1.6(6.3) (4a&c) P-137&139}** **Subtopics & SLO: Safe Working Practices** 1.1. Understand Risk and hazards of Arc Welding and demonstrate Safe working practices while working on welding machines	1
Subtopic & SLO **1.2. Arc welding operation – Striking arc and bead making** 1.2.1 Demonstrate safe working method using arc welding 1.2.2 Demonstrate Arc striking operation on a job 1.2.3 Make the arc length shorter and Demonstrate straight line welding using arc welding method 1.2.4 Demonstrate good bead while performing welding	3
Subtopic & SLO **1.3. Arc welding operation – Butt weld, T- Joint, Lap Joint**	5

1.3.1 Demonstrate safe working method using arc welding 1.3.2 Demonstrate butt welding operation on two work pieces using arc welding 1.3.3 Demonstrate T- Joint welding operation on two work pieces using arc welding 1.3.4 Demonstrate Lap joint welding operation on two work pieces using arc welding	
Subtopic & SLO **1.4. Single V and Double V joint (Without gap)** 1.4.1 Demonstrate safe working method using arc welding 1.4.2 Demonstrate single V and double V operation on two work pieces with groove using arc welding	4
Subtopic & SLO **1.5. Gas welding operation (with filler) and Cutting** **{IMO 7.04,2014/3.1.6(6.3) (4b&4e) P-138&139}** 1.5.1 Demonstrate safe working method using gas welding 1.5.2 Make different flames using gas welding 1.5.3 Demonstrate gas welding operation for making T- Joint using filler material 1.5.4 Demonstrate Cutting operation using gas Cutting technique	5
Subtopic & SLO **1.6 Common weld defects, cause and remedies** **{IMO 7.04,2014/3.1.6(6.3) (4d) P-139}** 1.6.1 Explain the reasons for different weld defects and remedies like blow holes, spatters, slag inclusion, pin hole, blow hole, undercut	2

SEMESTER 3

Subject Name/Code: Basic Control Engineering/301

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Modern Control Engineering; D Roy Choudhury; PHI.
2. Reeds Volume:10, Instrumentation and Control Systems.

Reference:

1. D. A. Taylor, 'Marine Control Practice', Butterworth & Co (Publishers) Ltd.
2. Ogata, K, 'Modern Control Engineering', Pearson Education.
3. Roy Choudhury, D., 'Control System Engineering', PHI.
4. Kuo, B.C., 'Automatic Control System', PHI.

Table of Topics

Section	Topics	Hours (L)
1	Control System	16
2	Measurement of physical Parameter	29
Total		**45**

Learning Objectives	L
A. Control system **General Learning Objective** Understand the basics, types, terminologies and design features of the control system Understand types of the controllers and basic terms related to controllers	**16**
A1. Sub-topic: Basics of Control System (IMO 7.02,2014: F2/1.3) **Sub-subtopics & SLOs** 1.1 Characteristics of control system 1.2 Basic terminologies 1.3 Types of control System 1.4 Open loop and close loop systems	**3**
Specific Learning Objectives: 1.1 **Characteristics of control system** 1.1.1 Define the different characteristics of control system 1.1.2 Explain characteristics like accuracy, precision, sensitivity, hysteresis, bandwidth, repeatability in detail 1.1.3 Explain disturbance	1
Specific Learning Objectives: 1.2 **Basic terminologies** 1.2.1 Explain different signals in a control loop with examples 1.2.2 Explain different instruments in a control loop	0.5
Specific Learning Objectives: 1.3 **Types of control systems** 1.3.1 Explain different types of control system based on different criteria 1.3.2 Explain open loop and close loop system 1.3.3 Explain Linear & non-linear loop system 1.3.4 Explain Analog & digital system 1.3.5 Explain Time variant and time invariant system 1.3.6 Explain the difference between Time variant and time invariant systems 1.3.7 Explain Adaptive control system	0.5
Specific Learning Objectives: 1.4 **Open loop and close loop systems** 1.4.1 Explain advantages and disadvantages of open loop system 1.4.2 Explain advantages and disadvantages of close loop system 1.4.3 Explain types of close loop system 1.4.4 Explain feedback control system 1.4.5 Explain feedforward control system	1
A2. Sub-topic: Mathematical modelling of control system (IMO 7.02,2014: F2/2.1.2.2) **Sub-subtopics & SLOs** 2.1 Introduction to Mathematical modelling for control system 2.2 Mathematical modelling of basic electrical and mechanical systems 2.3 Different reduction techniques	**5**
Specific Learning Objectives: **2.1 Introduction to Mathematical modelling for control system**	1

2.1.1 Explain the Need of Laplace Transform 2.1.2 List the Laplace Formulae 2.1.3 Define Transfer function 2.1.4 Explain generalised form of transfer function 2.1.5 Explain the basic terms like poles, zeros, gain factor, characteristics equation and pole zero plot	
Specific Learning Objectives: **2.2 Mathematical modelling of basic electrical and mechanical systems.** 2.2.1 Explain the transfer function of individual components like L, R, C in electrical circuit 2.2.2 Solve numerical based on transfer function of basic electrical circuits 2.2.3 Explain the transfer function of individual components like M, B, K, J in translational and rotational mechanical systems 2.2.4 Explain force current and force voltage analogy 2.2.5 Write system equations using nodal diagram and free body diagram 2.2.6 Prepare the transfer function for basic translational and rotational mechanical systems	2
Specific Learning Objectives: **2.3 Different reduction techniques**. 2.3.1 Explain basics of block diagram algebra 2.3.2 Find the transfer function of control system using block diagram reduction rules 2.3.3 Explain basics of signal flow graphs 2.3.4 Define Mason's gain formula 2.3.5 Find the transfer function of control system using signal flow graph	2
A3. Sub-topic: Theory of controllers (IMO 7.04, 2014: F2/2.1.3.1, 3.2, 3.3) **Sub-subtopics & SLOs** 3.1 Classification of controllers 3.2 Different lags in the control systems 3.3 Types of controllers based on controller mode. 3.4 PID controllers 3.5 Application on ship using controllers	**8**
Specific Learning Objectives: **3.1 Classification of controllers** 3.1.1 Explain types of controllers based on supply required 3.1.2 Explain types of controllers based on controller mode	1
Specific Learning Objectives: **3.2 Different lags in the control systems** 3.2.1 Explain lags in terms of 'lag because of components' in control loop 3.2.2 Explain controller lag and process lag using graphs 3.2.3 Explain Distance Velocity Lag, Measurement and Transfer Lags, Dead time	1
Specific Learning Objectives: **3.3 Types of controllers based on discontinues controller mode.** 3.3.1 Explain On-off controllers 3.3.2 Explain multi-position controllers 3.3.3 Explain Stacked Type Controllers 3.3.4 Explain Pulse controller	2
Specific Learning Objectives: **3.4 PID controllers** 3.4.1 Explain the basics of time domain specifications 3.4.2 Explain P controller 3.4.3 Explain Effect of KP (proportional gain) on different output characteristics 3.4.4 Explain need of I controller 3.4.5 Explain Effect of KI (integral gain) on different output characteristics 3.4.6 Explain need of D controller 3.4.7 Explain Effect of KD (derivative gain) on different output characteristics	2

3.4.8 Explain Pneumatic PID controller	
Specific Learning Objectives: 3.5 **Application on ship using controllers** 3.5.1 Explain split range control 3.5.2 Explain ratio control 3.5.3 Explain cascade control	2
B. Measurement of Physical Parameters **General Learning Objective** Understand measurement of different physical parameters using sensors and transducers Understand actuators, control valves and other on board equipment	**29**
B1. Sub-topic: Transducers and Transmitters (IMO 7.02,2014: F2/1.3) + (IMO 7.04, 2014: F2/2.1.3.6) **Sub-subtopics & SLOs** 1.1 Classification of transducers 1.2 Different parameter measurement using transducers 1.3 SMART transmitters 1.4 Transmitters	**9**
Specific Learning Objectives: 1.1 Classification of transducers. 1.1.1 Explain analogue and digital transducers 1.1.2 Explain primary and secondary transducers 1.1.3 Explain active and passive transducers 1.1.4 Explain transducers and inverse transducers	1
Specific Learning Objectives: 1.2 Different parameter measurements using transducers 1.2.1 Explain different temperature transducers like RTD (2, 3, 4 wire) thermocouples (cold junction compensation, laws of thermocouple), thermistor 1.2.2 Explain primary sensing devices for pressure measurement 1.2.3 Explain electrical devices for pressure measurement like stain gauge, LVDT, Piezoelectric crystal 1.2.4 Explain flowmeters venture, pitot tube, rotameter, orifice plate, hot wire anemometer 1.2.5 Explain square root extractor 1.2.6 Explain level measurement using pressure gauge, DP transmitter, air bubbler, RADAR method 1.2.7 Explain Photo voltaic, photo conductive and photo electric cells	4
Specific Learning Objectives: 1.3 SMART transmitters 1.3.1 Explain concept of SMART transmitters 1.3.2 Explain working of SMART transmitters 1.3.3 Explain HART Protocol	1
Specific Learning Objectives: 1.4 Transmitters 1.4.1 Explain flapper Nozzle system with negative feedback and its characteristics 1.4.2 Explain the various pneumatic transmitters (Position balance and force balance type), Pneumatic pressure transmitter, Pneumatic DP transmitter, Pneumatic temperature transmitter) 1.4.3 Explain Zero and Span calibration in pneumatic transmitters	3
B 2 Sub-topic: Actuators, control valves and others (IMO 7.04, 2014: F2/3.7,2.1.3.8) **Sub-subtopics & SLOs** 2.1 Different types of actuators 2.2 Positioners 2.3 Valves	**8**
Specific Learning Objectives: **2.1 Different types of actuators**	3

2.1.1 Explain Diaphragm actuators, Direct acting and Reverse acting actuators 2.1.2 Explain piston actuators (Single and Double acting) 2.1.3 Explain the various combinations of pneumatic diaphragm actuator and Valves, Air to open / air to close valves with actuators. Forward/ reverse acting actuators 2.1.4 Explain Electrohydraulic actuators 2.1.5 Explain electric actuators, Electrical Servomotor, and Hydraulic servomotor	
Specific Learning Objectives: **2.2 Positioners** 2.2.1 Explain valve positioner and Volume Booster 2.2.2 Explain Cylindrical valve positioner with zero / span adjustment	2
Specific Learning Objectives: **2.3 Valves** 2.3.1 Explain Control valve characteristics (Linear, quick opening and equal percentage) 2.3.2 Explain Self-acting thermostatic valve 2.3.3 Explain Fail Safe and fail Set Strategies with respect to final control elements 2.3.4 Explain Proportional and servo valves	3
B3 Sub-topic: On board Applications (IMO 7.04, 2014: F2/3.7,2.1.3.8) **Sub-subtopics & SLOs** 3.1 Applications on board ships	**6**
Specific Learning Objectives: 3.1 **Applications on board ships** 3.1.1 Explain Boiler feed water control (single, two and three element types) 3.1.2 Explain Fuel Oil Viscosity Control 3.1.3 Explain the Piston cooling water temperature control system 3.1.4 Explain the Main Engine Lubricating oil temperature control system 3.1.5 Explain the Fuel valve cooling water temperature control 3.1.6 Explain Fresh water Hydrophore system using On-Off controller	6
B4 Sub-topic: Miscellaneous equipment on board ship (IMO 7.04, 2014: F2/3.7,2.1.3.8) **Sub-subtopics & SLOs** 4.1 Different miscellaneous equipment on ship	**6**
Specific Learning Objectives: **4.1 Different miscellaneous equipment on ship** 4.1.1 Explain Fire detection system sensors 4.1.2 Explain the working of flame eye sensor 4.1.3 Explain Oil in water monitor 4.1.4 Explain Echo sounder and Speed log (Pressure tube, Electromagnetic and Doppler log) 4.1.5 Explain Instrument for UMS classification 4.1.6 Explain ICCP system 4.1.7 Explain alarm and monitoring system (Distributed control system) 4.1.8 Explain cargo hold smoke detection system	6

Subject Name: Solid Mechanics/302

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, practical in workshops and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

Pre-requisites: Fundamentals of Mechanics of Machines (Engineering Mechanics).

Recommended Text:

1. Reed Volume 2: Applied Mechanics for Engineers; By William Embleton; Revised by J.T. Gunn; Publisher Sunderland Tyne and Wear) Thomas Reed.1983: ISBN0900335874.
2. Applied Mechanics, J. Hannah and M.J. Hiller, Longman,1998, ISBN:9780582256323.

Reference:

1. Strength of Materials, G. H. Ryder, Macmillan Pub, India.
2. Strength of Materials, Ramamrutham S, Dhanpat Rai Publishing, New Delhi.
3. Strength of Materials, Rajput R.K, S. Chand Publishing, New Delhi.
4. A textbook of Engineering Mechanics by R.S Khurmi, S. Chand Publishing, New Delhi.

Table of Topics

Section	Topics	Hours (L)
A	Materials under the load	07
B	Stress and strain	12
C	Combined stress	10
D	Torsion	09
E	Simple Harmonic motion	07
	Total	**45**

Learning Objectives	L
General Learning Objective: Understand fundamental concepts related to mechanical behaviour of materials under the load, stresses, strains, Strain energy, principle stresses and principle planes, torsional moment and simple harmonic motion **Specific Learning Objectives: (IMO 7.04,2014: 3.1.3.1, IMO 7.02,2014: 1.2.2,1.2.3,1.2.4,1.2.5)** **A. Materials under the load. (IMO 7.04,2014: 3.1.3.1)**	**7**
1.0 Materials under the load. (IMO 7.04,2014: 3.1.3.1) **Specific Learning Objective:** Understand mechanical behaviour of materials under the load	**7**
1.1 Describe three types of loading as: tensile, compressive and shear (IMO 7.04,2014: 3.1.3.1) 1.1.1 Classification of loads	1
1.2 Illustrate with the aid of simple sketch, a material under each of the applied loadings given in the below objectives, using arrows to indicate load and stress and dotted lines to indicate deformation (IMO 7.04,2014: 3.1.3.1) 1.3 Define stress as the internal resistance per unit area of a material to an externally applied load (IMO 7.04,2014: 3.1.3.1) 1.3.1 Definition of stress 1.3.2 Types of stress	1
1.4 Define strain as the deformation produced in a material by an externally applied load **(IMO 7.04,2014: 3.1.3.1)** 1.4.1 Definition of strain 1.4.2 Types of strain	1
1.5 Explain how stress and strain can be calculated in terms of loading and material dimensions, for the cases in the above objectives **(IMO 7.04,2014: 3.1.3.1)** 1.5.1 Principle of superposition 1.5.2 Analysis of bars varying section 1.5.3 Numerical	1

1.6 Define, for an elastic material subjected to a tensile load: elastic limit, yield point, ultimate strength, breaking strength (IMO 7.04,2014: 3.1.3.1) 1.7 Show, on a sketched graph of load to a base of corresponding extension values, the behaviour of elastics materials under tensile loading and indicates the condition points listed above **(IMO 7.04,2014: 3.1.3.1)** 1.7.1 Stress-strain diagram for a ductile material under tension 1.7.2 Define all the terms: • Limit of proportionality • Elastic limit • Upper yield point • Lower yield point • Ultimate strength • Breaking strength 1.8 State the significance in engineering practise of physical properties in the above objective **(IMO 7.04,2014: 3.1.3.1)** 1.8.1 State the significance in engineering practice	2
1.9 State that, within the elastic limit, Hooke's law will apply. (IMO 7.04,2014: 3.1.3.1) 1.10 Define Hooke's Law as stress/strain=a constant. (IMO 7.04,2014: 3.1.3.1) 1.11 Define the constant contained in Hooke's Law as the Modulus of Elasticity **(IMO 7.04,2014: 3.1.3.1)** 1.11.1 Define Elastic constant as Modulus of Elasticity 1.11.2 Define Elastic constant as Modulus of Rigidity 1.11.3 Define Elastic constant as Bulk Modulus 1.11.4 Relationship between Modulus of Elasticity, Modulus of Rigidity and Bulk Modulus 1.11.5 State the significance in engineering practice 1.11.6 Generalized hooks law for tri-axial stress condition	1
B. Stress and strain. (IMO 7.02,2014: 1.2.3) **Specific Learning Objective:** Understanding fundamental concept related to stresses, strains, and Strain energy 1.1 Stress in compound bars 1.2 Thermal Stress 1.3 Elastic Strain energy 1.4 Stresses due to gradually applied and shock load 1.5 Stress and strain relationships in thin cylindrical and spherical shells 1.6 Stress in thin, rotating rims	**12**
1.1 Stress in compound bars (IMO 7.02,2014: 1.2.3) 1.1.1 Analysis of stresses in compound bars 1.1.2 Numerical	1
1.2 Thermal Stress (IMO 7.02,2014: 1.2.3) 1.2.1 Define thermal stresses and strain 1.2.2 Thermal stresses in composite bars 1.2.3 Numerical	2
1.3 Elastic Strain energy (IMO 7.02,2014: 1.2.3) 1.3.1 Concept of Strain energy 1.3.2 Define Resilience, Proof Resilience and Modulus of Resilience	1

1.4 Stresses due to gradually applied and shock load (IMO 7.02,2014: 1.2.3) 1.4.1 Strain energy stored in the member due to gradually applied load 1.4.2 Strain energy stored in the member due to suddenly applied load 1.4.3 Strain energy stored in the member due to impact loads 1.4.4 Strain energy stored in the member due to shock load 1.4.5 Numerical	2
1.5 Stress and strain relationships in thin cylindrical and spherical shells. (IMO 7.02,2014: 1.2.3) 1.5.1 Define a thin cylindrical shell 1.5.2 Failure of thin cylindrical shell due to internal fluid pressure 1.5.3 Assumptions for thin cylindrical shell parameter calculations 1.5.4 Stresses in thin cylindrical shell: Circumferential stress, Longitudinal stress and maximum shear stress	2
1.5.5 Built up cylindrical shell 1.5.6 Change in dimensions of a thin cylindrical shell 1.5.7 Spherical shell subjected to an internal fluid pressure	2
1.6 Stress in thin, rotating rims (IMO 7.02,2014: 1.2.3) 1.6.1 Stress analysis of rotating rim 1.6.2 Stress analysis of thin disc	2
C. Combined stress (IMO 7.02,2014: 1.2.5) **Specific Learning Objective:** Understand fundamental concept of combined stresses in structural element 1.1 Explain Stresses on an oblique plane 1.2 Explain state of a Material subjected to two mutually perpendicular stresses 1.3 Explain Mohr's stress circle, principle stresses and strains	**10**
1.1 Stresses on an oblique plane (IMO 7.02,2014: 1.2.5) 1.1.1 Define complex stress 1.1.2 Define Principal stresses and principal planes 1.1.3 Method for the stresses on an Oblique section of a body: Analytical method and Graphical method (Mohr's Circle method) 1.1.4 Uni-axial State of stress: stresses on an oblique section of a body subjected to direct stress in one plane by analytical method 1.1.5 Numerical	2
1.2 Material subjected to two mutually perpendicular stresses (IMO 7.02,2014: 1.2.5) 1.2.1 Direct stresses in two mutually perpendicular directions by analytical method 1.2.2 Simple shear stress by analytical method 1.2.3 Numerical	2
1.2.4 Direct stress in One Plane & accompanied by a Simple Shear Stress by analytical method 1.2.5 Direct stresses in Two mutually perpendicular Directions Accompanied by a Simple Shear Stress by analytical method 1.2.6 Numerical	2
1.3 Mohr's stress circle, principle stresses and strains (IMO 7.02,2014: 1.2.5) 1.3.1 Define Mohr's circle 1.3.2 Uni-axial State of stress: stresses on an oblique section of a body subjected to direct stress in one plane by Mohr's circle method 1.3.3 Numerical	2

1.3.4 Direct stresses in two mutually perpendicular directions by Mohr's circle method 1.3.5 Direct stress in one Plane & accompanied by a simple Shear Stress by Mohr's circle method 1.3.6 Direct stresses in two mutually perpendicular directions accompanied by a Simple Shear Stress by Mohr's circle method 1.3.7 Numerical	2
D. Torsion (IMO 7.02,2014: 1.2.4) **Specific Learning Objective:** Understand the concept of torsional moment in structural elements 1.1 Explain Stress, strain and Strain energy due to torsion 1.2 Explain Fundamentals torsion equation 1.3 Explain Deflection of Helical Spring 1.4 Explain Reciprocating engine crank effort 1.5 Explain Rudder stock turning moment from steering gear	**9**
1.1 Stress, strain and Strain energy due to torsion (IMO 7.02,2014: 1.2.4) 1.1.1. Define torsional resilience 1.1.2 Derivation on Strain energy due to torsion	1
1.2 Fundamentals torsion equation (IMO 7.02,2014: 1.2.4) 1.2.1 Define torsion of shaft 1.2.2 Assumptions in torsion equation 1.2.3 Derivation on torsion equation 1.2.4 Numerical	2
1.2.5 Comparison of solid and hollow shafts 1.2.6 Shafts are connected in series and parallel 1.2.7 Numerical	2
1.3 Deflection of Helical Spring (IMO 7.02,2014: 1.2.4) 1.3.1 Close-coiled helical spring with Axial load (circular section wire springs) 1.3.2 Numerical	2
1.4 Reciprocating engine crank effort (IMO 7.02,2014: 1.2.4) 1.4.1 Reciprocating engine crank effort	1
1.5 Rudder stock turning moment from steering gear (IMO 7.02,2014: 1.2.4) 1.5.1 Rudder stock turning moment from steering gear	1
E. Simple Harmonic motion (IMO 7.02,2014: 1.2.2) **Specific Learning Objective:** Understand the concept and application of simple harmonic motion 1.1 Define Amplitude, frequency and periodic time 1.2 Define Equation of simple harmonic motion 1.3 Define Springs 1.4 Define Resonance 1.5 Define Transmissibility 1.6 Define Vibration of flywheel and Gearwheels	**7**
1.1 Amplitude, frequency and periodic time. (IMO 7.02,2014: 1.2.2) 1.1.1 Define amplitude, Oscillation, Beat, Periodic time, and Frequency **1.2 Equation of simple harmonic motion (IMO 7.02,2014: 1.2.2)** 1.2.1 General conditions of simple harmonic motion 1.2.2 Velocity and acceleration of a particle moving with Simple harmonic motion 1.2.3 Numerical	1

1.2.4 Maximum Velocity and acceleration of a particle moving with Simple harmonic motion 1.2.5 Numerical	1
1.3 Springs **(IMO 7.02,2014: 1.2.2)** 1.3.1 Derivation of natural frequency of oscillation for helical spring 1.3.2 Numerical	1
1.4 Resonance **(IMO 7.02,2014: 1.2.2)** 1.4.1 Define resonance. 1.4.2 Relation between resonance and stiffness	1
1.5 Transmissibility **(IMO 7.02,2014: 1.2.2)** 1.5.1 Define transmissibility. 1.5.2 Relation between the transmissibility and frequency ratio	1
1.6 Vibration of flywheel and Gearwheels **(IMO 7.02,2014: 1.2.2)** 1.6.1 Natural frequency of free torsional vibrations of flywheel 1.6.2 Free torsional vibration of geared system	2

Subject Name/Code: Fluid Mechanics/303

Instructional hours:

Lecture	: 30 hours
Total contact hours	: 30 hours
Credits	: 2

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, practical in laboratory and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

Pre-requisites: Class 12 Physics, Chemistry, Maths.

Recommended Text:

1. Fluid Mechanics and Hydraulics R K Bansal.
2. Hydraulics and Fluid Mechanics – P. N. Modi and S. M. Seth.

Reference

1. Fluid Mechanics and Hydraulic Machines – R. K. Rajput.
2. Fluid Mechanics (Part 1 and Part 2) – J. F. Douglas.
3. Fluid Mechanics and Hydraulic Machines – R. K. Bansal.
4. Mechanics of Fluids – Bernard Massey and John Ward Smith.
5. Fundamentals of Fluid Mechanics – G. S. Sawhney.

Table of Topics

Section	Topics	Hours (L)
A	**Fluid Properties** A1 – Fluid flow A2 – Dynamic and kinematic viscosity	2
B	**Fluid Pressure** B1 – Properties of pressure B2 – Pressure variation B3 – Pressure measurement	3
C	**Hydrostatics**	2
D	**Hydraulics** D1 – Head of liquid D2 – Flow rate	2
E	**Fluid Flow** E1 – Bernoulli's equation E2 – Venturimeter E3 – Reynolds' number E4 – Flow losses in pipes and fittings E5 – Jets E6 – Orifice coefficients	8
F1	**Centrifugal Pumps** F1 – Pump basics F2 – Pump head and efficiency F3 – Pump operation	5
G1	**Fluid Flow and Characteristics of Major Systems** G1 – Diesel engine propulsion plant G2 – Steam engine propulsion plant G3 – Pipes and fittings G4 - Valves	8
Total		**30**

Learning Objectives	L
General Learning Objective: Understand concepts of fluid mechanics, hydraulic machines and systems	
A. Fluid Properties (Ref: IMO 7.04 Appendix 1 Section 1.4 Page 244) **General Learning Objective:** Understand fluid flow and fluid properties like density, specific gravity, viscosity etc.	
A1. Fluid Flow (Ref: IMO 7.04 Appendix 1 Section 1.4 Page 244) **Specific Learning Objective:** Understand fluid flow, Newtons law of viscosity and fluid density 1.1 Define fluid flow 1.2 State Newtons law of viscosity 1.3 Define Newtonian and Non-Newtonian Fluid 1.4 Define Ideal and Real fluids 1.5 Define mass density, weight density and specific gravity	1
A2. Dynamic and Kinematic Viscosity (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** Understand the fluid property of viscosity 2.1 Explain Definition and equation of dynamic viscosity 2.2 Explain Unit of dynamic viscosity 2.3 Explain Definition and equation of kinematic viscosity 2.4 Explain Unit of kinematic viscosity 2.5 Explain Relation between dynamic and kinematic viscosity 2.6 Explain Effect of temperature on viscosity	1
B. Fluid Pressure (Ref: IMO 7.04 Appendix 1 Section 1.4 Page 244) **General Learning Objective:** Understand pressure exerted by fluid on different surfaces and pressure measurement	
B1. Properties of Pressure (Ref: IMO 7.04 Appendix 1 Section 1.4 Page 244) **Specific Learning Objective:** Understand fluid pressure, its unit and types 1.1 Define pressure, i.e., force (newtons) / area (metres^2) 1.2 State that the unit of pressure is the pascal (Pa) 1.3 State that a practical unit of pressure is 10^5 Newton/m^2 and is 1 bar 1.4 State that atmospheric pressure is approximately 1 bar 1.5 Solve problems involving force, area and pressure 1.6 Explain in simple terms what is meant by: atmospheric pressure, vacuum, partial vacuum, absolute zero pressure, gauge pressure 1.7 Convert between absolute and gauge pressure	1
B2. Pressure Variation (Ref: IMO 7.04 Appendix 1 Section 1.4 Page 244) **Specific Learning Objective:** Understand variation of fluid pressure with height 2.1 State that the pressure at any level in a fluid is equal in all directions (Pascal's law) 2.2 State that pressure acts in a direction normal to a surface 2.3 State that the pressure at any level in a liquid depends upon the vertical height to the liquid surface (its head) and the density of the liquid 2.4 solve simple problems involving 9.8 × head × density	1
B3 Pressure Measurement (Ref: IMO 7.04 Appendix 1 Section 1.4 Page 244) **Specific Learning Objective:** Understand working of different pressure measuring devices 3.1. Differentiate between manometer and mechanical gauges 3.2. Construction and working of piezometer with simple diagram 3.3. Construction and working of manometer with simple diagram 3.4. Construction and working of simple barometer with simple diagram 3.5. Construction and working of bourdon pressure gauge with simple diagram	1
C. Hydrostatics (Ref: IMO 7.04 Appendix 4 Section 1.3 page 255) **General Learning Objective:** Understand pressure exerted by fluid on different surfaces 1.1 State the formulae for the pressure exerted by a liquid at any given vertical depth 1.2 Deduce the equation F = 9.81 × head × density × area, to give the force on the surfaces of a rectangular tank when filled with liquid 1.3 Define the effect of 'sounding pipes', 'air release pipes' or other 'standpipes' when containing liquid 1.4 Define Simple numerical calculations related to the elements in the above objectives 1.5 Study design and working of a hydraulic lifting machine	2
D. Hydraulics (Ref: IMO 7.04 Appendix 4 Section 1.4 Page 255) **General learning objective:** Understand (a) different energies stored in a liquid when in motion as potential energy, pressure energy and kinetic energy and (b) mass and volume flow rate	

D1. Head of Liquid (Ref: IMO 7.04 Appendix 4 Section 1.4 Page 255) **Specific learning objective:** Understand different heads in fluid flow 1.1. Define the 'head of a liquid' 1.2. State the energy components in a moving liquid in terms of its head as potential head, kinetic head and pressure head	1
D2. Flow Rate (Ref: IMO 7.04 Appendix 4 Section 1.4 Page 255) **Specific learning objective:** Understand flow rate and continuity equation 2.1. State the expression to give the volumetric flow of liquid as velocity × cross-sectional area, measured in m3/second 2.2. State the expression to give the mass flow of liquid as its velocity × cross-sectional area × density, measured in kilogram/second 2.3. State and derive continuity equation 2.4. Simple problems concerning the above objectives	1
E. Fluid Flow (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **General Learning Objective:** Understand loss of energy in fluid flow due to major and minor losses	
E1. Bernoulli's equation (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** Understand Bernoulli's equation 1.1. Explain Statement and derivation of Bernoulli's equation 1.2. Explain Assumptions made in Bernoulli equation 1.3. Explain Bernoulli's equation for ideal and real fluids 1.4. Explain Determine direction of flow and losses occurring in flow 1.5. Explain Simple numerical based on Bernoulli's equation	2
E2. Venturi meter (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** Understand working of a venturimeter 2.1. Explain Working principle of venturi meter 2.2. Explain Derive equation of coefficients of discharge 2.3. Explain Venturi meter in horizontal vertical and inclined position	1
E3. Reynolds' number (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** Understand Reynolds' number and classify laminar and turbulent flow 3.1. Definition of Reynolds' number 3.2. Derivation of Reynolds' number 3.3. Determine laminar and turbulent flow from Reynolds' number 3.4. Determine friction coefficient from Reynolds' number	1
E4. Flow losses in pipes and fittings (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** Understand major and minor losses occurring in fluid flow 4.1. Explain Major loss and minor losses 4.2. Explain Frictional loss in flow through pipes 4.3. Explain Darcy's formula for frictional loss in pipes 4.4. Explain Loss due to sudden expansion 4.5. Explain Loss due to sudden contraction 4.6. Explain Entry and exit loss 4.7. Explain Other minor losses due to fittings, obstruction, bends etc. 4.8. Explain Simple numerical exercises on flow through pipes considering major and minor losses	2
E5. Jets (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) 5.1. Describe Force exerted by jet on stationary and moving flat plates 5.2. Describe Force exerted by jet on stationary and moving curved plates 5.3. Describe Simple numerical exercises on force exerted by jets	1
E6. Orifice coefficients (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) 6.1. Determine Orifice and orifice meter 6.2. Determine Coefficient of discharge 6.3. Determine Coefficient of contraction 6.4. Determine Coefficient of velocity	1
F. Centrifugal pumps (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **General Learning Objective:** Understand centrifugal pump	
F1. Pump Basics (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** Understand construction and working of centrifugal pumps 1.1. Working principle of centrifugal pump 1.2. Classification of centrifugal pump 1.3. Construction and working of centrifugal pump	1

F2. Pump Head and Efficiency (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** Understand different heads and efficiency of centrifugal pumps 2.1. Define Work done by impeller 2.2. Define Inlet and outlet velocity triangles 2.3. Define Suction head, delivery head, Euler head and manometric head 2.4. Define Volumetric efficiency, hydraulic efficiency, mechanical efficiency and overall efficiency 2.5. Define Simple numerical on efficiency of centrifugal pump	2
F3 Pump Operations (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** Understand cavitation in a centrifugal pump 3.1. Explain Priming of centrifugal pump 3.2. Explain Minimum speed for starting centrifugal pump 3.3. Explain Net positive suction head 3.4. Explain Cavitation in centrifugal pump 3.5. Explain Pump characteristics curve	2
G. Fluid flow and characteristics of major systems (Ref: IMO 7.04 Competence 1.4 Section 1.9 Page 54-55) **General Learning Objective:** Understand the working of different components of major systems like diesel engine propulsion plant, steam turbine propulsion plant such as valves, piping etc.	
G1. Diesel Engine Propulsion Plant (Ref: IMO 7.04 Competence 1.4 Section 1.9 Page 54-55) **Specific Learning Objective:** Demonstrate knowledge and working of different components of diesel engine propulsion plant 1.1. Describe fluid flow of fuel oil system 1.2. Describe fluid flow of lubricating oil system 1.3. Describe fluid flow of cooling freshwater system 1.4. Describe fluid flows of cooling sea water system	1
G2. Steam Engine Propulsion Plant (Ref: IMO 7.04 Competence 1.4 Section 1.9 Page 54-55) **Specific Learning Objective:** Understand the working of different components of a steam engine propulsion plant 2.1. Describe fluid flows of main steam 2.2. Describe fluid flow of condensate water and feed water 2.3. Describe fluid flow of lubricating oil	1
G3. Pipes and Fittings (Ref: IMO 7.04 Competence 1.4 Section 1.9 Page 54-55) **Specific Learning Objective:** Understand different types of pipes and fittings 3.1. Describe what sorts of fittings are used to construct each plant system taking examples such as various types of valves, piping, pressure regulator and the like	1
3.2. Describe characteristics appeared in each piping system taking examples such as supplementary devices/piping, pipe colouring and location of equipment/installations	1
3.3. Describe the means by which lengths of pipe are joined together, naming the materials used to seal joints for: steam pipes, seawater pipes, the fire main bilge and ballast pipes, starting air pipes, control air pipes 3.4. Explain how pipes are supported to reduce vibration 3.5. Explain how expansion and contraction of pipes is catered for 3.6 Name the materials used for the construction pipes carrying the fluids listed in the above objective 3.7. Explain how pipelines are blanked off	1
G4. Valves (Ref: IMO 7.04 Competence 1.4 Section 1.9 Page 54-55) **Specific Learning Objective:** Understand different types of valves 4.1. Describe the principal construction of a cock and materials generally used 4.2. Explain how the arrangement of ports in the plug is displayed 4.3. Describe the main features of a globe valve 4.4. Explain the difference between a screw-lift valve, a screw-down non-return valve and a non-return valve	1
4.5. Describe the main features of a gate valve 4.6. Describe a typical relief valve 4.7. List and describe the applications of quick-closing valve 4.8. Describe the main features of a quick-closing valve	1
4.9. Make a single line sketch of a change-over sea chest 4.10. Explain the purpose and applications of change-over sea chests 4.11. Describe the main features of a mud box	1

Subject Name/Code: Applied Thermodynamics/304

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. McConkey, A., Eastop, T. D. (1983). Applied Thermodynamics for Engineering Technologist: SI Units. United Kingdom: Longman.

Reference:

1. Çengel, Y.A., Boles. (2014). Thermodynamics: An Engineering Approach. India: McGraw Hill Education.
2. Pulkrabek, W. W. (1997). Engineering fundamentals of the internal combustion engine. United Kingdom: Prentice Hall.
3. Van Ness, H. C., Abbott, M. M., Smith, J. M. (1996). Introduction to chemical engineering thermodynamics. Colombia: McGraw Hill.
4. Anderson, J. D. (1982). Modern compressible flow: with historical perspective. United Kingdom: McGraw Hill.
5. Marine Engineering. (1992). United State: Society of Naval Architects and Marine Engineers. Roy L Harrington Editor.

Books that can be referred to on internet (Free sources):

1. Keenan, J.H., Hatsopoulos, G.N. (1965). Principles of general thermodynamics. United Kingdom: Wiley. - www.archive.org
2. Karamchandani, C.J., Patel, R.C.(1963).Elements of Heat Engines.(n.p.):Acharya Book Depot [1962-63, vol 1 - 3 - http://thermodynamicsheatengines.com/downloads.html
3. The Dynamics and Thermodynamics of Compressible Fluid Flow. (1953). United State: Ronald Press. Vols I and II - www.archive.org

Table of Topics

Section	Topics	Hours (L)
A	Gas Power Cycles	10
B	Reciprocating Compressors	4
C	Vapour and Combined Power Cycles	6
D	Thermodynamic Property Relations	4
E	Gas Mixtures and Solutions	8
F	Phase Equilibrium	6
G	Compressible Flow	7
Total		**45**

Learning Objectives	L : P
General Learning Objective: Understand theoretical concepts related to analysis of Internal Combustion Engines, Vapour power cycles used in steam plants, combined power plants and reciprocating air compressors.	
A Gas power cycles (IMO 7.02,2014: F1/1.1.7.4, 1.2.1, 1.2.4.1, 1.2.4.3, 1.3.3) (IMO 7.04,2014: 1.4.1.1, 1.4.1.3,) **Specific Learning Objectives** 1. Evaluate the performance of gas power cycles for which the working fluid remains a gas throughout the entire cycle 2. Develop simplifying assumptions applicable to gas power cycles 3. Review the operation of reciprocating engines 4. Analyse both closed and open gas power cycles 5. Solve problems based on the Otto, Diesel, Stirling, and Ericsson cycles 6. Solve problems based on the Brayton cycle; the Brayton cycle with regeneration; and the Brayton cycle with intercooling, reheating, and regeneration 7. Analyse jet-propulsion cycles Perform second-law analysis of gas power cycles 8. Explain the following: - Basic considerations in the analysis of power cycles - The Carnot cycle and its general interpretations - Air standard and cold air standard assumptions, Air standard cycles. Basic Engine cycles – Four Stroke SI and CI Engine, Two stroke SI and CI Engine - Operating characteristics: Engine parameters, work, indicator diagrams, indicated power, brake power. Mean effective pressure, Torque and power, Dynamometers, A/F Ratio and F/A Ratio, Specific fuel consumption, Engine efficiencies, Volumetric efficiency, Specific Emissions - Engine cycles – Otto cycle, Real Air – Fuel Engine Cycles, Exhaust process, Diesel Cycle, Dual Cycle, Comparison of Otto, Diesel and Dual Cycles - Miller Cycle, Comparison of Miller Cycle and Otto Cycle, Two – Stroke Cycles, Stirling and Ericsson Cycles - Brayton cycle and modifications for improving its efficiency such as Regeneration, Intercooling and Reheating and deviations from ideal cycles	10: 0
B Reciprocating Air Compressors **(IMO 7.02,2014: F1/1.2.1.1, 1.3.3.11) (IMO 7.04,2014: 1.4.1.6)** **Specific Learning Objectives:** 1. Describe working of various types of reciprocating and rotary Compressors with performance calculations of positive displacement compressors, calculation of efficiency, reducing work in compression, effect of multistage and intercooling and understanding the technical specifications for	4 : 0

reciprocating compressor 2. Describe the following: - Positive displacement compressor – reciprocating type, terminology - Ideal P-v diagram and work input calculations, indicated power - Actual indicator diagram - Free Air Delivery (FAD), Volumetric efficiency, Effects of discharge pressure on volumetric efficiency - Multi-staging and two stage compression P-v diagrams, effect of intercooling on the compression work - Steady flow analysis work	
C Vapour and combined cycles **(IMO 7.02,2014: F1/1.1.7.4, 1.2.1.1, 1.2.4.2, 1.3.3) (IMO 7.04,2014: 1.1.1, 1.1.3, 1.4.1.2)** **Specific Learning Objectives:** 1. Analyse vapour power cycles in which the working fluid is alternately vaporized and condensed. Investigate ways to modify the basic Rankine vapour power cycle to increase the cycle thermal efficiency. Analyse the reheat and regenerative vapour power cycles 2. Perform second-law analysis of vapour power cycles 3. Analyse power generation coupled with process heating, called cogeneration 4. Analyse power cycles that consist of two separate cycles known as combined cycles 5. Analyse the following: - The Carnot vapour cycle - Rankine cycle – ideal, real, Methods to improve efficiency such as employing vacuum condenser, superheating of inlet steam, increasing boiler pressure, Reheat and Regenerative Rankine cycles - Combined steam and gas cycles	6 : 0
D Thermodynamic Property Relationships **(IMO 7.02,2014: F1/1.2.1.1) (IMO 7.04,2014: 1.1.1, 1.1.3, 3.1)** **Specific Learning Objectives:** 1. Develop fundamental relations between commonly encountered thermodynamic properties and express the properties that cannot be measured directly in terms of easily measurable properties 2. Develop the Maxwell relations, which form the basis for many thermodynamic relations 3. Develop the Clapeyron equation and determine the enthalpy of vaporization from P, v, and T measurements alone. Develop general relations for c v, c p, du, dh, and ds that are valid for all pure substances 4. Discuss the Joule-Thomson coefficient 5. Develop a method of evaluating the Δ h, Δ u, and Δ s of real gases through the use of generalized enthalpy and entropy departure charts 6. Explain the following: - The Maxwell relations - The Clapeyron equation - General relationships for du, dh, cv and cp - The Joule-Thomson Coefficient - The Dh, Du, and Ds of Real gases	4 : 0
E Gas Mixtures and Solutions **(IMO 7.02,2014: F1/1.2.1.1) IMO 7.04,2014: F1/1.4.1.6, 1.4.3.4) IGF Code / Fuels** **Specific Learning Objectives:** 1. Develop rules for determining non-reacting gas mixture properties from knowledge of mixture composition and the properties of the individual components 2. Define the quantities used to describe the composition of a mixture, such as mass fraction, mole fraction, and volume fraction 3. Apply the rules for determining mixture properties of ideal-gas mixtures and real-gas mixtures 4. Predict the P-v-T behaviour of gas mixtures based on Dalton's law of additive pressures and Amagat's law of additive volumes 5. Describe the following: - Measures of Composition of a Gas Mixture: Mass and Mole fractions	8 : 0

- P-v-T behaviour of gas mixtures: Ideal and Real Gases - Properties of Gas Mixtures: Ideal and Real Gases - Fundamental Property Relation - The chemical potential and equilibrium - Partial properties and Ideal gas state mixture model - Fugacity and Fugacity coefficient: pure species and species in solution - Generalized correlations for the fugacity coefficient - The ideal solution model - Property changes of mixing	
F Phase Equilibrium: IMO 7.02,2014: F1/1.2.1.1) IMO 7.04,2014: F1/1.4.1.6, 1.4.3.4) IGF Code / Fuels **Specific Learning Objectives:** 1. Develop the equilibrium criterion for reacting systems based on the second law of thermodynamics. Develop a general criterion for chemical equilibrium applicable to any reacting system based on minimizing the Gibbs function for the system 2. Define and evaluate the chemical equilibrium constant 3. Apply the general criterion for chemical equilibrium analysis to reacting ideal-gas mixtures 4. Apply the general criterion for chemical equilibrium analysis to simultaneous reactions 5. Relate the chemical equilibrium constant to the enthalpy of reaction 6. Establish the phase equilibrium for non-reacting systems in terms of the specific Gibbs function of the phases of a pure substance 7. Apply the Gibbs phase rule to determine the number of independent variables associated with a multicomponent, multiphase system 8. Apply Henry's law and Raoult's law for gases dissolved in liquids 9. Explain the following: - The nature of equilibrium - The phase rule and Duhem's theorem - Vapour – Liquid equilibrium qualitative behaviour - Equilibrium and Phase Stability - Raoult's Law, Modified Raoult's Law and Henry's Law - Correlations for Liquid phase activity coefficients	6 : 0
G Compressible Flow: IMO 7.02,2014: F1/1.2.4.2, 1.2.4.3, 1,2,2) **Specific Learning Objectives:** 1. Develop the general relations for compressible flows encountered when gases flow at high speeds. Introduce the concepts of stagnation state, speed of sound, and Mach number for a compressible fluid. Develop the relationships between the static and stagnation fluid properties for isentropic flows of ideal gases 2. Derive the relationships between the static and stagnation fluid properties as functions of specific-heat ratios and Mach number 3. Derive the effects of area changes for one-dimensional isentropic subsonic and supersonic flows. Solve problems of isentropic flow through converging and converging–diverging nozzles. 4. Discuss the shock wave and the variation of flow properties across the shock wave **5.** Develop the concept of duct flow with heat transfer and negligible friction known as Rayleigh flow 6. Examine the operation of steam nozzles commonly used in steam turbines 7. Explain the following: - Definition of compressible flow, flow regimes, - Conservation equations for inviscid flows – mass, momentum and energy equations – (Integral forms) - One dimensional isentropic flow - Speed of sound and Mach number - Stagnation Properties - Different type of nozzles, dependency of cross sectional areas on thermodynamic properties - Isentropic flow through nozzles – gas and steam, critical pressure, choked condition, mass flow rate relationships, variation of cross sectional areas for nozzles and diffusers	7 : 0

Subject Name/Code: Statistics and Data Analysis Using Python and R/305

Instructional hours:

Lecture	: 30 hours
Tutorial	: 15 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisites: Class 10, + 1 and +2 scheme (MPC Group) / Mathematics – I & II.
2. Suitable Courses will be identified from NPTEL (Sway am) for further upgradation and may be offered under Micro-Credit Electives etc.

Recommended Text:

1. A byte of Python by C H Swaroop https://python.swaroopch.com/.
2. Introduction to Statistics by David Lane https://open.umn.edu/opentextbooks/textbooks/459.
3. Introduction to R by W.N. Venables, D.M. Smith, et.al https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf.

Reference:

1. Python Documentation : https://docs.python.org/3/.
2. Python Data Science Handbook by Jake Vander Plas https://jakevdp.github.io/PythonDataScienceHandbook/.
3. Adler. (2012). R in a Nutshell: A Desktop Quick Reference. United State: O'Reilly Media.
4. McKinney. (2013). Python for Data Analysis. Taiwan: O'Reilly Media, Incorporated.
5. Ripley, B. D., Venables, W. N. (1997). Modern Applied Statistics with S-PLUS. Springer Science Business Media New York.

Table of Topics

Section	Topics	Hours (L:T)
A	**Python Programming** A1 – Introduction to Python A2 – Python Basics A3 – Control Flow A4 – Functions A5 – Data Structures A6 – Modules A7 – File Handling	9: 7
B	**Data Analysis** B1 – Introduction to Data Analysis B2 – Data measurement B3 – Central Tendency B4 – Dispersion B5 – Measures of Shapes	8: 0
C	**Python for Data Analysis** C1 – NumPy C2 – Reading Data with Pandas C3 – Pandas Data frames C4 – Data Pre-processing C5 – Exploratory Data Analysis C6 - Data Visualization C7 – Case Study on Exploratory Data Analysis	11:7
D	**Introduction to R Programming** D1 – Introduction D2 - Vectors	2:1
	TOTAL	**30:15**

Learning Objectives	L: T
A. Python Programming **General Learning Objective:** Understand and demonstrate writing and executing Python programs.	
A1. Introduction to Python **Specific Learning Objectives:** Demonstrate knowledge and understanding of Python language and its installation. 1.1. Characteristics of Python 1.2. Installing Python 1.3. Documentation and help 1.4. Python standard Library 1.5. Installing packages 1.6. Python interpreter/IDLE 1.7. Python IDE examples – I python, PyCharm, Jupyter, Spyder etc.	1:0
1.8. Tutorial on following exercises - installing Python - installing Python packages - exploring python interpreter/ IDLE - exploring various python IDE like Jupyter, PyCharm etc. - accessing Python documentation and help files	0:1
A2. Python Basics **Specific Learning Objectives:** Demonstrate knowledge and understanding of Python syntax, input and output.	1:0

2.1. basic input and output 2.2. syntax, keywords 2.3. writing and running program 2.4. variables and data types 2.5. operators and expressions	
A3. Control Flow **Specific Learning Objectives:** Demonstrate knowledge and understanding of conditions and loops used in Python. 3.1. If statements 3.2. while statement 3.3. for statements 3.4. range function 3.5. break and continue statements 3.6. pass statement	1:0
3.7. programming exercise on control flow	0:1
A4. Functions **Specific Learning Objectives:** Demonstrate knowledge and understanding of defining and implementing functions in Python. 4.1. defining function 4.2. function parameters/arguments 4.3. docstring 4.4. local and global variables 4.5. return statement	1:0
4.6. programming exercise on functions	0:1
A5. Data Structures **Specific Learning Objectives:** Demonstrate knowledge and understanding of Python data structures. 5.1. Lists 5.2. Tuples 5.3. Sets 5.4. Dictionaries 5.5. Sequences 5.6. array 5.7. sequence data type operations – initialization, indexing, slicing, concatenation, multiplication, methods	3:0
5.8. programming exercise on strings, list, tuples, dictionary	0:2
A6. Modules **Specific Learning Objectives:** Demonstrate knowledge and understanding of using modules in Python. 6.1. use of modules 6.2. import statements 6.3. accessing module variables and functions 6.4. Python standard modules e, g, os, sys 6.5. dir function	1:0
6.6. programming exercise on modules	0:1
A7. File Handling **Specific Learning Objectives:** Demonstrate knowledge and understanding of file handling operations in Python. 7.1. open and close file 7.2. read, write and append mode	1:0
7.3. programming exercise on file handling	0:1
B. Data Analysis **General Learning Objective:** Demonstrate knowledge and understanding of basic statistical concepts useful for exploratory data analysis.	
B1. Introduction to Data Analysis	1:0

Specific Learning Objectives: Demonstrate knowledge and understanding of data analysis and its role in industry. 1.1. Explain what is data analysis 1.2. data and its importance 1.3. data sources 1.4. data products 1.5. data analysis vs data analytics	
B2: Data Measurement **Specific Learning Objectives:** Demonstrate knowledge and understanding of data measurement levels. 2.1. categorical and numerical data 2.2. discrete and continuous data 2.3. levels of data measurement – nominal, ordinal, interval , ratio	1:0
B3: Central Tendency **Specific Learning Objectives:** Demonstrate knowledge and understanding of determining central tendency in a given data set. 3.1. Arithmetic mean 3.2. population mean and sample mean 3.3. mean of grouped data 3.4. weighted average 3.5. median 3.6. median of grouped data 3.7. mode 3.8. mode of grouped data 3.9. percentile 3.10. calculation of p th percentile location e.g., 90^{th} percentile, 50^{th} percentile etc. Note: Simple numerical on determining mean, median, mode and percentile	2:0
B4: Dispersion **Specific Learning Objectives:** Demonstrate knowledge and understanding of determining dispersion in a given data set. 4.1. Variability 4.2. range 4.3. quartiles 4.4. interquartile range 4.5. deviation from the mean 4.6. mean absolute deviation 4.7. population variance 4.8. population standard deviation 4.9. sample variance 4.10. sample standard deviation 4.11. uses of standard deviation Note: simple numerical on above topics using data set comprising 5-6 numbers	2:0
B5: Measures of shapes **Specific Learning Objectives:** Demonstrate knowledge and understanding of visualizing skewness in a given data set. 5.1. Skewness 5.2. coefficient of skewness 5.3. Kurtosis – Leptokurtic, Mesokurtic, Platykurtic 5.4. box and whisker plots	1:0
B6. Data Analysis Tools **Specific Learning Objectives:** Demonstrate knowledge and understanding of tools used in industry to perform data analysis.	1:0

6.1. examples – MS Excel, Python, R, SAS, SPSS, tableau, Hadoop etc. 6.2. suitability of Python for data analysis 6.3. Python data analysis libraries – NumPy, pandas, matplotlib etc.	
C. Python for Data Analysis **General Learning Objective:** Demonstrate knowledge and understanding of using Python as a tool for data analysis.	
C1. NumPy **Specific Learning Objectives:** Demonstrate knowledge and understanding of handling arrays using Python's NumPy library. 1.1. NumPy array 1.2. creation of array 1.3. NumPy array attributes – ndim, shape, item size etc. 1.4. Arithmetic operations – addition, subtraction, multiplication, division	1:0
1.5. programming exercise on NumPy array	0:1
C2. Reading data with Pandas **Specific Learning Objectives:** Demonstrate knowledge and understanding of importing and reading data using Python's Pandas library. 2.2. Pandas library 2.2. file formats for storing data – csv, xlsx, json, txt, xml etc. 2.3. importing csv data with pandas 2.4. importing spreadsheet data with pandas 2.5. importing txt data with pandas	1:0
C3. Pandas Data frames **Specific Learning Objectives:** Demonstrate knowledge and understanding of Pandas data frames and its methods. 3.1. Data frames 3.2. data attributes – index, columns, size, shape, dimensions etc. 3.3. indexing and selecting data	1:0
3.4. datatypes – numeric, character 3.4. datatype of each column 3.5. unique data type count 3.6. data selection based on datatype 3.7. data frame summary 3.8. format of each column 3.9. unique elements of column	2:0
3.10. programming exercise on Pandas data frames	0:1
C4. Data pre-processing (Pandas) **Specific Learning Objectives:** Demonstrate knowledge and understanding of performing pre-processing operations on data for data analysis. 4.1. converting variables data type 4.2. object and category data type 4.3. cleaning columns 4.4. detect missing values 4.5. count of missing values 4.6. filling missing values in case of numerical variables 4.7. filling missing values in case of categorical variables	2:0
C5. Exploratory Data Analysis (Pandas) **Specific Learning Objectives:** Demonstrate knowledge and understanding of basic exploratory data analysis. 5.1. Frequency tables 5.2. Two way tables 5.3. joint probability 5.4. marginal probability 5.5. conditional probability 5.6. Correlation	2:0
5.7. Programming exercise on exploratory data analysis	0:1

C6. Data Visualization (Matplotlib and seaborn) **Specific Learning Objectives:** Demonstrate knowledge and understanding of visualizing data by using plots. 6.1. Explain what is data visualisation 6.1. plotting libraries – matplotlib, seaborn, ggplot, etc. 6.2. matplotlib and seaborn 6.3. scatterplot 6.4. histogram 6.5. bar plots 6.6. box and whiskers plot 6.7 pairwise plots	2:0
6.8. programming exercise on data visualization	0:1
C7. Case Study **Specific Learning Objectives:** To apply data analysis concepts of this course on an industry relevant data set. Perform exploratory data analysis on a given data set – obtain industry relevant data set - perform pre-processing operations on data set - perform exploratory data analysis and derive useful business/decision making insights using frequency, correlation, probability etc. - visualize results with user friendly plots - Make report	0:3
D. Introduction to R Programming **General Learning Objective:** To obtain a preliminary introduction of R programming.	
D1. Introduction **Specific Learning Objectives:** Demonstrate knowledge and understanding of executing R programming commands. 1.1. overview of R programming 1.2. R and statistics 1.3. installing R 1.4. Executing commands	1:0
D2. Vectors **Specific Learning Objectives:** Demonstrate knowledge and understanding of R programming vectors. 2.1. Vector assignment 2.2. Vector arithmetic 2.3. arithmetic functions – e.g., max, min, sin, cos, tan, log, exp, range, length, sum, prod, sort etc. 2.4. generating regular sequences 2.5. logical vectors 2.6. character vectors 2.7. index vectors	1:0
2.8. programming exercise on vector operations	0:1

Subject Name/Code: Marine Machinery Systems/306

Instructional hours:

Lecture	: 45 hours
Tutorial	: 15 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Marine Auxiliary machinery; H.D. McGeorge.
2. Basic Marine Engineering; J.K. Dhar.

Reference:

1. Marine Engineering Practice; IMEI Publication.
2. General Engineering Knowledge for Marine Engineers-Reeds Volume 8.
3. Marine Machineries-Operation & Maintenance- T.B. Srinivasan, IMEI Publication.
4. The Running &. Maintenance of Marine Machinery-J. Cowley by IMEI Publication.

Table of Topics

Section	Topics	Hours (L:T)
A1-A2	**Engine Room Layout** **Sub-Topics:** Layout of main & auxiliary machinery in engine room in different ships.	2:0
B1-B4	**Engine Room Piping Layout** **Sub-Topics:** Layout and arrangement of important Pipe lines in Engine Room with fittings and its materials of construction. (e.g., Systems: Steam, Bilge, Ballast, Sea water, Fire Fighting systems etc. Fresh water / Sea water Hydrophore systems, distilled water, Drinking water systems and their filling lines). Colour codes and other symbols used to identify pipelines.	8:0
C1-C2	**Bunker & Oil Transfer** **Sub Topics:** Standard practice followed for Bunkering fuels including sampling & spill containment system; sludge discharge to shore reception & other oil transfer procedures.	3:0
D1-D3	**Filters** **Sub Topics:** Strainers & filters, type of marine filters. different types of filter materials, auto clean & duplex filters, static filter, magnetic filter, micro filters. Priming & core maintenance of filters.	5:1
E1-E3	**Pumps** **Sub Topics:** Types of pumps for various requirements, their characteristics and application in ships. Centrifugal Pumps, Gear Pumps, Screw Pumps & Reciprocating pumps. Care and maintenance of pumps. Automation of pumps & pumping systems.	7:4
F1-F2	**Air Compressors** **Sub Topics:** Operation & Constructional details of Compressors used on board ships. Uses of Compressed Air. Air battles, construction, mountings, compressor safeties & associated systems.	6:3
G1-G5	**Evaporators** **Sub Topics:** Construction & Operation of different types of Evaporators & maintenance. Fresh water Generators distillers. Reverse Osmosis process, Conditioning arrangements of distilled water for drinking purpose.	5:1
H1-H6	**Oil Purification** **Sub Topics:** Theory of oil purifications, various methods of oil purifications, use of settling/service tanks & precautions taken before entering/cleaning tanks. Principles of operation & construction of different Centrifuges for heavy fuel and lubricating oil such as self-de-sludging & ALCAP system.	6:5
I1-I2	**Other Shipboard Machineries** **Sub Topics:** Different types of ship stabilizer. Bow Thrusters, Hull protection arrangements & Marine Growth Protection System.	3:1
	Total	**45:15**

Learning Objectives	L: T
A. Engine Room Layout	
General Learning Objectives Understand/familiarize with machinery layout at various platforms in various kinds of ships engine room.	
A1 Sub-topic: Various types of Merchant ship & propulsion **Subtopics & SLOs** 1.1. Describe the various types of merchant ships and explain various types of propulsion on merchant vessels	1:0
A2 Sub-topic: Layout of various machineries on different platforms **Subtopics & SLOs** 2.1. Explain the layout of various machineries on different platforms in engine room 2.2. Explain layouts with reasons for their locations 2.3. Explain the purpose of fitting various components, their mountings and maintenance procedures 2.4. Explain purpose and location of emergency bilge suction, emergency fire pump, its suction valve, SW pumps , SW overboard, high sea suction chest and Low sea suction chest, mountings and their purpose	1:0
B. Engine Room Piping Layout **General learning Objective:** Understand the layout & arrangement of important pipe lines in Engine room with fittings & its material	
B1. Sub –topic: Routine pumping operations **Subtopics & SLOs** 1.1 State the need of understanding the pipelines, pumping systems, in order to maintain the normal operation of the plant and colour code of Pipe lines 1.2 Examine the status of valves concerned in both manual and automatic pumping systems which must be periodically checked	2:0
B2. Sub-topic: Bilge & ballast pumping system: **Subtopics & SLOs** 2.1 Describe the purpose of bilge pumping system 2.2 Explain why non return valves are fitted to bilge pipes in water tight compartment which contain the open end of the pipe 2.3 Sketch a diagrammatic arrangement of a bilge pumping system, including the connections to other pumps 2.4 Formulate the requirement of the critical dimensions of the piping's of bilge system as per MARPOL, Describe the purpose, siting and common principal connections of an emergency bilge suction 2.5 Explain the purpose of a ballast pumping system 2.6 Sketch a diagrammatic arrangement of a ballast system	2:0
B3. Sub-topic: Steam line: **Subtopics & SLOs** 3.1 Sketch a schematic diagram of Aux. steam line	2:0
B4. Sub-topic: Fresh water and sea water system **Subtopics & SLOs** 4.1 Explain a schematic diagram of Main Engine Jacket cooling system and centralizing cooling water system 4.2 Describe a domestic fresh water (Hydrophore) Supply system, explain how: i. The water pressure is maintained ii. The pump is started and stopped iii. The water is heated	2:0

iv. Describe the treatment necessary for water produced by evaporators for human consumption 4.3 Explain Sea water cooling system 4.4 Explain Firefighting system (Sea Water)	
C. Bunker & Oil Transfer **General learning Objective:** Understand the standard practices followed for bunkering of fuel oil & sludge discharge	
C1. Sub –topic: Introduction to Bunkering procedure **Subtopics & SLOs** 1.1 Explain Bunkering procedure on board ship along with safety and precautions 1.2 Line diagram for H.F.O & D.O	2:0
C2. Sub-topic: Sludge discharge to shore reception & other oil transfer procedures **Subtopics & SLOs** 2.1 Explain Line Diagram for sludge discharge to shore reception facility 2.2 Explain Safer precautions to be followed during sludge discharge operation	1:0
D. Filters **General learning Objective.** Understand various types of filters used on board ship	
D1. Sub-topic: Filter & Strainer **Subtopics & SLOs** 1.1 Explain the requirements of filters 1.2 Explain types of Strainer & Filters 1.3 Explain specification of filters 1.4 Explain various types of filters used on the Ship	2:1
D2. Sub-topic: Construction & working of various types of filters **Subtopics & SLOs** 2.1 Explain working & construction of Auto Clean Filter 2.2 Explain working & construction of Duplex Filter 2.3 Explain working & construction of Magnetic Filter 2.4 Explain working & construction of Micro filter	2:0
D3. Sub-topic: Priming & Core maintenance of filter **Subtopics & SLOs** 3.1 Describe Priming & Core maintenance of filter	1:0
E. Pumps **General Learning Objective** Understand the types of pumps for various requirements, their characteristics & applications on the ships	
E1. Sub-topic: Types of pumps **Subtopics & SLOs** 1.1 Types of pumps for various requirements, their characteristics and application in ships 1.2 Explain Centrifugal Pumps, Gear Pumps, Screw Pumps and Reciprocating pumps	4:1
E2. Sub-topic: Care & Maintenance of Pumps: **Subtopics & SLO** 2.1 Explain Use , Care & Maintenance of various types of pumps in the ship	2:2
E3. Sub-topic: Automation and control of pumps & pumping systems **Subtopics & SLO** 3.1 Describe Automation control of pumps & pumping systems on board the ship	1:1
F. Air Compressors	

General Learning Objective: Understand constructional & operational details of Air compressors & air bottles used on board	
F1. Sub-topic: Introduction to operational and constructional details of compressors & uses of compressed air on board ship **Subtopics & SLOs** 1.1 Explain operational and constructional details of compressors used on board ships 1.2 Explain uses of compressed air in the ship	3:2
F2. Sub-topic: Air bottle construction & mountings **Subtopics & SLOs** 2.1 Elaborate Air Bottles, Construction, mountings & associated system	3:1
G. Evaporators **General Learning Objective** Understand the features, working principle, operation and maintenance of evaporators & Fresh water Generators	
G1. Sub-topic: Introduction **Subtopics & SLOs** 1.1 Explain why 'fresh water' may have to be produced from seawater 1.2 Explain List the purposes for which the water might be used 1.3 Explain the effect that distillation has on the dissolved solids in seawater 1.4 Define the term distillation as used in marine engineering practice 1.5 State that evaporators and distillers are pressure vessels and as such must conform to approved standards for materials, fittings and construction	1:1
G2. Sub-topic: Principles of vapour formation **Subtopics & SLOs** 2.1 State that there are two main methods of obtaining vapour from seawater i.e., by direct boiling, using boiling water evaporators and by the evolution of vapour when the seawater is 'supersaturated', using flash evaporators 2.2 Describe in simple terms, using line Sketch, the construction of a shell and coil evaporator, naming the materials of the principal parts	1:0
G3. Sub-topic: Construction, mountings and working principle of Evaporators **Subtopics & SLOs** 3.1 List the mountings fitted to a simple shell and coil evaporator 3.2 State that the heat transfer can be obtained from: ➢ a supply of steam or other hot fluid passing through coils tubes which are immersed in the seawater or an electrical element immersed in the seawater 3.3 Explain why low-pressure evaporators are used 3.4 Explain what is meant by single-effect and by double-effect evaporation 3.5 Explain the principle of flash evaporation 3.6 State that flash evaporators can use a number of stages, with seawater feed passing through each stage in succession 3.7 Describe, with the aid of a simple sketch, a two-stage flash evaporator 3.8 Explain the principle of operation of the evaporator in the above objective (Multiple-effect Evaporation)	1:0

3.9 State that shell and coil evaporators can be connected in series, with the vapour produced in the first unit being used as the heating fluid in the next unit, the seawater passing through-each unit in turn 3.10 State that production of vapour in the second and successive units occurs partly by boiling and partly by flash evaporation 3.11 State that such a system is termed 'multiple effect' 3.12 State that multiple-effect evaporation produces an increased quantity of fresh water compared to a single evaporator using a similar input of heat 3.13 Describe, with the aid of a single line sketch, the arrangement of a two-stage Flash-evaporation plant	
G4. Sub-topic: Starting and stopping procedures: **Subtopics & SLOs** 4.1 Describe the need for starting fresh water generator and the limitations of keeping it running 4.2 State the procedure of starting and stopping of vacuum distillation plant 4.3 Explain how the formation of scale on the heating surfaces of coils, tubes and other heat-transfer elements is controlled	1:0
G5. Sub-topic: Reverse osmosis type FWG (fresh Water Generator) **Subtopics & SLOs** 5.1 Explain the theory of osmosis process i.e., fluid flows due to change in energy level in two solutions 5.2 Explain the theory of reverse osmosis 5.3 Describe a reverse osmosis plant for generation of fresh water	1:0
H. Oil Purification. **General Learning Objective:** Learn about the various centrifuge and working principles and understand the purpose of settling & service tank & precautions taken before entering & cleaning tanks	
H1. Sub-topic: Introduction: **Subtopics & SLO** 1.1 Explain why fuel oil treatment is necessary	1:1
H2. Sub-topic: Fundamentals of Purification: **Subtopics & SLOs** 2.1 State principles of purifying to eliminate water or dirt particles from oil 2.2 Explain in simple terms, the purification by using gravity force and filters, and centrifugal separation 2.3 Explain how the force of gravity is used to separate out liquids and solids of different densities 2.4 Explain the velocity of separation due to 'Stoke's Law' -Explain why the use of centrifugal separation is much faster and more effective than gravity in the separation process	1:1
H3. Sub-topic: Construction and operation of Purifiers **Subtopics & SLOs** 3.1 Describe the operation principles of an oil purifier	1:1

3.2 Describe the following with the aid of Sketch: bowl, operating water valve, gravity disk, valve cylinder, plug screw & disks 3.3 Describe, with the aid of simple sketch, a bowl separator and a tube separator, showing the main components and the principal differences between the two 3.4 State the rotation speeds used in the equipment described in the above objective State sequence of discharging sludge 3.5 State why oil purifier needs following data concerning oil: Temperature, quantity of flow, density/specific gravity 3.6 Explain the function of gravity disk 3.7 Explain the function of low and high pressure water 3.8 Describe sludge discharging mechanism of an oil purifier 3.9 Explain the difference between purifying and clarifying process 3.10 Describe the purification process of fuel oil, stating the approximate temperatures of the oil necessary for both in the supply tank and immediately prior to centrifuging 3.11 Explain precautions for starting purifier and various check point for ensuring efficient operation 3.12 Describe the correct procedures for the disposal of waste oil, sludge residue, etc.	
H4. Sub-topic: ALCAP Separators: **Subtopics & SLO** 4.1 Describe the operation of ALCAP system	1:1
H5. Sub-topic: Transmission of power in purifier **Subtopics & SLOs** 5.1 How motor drive is transmitted to Vertical Shaft in a centrifugal purifier	1:1
H6. Sub-topic: Settling Tank **Subtopics & SLO** 6.1 Use of settling service tank & precautions taken before entering /cleaning tanks	1:0
I. Sub-topic: Other Shipboard Machineries **General Learning Objective:** Learn about construction & operation of different types of ship stabilizer, Bow-thruster, Hull protection arrangement & Marine Growth Protection system	
I1. Sub-topic: Different types of ship stabilizer **Subtopics & SLOs** 1.1 Explain the Working principle of various types of ship stabilizer	2:1
I2. Sub-topic: Bow thruster & Hull protection system **Subtopics & SLOs** 2.1 Explain Operation of Bow thruster 2.2 Explain Hull protection & Marine Growth Protection system	1:0

Subject Name/Code: Electrical Machines/307

Instructional hours:	
Lecture	: 45 hours
Tutorial	: 15 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted with classroom/online lectures, tutorials and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

Pre–requisite for this Subject: Class 12 Physics, Maths.

Recommended Text:

1. A Textbook of Electrical Technology: - AC and DC Machines (Volume - 2) (English, Paperback, Theraja A. K.); Publisher S. Chand.
2. Problems in Electrical Engineering; Parker Smith; CBS Publishers and Distributors.
3. Marine Electrical Technology 11th Edition; By Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN: 9789352139514.
4. Marine Electrical Engineering, Fernandez, F.A. Shroff and Publishers.

Reference:

1. Marine High Voltage Technology; By J. Majumder, Elstan A. Fernandez, Lakshman Singh Yadav; Publisher: Shroff Publishers and Distributors; Year: 2018; ISBN: 9788175981799.
2. Electrical Machines; D.P Kothari and I.J Nagrath, Publisher Tata McGraw Hill.
3. The Explosion Protection Equipment Guide for Mariners; J. Majumder, Elstan A. Fernandez; Shroff Publishers and Distributors; Year: 2019; ISBN: 9789352138630.
4. Maintenance and troubleshooting of Marine Electrical Systems; Elstan A. Fernandez, Lakshman Singh Yadav; Zed Kuailz Publishers OPC Private Limited; Year: 2020; ISBN: 9788194710608.
5. Maintenance and troubleshooting of Marine Electrical Systems – Volume 2; Harbhajan Singh, Elstan A. Fernandez, Lakshman Singh Yadav; Year 2020; ISBN: 9789385889851.

Table of Topics

Section	Topics	Hours (L : T)
A	**Electrical Motors** **Sub-Topics:** A.C. Motors, D.C. Motors	11 : 3
B	**Three Phase A.C. Motors** **Sub-Topics:** Salient Features of Three phase A.C. motors; Basics of Starting and Running of Three phase Induction motors	4 : 2
C	**Three Phase Synchronous Motors** **Sub-Topics:** Salient Features of Three phase Synchronous motors, Load Characteristics and power factor improvement	3 : 1
D	**Electrical Motor Starting Methodologies** **Sub-Topics:** Electrical motor starting methodologies for DC Motors; Electrical motor starting methodologies for AC Motors; Recovery after Power supply failure (blackout)	6 : 2
E	**Electrical Motor Protection** **Sub-Topics:** Electrical Motor Protection Components and Circuits	2: 1
F	**Electrical Motor Speed Control** **Sub-Topics:** Suitable Operating conditions with respect to speed; Basic Speed Control Methods; Effect of varying frequency and voltage of A.C.; Insulated Gate Bipolar Transistor (IGBT) motor speed control; Motor speed control by thyristors;	7:2
G	**High-voltage Installations and Their Operational safety** **Sub-Topics:** Suitable Operating conditions with respect to speed; Basic Speed Control Methods; Effect of varying frequency and voltage of A.C.; Insulated Gate Bipolar Transistor (IGBT) motor speed control	12 : 4
	Total	**45 : 15**

Learning Objectives	L :T
A Electrical Motors **General Learning Objectives** • Understand the fundamentals and features of electrical motors in general • Know the differences in construction and usage of AC and DC motors • Know how to operate the motors **Topic 1 Electrical Motors** **Sub-Topics:** 1.1 A.C. Motors 1.2 D.C. Motors	
A1 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 – 1.5)	
1.1 A.C. Motors 1.1.1 State the normal supply for three-phase induction motors 1.1.2 Name the types of motor commonly used on board ships, giving their applications 1.1.3 Given the actual components from a three-phase induction motor, identify: - rotor - bearings - fan - stator - field windings - rotor cage - method of lubrication - terminals	2 : 1
1.1.4 Explain the differences between the following motor enclosure, describing how cooling is achieved in each case: - drip-proof - totally enclosed - deck watertight - flameproof	2: 0
1.1.5 Sketch a graph showing the relationship between speed and load and between current and load, from no load to full load 1.1.6 Explain the meaning of all of the information displayed, given a motor name plate 1.1.7 Explain in simple terms how the driving torque is produced in an induction motor 1.1.8 Explain why slip is essential	1: 0
1.2 D.C. Motors 1.2.1 Explain what is meant by the back e.m.f. (Eb) of a motor 1.2.2 Relate the supply voltage to the back e.m.f. and to the voltage drop in the armature (V = Eb + Ia Ra) 1.2.3 Explain why the starting current is high compared to the load current	2: 1
1.2.4. Explain why a starter is required and the principle involved	1: 0

1.2.5 State that rational speed (N) is approximately proportional to: applied voltage/filed flux or $N \propto \frac{V}{\Phi}$ 1.2.6 Explain from the above objective, how the rational speed is affected by: - varying the voltage - varying the strength of the magnetic field 1.2.7 Describe typical applications of: - shunt motors - series motors	2: 1
1.2.8 In compound motors, explain what is meant by: - long shunt - short shunt - cumulatively connected	1: 0
B Three Phase Induction Motors **General Learning Objectives** • Understand the difference between a single-phase and three-phase motor • Know the importance of three-phase motors on board ships • Know the operation and control of a three-phase motor **Topic 1. Three Phase Induction Motors** **Sub-Topics:** 1.1 Salient Features of Three phase A.C. motors 1.2 Basics of Starting and Running of Three phase Induction motors	
B1 Specific Learning Objectives: (IMO 7.02,2014: 2.1.3; 3.1, 3.2)	
1.1 Salient Features of Three Phase Induction motors 1.1.1 Construction, principle of operation of 3-phase induction motors 1.1.2 Design features of star and delta motors	2: 1
1.2 Basics of Starting and Running of Three phase A.C. motors 1.2.1 Starting, speed controlling and braking methods of 3-phase induction motors 1.2.2 Load-torque characteristics and protection	2: 1
C Three Phase Synchronous Motors **General Learning Objectives** • Understand the unique features and principle of operation of a synchronous motor • Understand the importance of a synchronous motor for power factor improvement **Topic 1. Three Phase Synchronous Motors** **Sub-Topics:** 1.1 Salient Features of Three Phase Synchronous motors 1.2 Load Characteristics and power factor improvement	
C1 Specific Learning Objectives: (IMO 7.02,2014: 2.1.3)	
1.1 Salient Features of Three Phase Synchronous motors 1.1.1 Construction 1.1.2 Principle of operation	2: 0
1.2 Load Characteristics and power factor improvement 1.2.1 Load characteristics 1.2.2 Power factor improvement with synchronous motors	1: 1

D Electrical Motor Starting Methodologies **General Learning Objectives** • Understand the importance of a starter in a motor's circuit • Understand the features of different starters and where to use them **Topic 1. Electrical Motor Starting Methodologies** **Sub-Topics:** 1.1 Electrical motor starting methodologies for DC Motors 1.2 Electrical motor starting methodologies for AC Motors 1.3 Recovery after Power supply failure (blackout)	
D1 Specific Learning Objectives: (IMO 7.02,2014: 2.1.1)	
1.1 Electrical motor starting methodologies for DC Motors 1.1.1 Explain the following starting methods for D.C. motors and its characteristics: - starting rheostat - automatic starter	2: 1
1.2 Electrical motor starting methodologies for AC Motors 1.2.1 Explain the following starting methods for A.C. motors and its characteristics: - direct on line starting - star- delta starting - compensator starting 1.2.2 State what should be taken into consideration when selecting starting methods for A.C. motors	2: 1
D2 Specific Learning Objectives: (IMO 7.04,2014: 1.4.2 - 2.3) / (IMO 7.02,2014: 2.1.3) **1.3 Recovery after Power supply failure (blackout)** 1.3.1 Explain specific conditions of blackout and procedures for recovery responding to their causes taking a physical system as an example, including the following: 1.3.2 Explain Equipment / installations to be promptly addressed 1.3.3 Explain Sequential restarting of auxiliaries	2: 0
E Electrical Motor Protection **General Learning Objectives** • Understand the importance of protection systems **Topic 1. Electrical Motor Protection** **Sub-Topics:** 1.1 Electrical Motor Protection Components and Circuits	
E1 Specific Learning Objectives: (IMO 7.04,2014: 1.4.2 - 2.3) / (IMO 7.02,2014: 2.1.3)	

1.1 Electrical Motor Protection Components and Circuits 1.1.1 Explain the basic reason for the provision of motor protection 1.1.2 Explain the principles of the most common overcurrent relays 1.1.3 Explain the difference between the largest possible overload current and a fault current 1.1.4 Describe the function of overcurrent trip, time delays and fuses with both overload and fault currents 1.1.5 Explain the basis upon which fuses are chosen 1.1.6 Explain the principle of a thermal relay, including the means of its adjustment 1.1.7 Explain what is meant by single phasing and its effects on a motor: - when running - when starting - if continued attempts to start are made 1.1.8 Describe the principle the protection against running with a phase open circuited 1.1.9 Explain why under voltage trips are necessary	2: 1
F Electrical Motor Speed Control **General Learning Objectives** • Understand the reasons for speed control of motors • Understand the design features of electronic speed controllers • Know the effect of varying frequency and voltage of A.C. motors **Topic 1. Electrical Motor Speed Control** **Sub-Topics:** 1.1 Suitable Operating conditions with respect to speed 1.2 Basic Speed Control Methods 1.3 Effect of varying frequency and voltage of A.C. 1.4 Insulated Gate Bipolar Transistor (IGBT) motor speed control 1.5 Motor speed control by thyristors	
F1 Specific Learning Objectives: (IMO 7.04,2014: 1.4.2 - 2.3) / (IMO 7.02,2014: 2.1.3)	
1.1 Suitable Operating conditions with respect to speed 1.1.1 State applications where the following speeds are suitable: - single fixed speed - two or three fixed speeds - infinitely variable speed 1.1.2 Describe briefly how stepped speeds can be provided 1.1.3 List the means of producing variable speed	2: 1
1.2 Basic Speed Control Methods 1.2.1 Describe the principle of the Ward-Leonard drive 1.2.2 Explain the principle of a variable-frequency motor	2: 0
1.3 Effect of varying frequency and voltage of A.C. motors 1.3.1 Explain Speed 1.3.2 Explain Temperature 1.3.3 Explain Torque 1.3.4 Explain Power Output 1.3.5 Explain Starting Time, Current	1: 0
1.4 **Insulated Gate Bipolar Transistor (IGBT) motor speed control** 1.4.1 Explain Gate Driving Characteristics with High Current 1.4.2 Explain High Frequency, High Current Switch 1.4.3 Explain Advantages of IGBT In Varying Motor Speed Control	1: 1
1.5 Motor speed control by thyristors 1.5.1 Explain Application of thyristors in motor speed control	1:0

Learning Objectives	L :T
G High-voltage Installations and Their Operational Safety **General Learning Objectives** • Understand Risks and Hazards involved in High Voltage Applications • Know how to avoid electrical accidents by adopting adequate safety measures • Know the advantages and disadvantages of High Voltage systems • Know the importance of Trapped Key and Key Safe Systems and use of PPE **Topic 1. Electrical Motor Speed Control** **Sub-Topics:** 1.1 Design features of high-voltage installations 1.2 Operational safety of high voltage installations	
G1 Specific Learning Objectives: (IMO 7.02,2014: 2.1.4)	
1.1 Design features of high-voltage installations 1.1.1 Explain Generation and Distribution of High Voltage On Ships 1.1.2 Explain Electric Propulsion System 1.1.3 Explain Synchro-Convertors And Cyclo-Convertors	2: 1
1.1.4 Describe Functional, Operational and Safety Requirements for a Marine High-Voltage System 1.1.5 Describe Assigning Qualified Personnel to Carry Out Maintenance and Repair of High-Voltage Switchgear of various types 1.1.6 Describe High-Voltage System Advantages 1.1.7 Describe Advantages of an Insulated System	2 : 1
1.1.8 Explain High-Voltage Circuit Breakers 1.1.9 Explain High-Voltage Cable 1.1.10 Explain High-Voltage Fuses 1.1.11 Explain Remedial Action Necessary During Faults in A High-Voltage System 1.1.12 Explain Switching Strategy for Isolating Components of a High-Voltage System 1.1.13 Explain Selection of Suitable Apparatus for Isolation and Testing of High-Voltage Equipment 1.1.14 Explain Switching and Isolation Procedure On a Marine High-Voltage System, Complete with Safety Documentation 1.1.15 Explain Performance Of Insulation Resistance And Polarization Index On High-Voltage Equipment	2: 1
1.2 Operational safety of high voltage installations 1.2.1 Explain how to use HV personal protection equipment (PPE): insulated gloves, goggles, insulating bars, insulating footwear, mates, earthing cables, HV testers 1.2.2 Explain terms of certification of personal protection equipment	2: 1
1.2.3 Explain HV safety procedures: - permission and coordination of HV works - information, warnings and protection against unauthorized influence on safety	2: 0
1.2.4 Explain HV safety procedures (cont.): - assisting during HV work - checking for voltage presence before any work starts	2: 0

Subject Name/Code: Mechanics of Machines/308

Instructional hours:

Lecture	: 15 hours
Tutorial	: 30 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Theory of Machines, R. S. Khurmi, S. Chand.
2. P L Ballaney, Theory of Machines, Khanna Publishers, New Delhi.

Reference:

1. S. S. Rattan, Theory of Machines, Tata McGraw Hill Publishing Company, New Delhi.
2. J. Hannah and R.C. Stephens, Advanced Mechanics of Machines, Viva publications, New Delhi.
3. Kenneth J. Waldron / Gary L Kinzel, Kinematics Dynamics and Design of machinery, John Wiley and Sons.
4. Thomas Bevan, The Theory of Machines, CBS Publishers and Distributors, New Delhi.
5. J. S. Rao, The Theory of Machines, New Age International Publishers.
6. Theory of Machines, Kinematics and Dynamics, Sadhu Singh, Pearson Publications,2013, Third Edition.

Table of Topics

Section	Topics	Hours (L:T)
A	Kinematics of Machines and Mechanisms **Sub topics**: Introduction to basic mechanisms, kinematic pairs, links and chain Inversions and variants of kinematic chains. Degrees of freedom	1:1
B	Marine Engine Dynamics **Sub topics**: Determination velocities and accelerations of Piston, Connecting Rod inertia forces of piston, connecting rod, crank by analytical method Dynamically equivalent system of connecting rod	2:3
C	Gears and Gear Trains **Sub topics:** Types and classification of all gears used in the field of marine engineering, Kinematics and Dynamics of Spur Gear, Helical Gear, Herringbone Gear, Rack and Pinion, Bevel Gears, Spiral (Skew) Gears, Worm Gears Type of Classification of Gear Trains Kinematics and Dynamics of Simple Gear Train, Compound Gear Train, Reverted Gear Train, Epicyclic Gear Train	5:11
D	Cam and Follower Mechanisms **Sub topics:** Types and Classification Cam and Follower mechanisms used in different machineries on board, Kinematics and Dynamics of Cam and Follower mechanisms and determination of cam profile for specified follower motions like uniform velocity, SHM, uniform acceleration and retardation, cycloidal motion.	2:4
E	Balancing **Sub topics:** Introduction to Concept of Balancing, Static balance and Dynamic Balance Single plane and multiplane balancing; Balancing of rotating components like pulley, gears, cams, sprockets etc. Balancing of reciprocating machinery on board Partial balancing Primary and Secondary balancing of Inline, radial and V- engines Complete balancing of reciprocating machinery	5:11
	Total	**15:30**

Learning Objectives	L : T
General Learning Objective Understand the development of machines from simple ideas to complicated levels. Understand the evolution and the historical development of various machines and mechanisms	
A Kinematics of Machines and Mechanisms (IMO 7.02,2014, 1.1) **Specific Learning Objectives:** 1.1 State how each one of the machines was brought into existence for the first and fore most. 1.2 Classify the types of basic kinematic chains, mechanisms, machines and explain their applications in the field of engineering 1.3 Explain the concept of kinematics pairs (joints) and to determine the number of degrees of freedom for a given mechanism 1.4 Identify the different types of four-bar mechanisms and their classifications. 1.5 Describe the method of obtaining various inversions of basic kinematic chains to suit different applications 1.6 Explain how all modern machines are developed from the basic chains	1:1
General Learning Objective: Understand the engine dynamics and methods of carrying out inertia force analysis of engine mechanisms	
B Marine Engine Dynamics (IMO 7.02,2014, 1.1)	2:3

Specific Learning Objectives: 1.1 Perform kinematic analysis of an engine mechanism to determine position, velocity, and acceleration of all members 12 Perform a kinetic analysis of an engine mechanism to determine the forces on all joints and the torque required to drive the mechanism 1.3 Determine velocities and accelerations of various links of given IC engine mechanism by analytical method 1.4 Evaluate the efficiency of a mechanism using the velocities and accelerations of various links 1.5 Evaluate inertia forces of piston, connecting rod, crank by analytical method 1.6 Determine load on engine foundation and frame corresponding to the fluctuations of inertia forces	
General Learning Objective: Understand various types of gears and gear trains and their kinematics used in the field of marine engineering.	
C Gears and Gear Trains **Specific Learning Objectives: (**IMO 7.02,2014, 1.1) 1.1 State the advantages of gear drives over belt drive 1.2 Explain the importance of positive drive w.r.t the field application 1.3 Classify all the gears w.r.t the positions of shaft axes 1.4 Analyse the kinematics and dynamics of spur, helical, herringbone, bevel, spiral and worm. 1.5 Describe the involute Gear tooth profile 1.6 Analyse the gears for interference and under cutting 1.7 Classify the different types of gear trains 1.8 Evaluate mechanical advantage of a given gear train 1.9 Analyse the kinematics and dynamics of Simple Gear Train, Compound Gear Train, Reverted Gear Train and Epicyclic Gear Train	5:11
General Learning Objective: Understand the types of cams and followers and their applications in the field of marine engineering.	
D Cam and Follower Mechanisms (IMO 7.02,2014, 1.1) **Specific Learning Objectives:** 1.1 Describe the function of cam and follower 1.2 Describe the kinematic analysis of a cam follower mechanism 1.3 Construct displacement, velocity, acceleration, jerk diagrams of a cam and follower mechanism 1.4 Determine cam profile graphically for specified follower motions like uniform velocity, SHM, uniform acceleration and retardation, cycloidal motion 1.5 Analyse the cam follower mechanisms required for specific applications on board like valve operations fuel injections, air starting, reversing in marine engines	2:4
General Learning Objective: Understand and apply concept of need and actual method of balancing as applied to compressors and multi cylinder in-line engines & V engines, radial engines, pumps etc., and to determine whether a system is balanced or not.	
E Balancing (IMO 7.02,2014, 1.2 1.2.2, 7.04,3.2,3.1.3) **Specific Learning Objectives:** 1.1Describe the need and method of balancing 1.2 Differentiate static and dynamic balancing 1.3 Describe types of machinery unbalance 1.4 Enumerate important balancing conditions 1.5 Describe principles of balancing like single plane balancing, two plane balancing 1.6 Evaluate and determine the primary and secondary balance of multi cylinder in-line engines and compressors, pumps 1.7. Describe the working of balancing machines 1.8 Determine the conditions for secondary balancing 1.9 Deduce and determine the conditions for primary and secondary balancing for high speed engines, compressors, pumps etc. 1.10 Describe the concept of partial balance and complete balance 1.11. Determine and design static, dynamic balancing of rotating, reciprocating, combined rotary and reciprocating, unbalance masses, reciprocating unbalance masses 1.12 Explain complete balancing of reciprocating machinery	5:11

Subject Name/Code: Basic Control Engineering (P)/309

Instructional hours:

Practical	: 25 hours
Total contact hours	: 25 hours
Credits	: 1

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. Modern Control Engineering, D Roy Choudhury, PHI.
2. Reeds Volume:10, Instrumentation and Control Systems.
3. Instrumentation and Control System, Boyd G & Jackson, Bloomsbury.

Reference:

1. Taylor, 'Marine Control Practice', Butterworth & Co (Publishers) Ltd.
2. Ogata, K, 'Modern Control Engineering', Pearson Education.
3. Roy Choudhury, D., 'Control System Engineering', PHI.
4. Kuo, B.C., 'Automatic Control System', PHI.

Table of Topics

Section	Topics	Hours (P)
1	Control System Practical Exercises	25
Total		**25**

Learning Objectives	P
Control system Practical Exercises	
General Learning Objective Understand the different transducers, controlling of physical parameters of a system using different controllers and different control applications **1 Topic: Control System Components** **Sub-topics** **1.1** Understand different types of valves **1.2** Understand pneumatic trainer with pneumatic equipment **1.3** Study of direct acting/reverse acting, ATO/ATC type diaphragm actuators, valve positioner, I-P converter, AFR (air filter regulator) **1.4** Study piston actuator, electric actuator **1.5** Study of flapper-nozzle characteristics	
Specific Learning Objectives: (IMO 7.02,2014: F2/2.2.1.12) 1.1 **Understand different types of valves.** 1.1.1 Differentiate between linear valve, quick opening and equal percentage valves 1.1.2 Plot the characteristics of the valves	1
Specific Learning Objectives: (IMO 7.02,2014: F2/2.1.5.2) 1.2 **Understand pneumatic trainer with pneumatic equipment** 1.2.1 Explain working of different pneumatic devices 1.2.2 Form Different pneumatic circuits using different pneumatic equipment on the trainer	2
Specific Learning Objectives: (IMO 7.04, 2014: F2/3.7,2.1.3.8) 1.3 **Study of direct acting/reverse acting, ATO/ATC type diaphragm actuators, valve positioner, I-P converter, AFR (air filter regulator)** 1.3.1 Explain the working of diagram actuators of different types 1.3.2 Explain the working of different types of converters used in control systems 1.3.3 Explain the working of valve positioners 1.3.4 Explain the working of AFR 1.3.5 Demonstrate working of all above stated components	2
Specific Learning Objectives: (IMO 7.04, 2014: F2/3.7,2.1.3.8) 1.4 **Study piston actuator, electric actuator** 1.4.1 Explain the working of piston actuator 1.4.2 Explain the working of electric actuator	1
Specific Learning Objectives: (IMO 7.04, 2014: F2/3.7,2.1.3.7) 1.5 **Study of flapper nozzle characteristics** 1.5.1 Plot the characteristics of flapper nozzle system 1.5.2 Describe working of the device	2
2 Topic: Physical parameter measurement and controlling using different controllers **Sub Topics** 2.1 Explain the different transducers and sensors for measurement of Pressure	2

2.2 Explain the different transducers and sensors for measurement of Temperature 2.3 Operation and utility of a 3 Term (P + I + D) controller for flow, on SCADA unit 2.4 Operation and utility of a 3 Term (P + I + D) controller for Pressure on SCADA unit. 2.5 Start/ Stop electrical motor using on/off controller (Pressure Switch) 2.6 Start/ Stop electrical motor using on/off controller (Thermostat)	
Specific Learning Objectives: (IMO 7.02,2014: F2/2.2.3.1) **2.1Understand the different transducers and sensors for measurement of Pressure** 2.1.1 Plot Loading characteristics of bonded type strain gauge 2.1.2Understand the working principle of strain gauge 2.1.3 Determine values at the output side of LVDT for different inputs 2.1.4 Explain the working principle of LVDT	2
Specific Learning Objectives: (IMO 7.02,2014: F2/2.2.3.1) **2.2 Understand the different transducers and sensors for measurement of Temperature** 2.2.1 Demonstrate working of RTD 2.2.2 Demonstrate working of thermistor 2.2.3 Demonstrate working of Thermocouple 2.2.4 Study characteristics of all 3 transducers	2
Specific Learning Objectives: (IMO 7.02,2014: F2/2.2.1.12) **2.3 Operation and utility of a 3 Term (P + I + D) controller for flow, on SCADA unit** 2.3.1 Demonstrate working of PID controller for flow control 2.3.2 Demonstrate working of PID control loop 2.3.3 Explain working of SCADA	2
Specific Learning Objectives: (IMO 7.02,2014: F2/2.2.1.12) **2.4 Operation and utility of a 3 Term (P + I + D) controller for Pressure on SCADA unit** 2.4.1 Demonstrate working of PID controller for pressure control 2.4.2 Demonstrate working of PID control loop 2.4.3 Explain working of SCADA	2
Specific Learning Objectives: (IMO 7.04, 2014: F2/3.7,2.1.3.8) **2.5 Start/ Stop electrical motor using on/off controller (Pressure Switch)** 2.5.1 Explain working of on-off controller 2.5.2 Operate electric motor using pressure switch 2.5.3 Explain working of Pressure switch	1
Specific Learning Objectives: (IMO 7.04, 2014: F2/3.7,2.1.3.8) **2.6 Start/ Stop electrical motor using on/off controller (Thermostat)** 2.6.1 Explain working of on-off controller 2.6.2 Operate electric motor using thermostat 2.6.3 Explain working of thermostat	1
3 Topic: Control Applications **Sub Topics** 3.1 Describe the functioning of mist detector 3.2 Describe the operation of fire detection unit using Ionization chamber type detector	1
Specific Learning Objectives: (IMO 7.02,2014: F2/2.2.3.1) **3.1 Understand the functioning of mist detector.** 3.1.1 Demonstrate functioning of mist detector 3.1.2 Study the working principle of mist detector	2
Specific Learning Objectives: (IMO 7.02,2014: F2/2.2.2.1) **3.2 Understand the operation of fire detection unit using Ionization chamber type detector** 3.2.1 Demonstrate the operation of fire detection unit using Ionization chamber type detector 3.2.2 Study the working principle of fire detection unit	2

Subject Name/Code: Solid Mechanics (P)/310

Instructional Hours

Practical	: 30 hours
Total contact hours	: 30 hours
Credits	: 1

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Additional Information on Subject:

Pre-requisites: Fundamentals of Engineering Mechanics.

Recommended Text:

1. Strength of Materials, Rajput R.K, S. Chand Publishing, New Delhi.
2. A textbook of Engineering Mechanics by R.S Khurmi, S. Chand Publishing, New Delhi.

Reference:

1. Reed Volume 2: Applied Mechanics for Engineers; By William Embleton; Revised by J.T. Gunn; Publisher Sunderland Tyne and Wear Thomas Reed.1983: ISBN0900335874.
2. Applied Mechanics, J. Hannah and M.J. Hiller, Longman,1998, ISBN:9780582256323.
3. Strength of Materials, G. H. Ryder, Macmillan Pub, India.
4. Strength of Materials, Ramamrutham S, Dhanpat Rai Publishing, New Delhi.

Table of Topics

Section	Topics	Hours (P)
A1-A 5	**A. Materials under the load** **Sub-Topics:** **A1:** Practical 1: To conduct a tensile test of a given ductile material specimen on universal testing machine (UTM) and determine the following :(i) Limit of proportionality, (ii) Elastic limit, (iii) Yield strength, (iv) Ultimate strength, (v) Young's modulus of elasticity, (vi) Percentage elongation, (vii) Percentage reduction in area. Also draw stress strain curve for the same. **A2:** Practical 2: To conduct the compression test and determine the ultimate compressive strength for a given specimen on universal testing machine (UTM). **A3:** Practical 3: To conduct the Shear test of ductile material on Universal Testing Machine(UTM). **A4:** Practical 4: To study the Brinell Hardness Machine and to determine the Brinell hardness of the given material. **A5:** Practical 5: To study the Rockwell Hardness Testing Machine and to determine the Rockwell Hardness of the given material.	10
B1-B3	**B. Stress and strain** **Sub-Topics:** **B1:** Practical 6: To conduct Izod impact test on Impact testing machine and calculate value of energy absorbed. **B2:** Practical 7: To conduct Charpy impact test on Impact testing machine and calculate value of energy absorbed. **B3:** Practical 8: To study and determine the stresses developed in thin cylindrical shell with schematic diagrams	6
C1	**C. Combined stress** **Sub-Topics:** **C1:** Practical 9: To study and determine the principal stresses for a given combined stress condition through graphical (Mohr's stress circle) and analytical method.	2
D1-D2	**D. Torsion** **Sub-Topics:** **D1:** Practical 10: To conduct torsion test on ductile circular bar and determine the modulus of rigidity. Also plot a curve of angle of twist vs torque. **D2:** Practical 11: To determine the stiffness and modulus of rigidity of the material of given close coiled helical the spring**.**	4

E1-E4	**E. Simple Harmonic motion** **Sub-Topics:** **E1:** Practical 12*:* To investigate simple harmonic motion using a simple pendulum and plot a graph between square of time period versus length of the pendulum. **E2:** Practical 13*:* To investigate simple harmonic motion using a compound pendulum and plot a graph between square of time period versus length of the pendulum. **E3:** Practical 14: To investigate simple harmonic motion using an oscillating spring; to determine the spring constant of a spring. **E4:** Practical 15: To determine the natural frequency of free torsional vibrations of flywheel.	8
	Total	**30**

Learning Objectives	P
A. Materials under the load (IMO 7.04,2014: 3.1.3.1) **General Learning Objective:** Demonstrate a knowledge and understanding of mechanical behaviour of materials under the load. **Topic 1: Materials under the load** **Sub-Topics:** **1.1:** Practical 1: Conduct a tensile test of a given ductile material specimen on universal testing machine (UTM) and determine the following :(i) Limit of proportionality, (ii) Elastic limit, (iii) Yield strength, (iv) Ultimate strength, (v) Young's modulus of elasticity, (vi) Percentage elongation, (vii) Percentage reduction in area Also draw stress strain curve for the same **1.2:** Practical 2: Conduct the compression test and determine the ultimate compressive strength for a given specimen on universal testing machine (UTM) **1.3:** Practical 3: Conduct the Shear test of ductile material on Universal Testing Machine(UTM) **1.4:** Practical 4: Study the Brinell Hardness Machine and to determine the Brinell hardness of the given material **1.5:** Practical 5: Study the Rockwell Hardness Testing Machine and to determine the Rockwell Hardness of the given material	**10**
A1 Specific Learning Objectives: (IMO 7.04,2014: 3.1.3.1) Demonstrate a knowledge and understanding of mechanical behaviour of materials under the tensile load. **1.1:** Practical 1: Conduct a tensile test of a given ductile material specimen on universal testing machine (UTM) and determine the following :(i) Limit of proportionality, (ii) Elastic limit, (iii) Yield strength, (iv) Ultimate strength, (v) Young's modulus of elasticity, (vi) Percentage elongation, (vii) Percentage reduction in area Also draw stress strain curve for the same 1.1.1 Define, for an elastic material subjected to a tensile load: elastic limit, yield point, ultimate strength, breaking strength, Percentage elongation, Percentage reduction in area 1.1.2 State the significance in engineering practise of four physical properties in the above objective	2

1.1.3 Explain and demonstrate the tensile test of a given ductile material specimen on universal testing machine (UTM) 1.1.4 Show, on a sketched graph of load to a base of corresponding extension values, the behaviour of elastics materials under tensile loading and indicates the condition points listed above 1.1.5 State that, within the elastic limit, Hook's law will apply 1.1.6 Define hooks as: stress/strain=a constant 1.1.7 Define the constant contained in Hooks Law as the Modulus of Elasticity	
A2 Specific Learning Objectives: (IMO 7.04,2014: 3.1.3.1) Demonstrate a knowledge and understanding of mechanical behaviour of materials under the compressive load **1.2: Practical 2: Conduct the compression test and determine the ultimate compressive strength for a given specimen on universal testing machine (UTM).** 1.2.1 Explain and demonstrate the compression test of a given material specimen on universal testing machine (UTM) 1.2.2 Show, on a sketched graph of load to a base of corresponding compression values, the behaviour of given materials under compression loading and indicates the condition points listed above 1.2.3 Determine the ultimate compressive strength for a given specimen on universal testing machine (UTM)	2
A3 Specific Learning Objectives: (IMO 7.04,2014: 3.1.3.1) Demonstrate a knowledge and understanding of mechanical behaviour of materials under the shear load **1.3: Practical 3: Conduct the Shear test of ductile material on Universal Testing Machine(UTM)** 1.3.1 Demonstrate a shear test attachment on universal testing machine (UTM) 1.3.2 Explain and demonstrate the shear test of a given ductile material specimen on universal testing machine (UTM) 1.3.3 Determine the shear strength for a given specimen on universal testing machine (UTM) 1.3.4 Understand the behaviour of failure	2
A4 Specific Learning Objectives: (IMO 7.04,2014: 3.1.3.1) Demonstrate a knowledge and understanding of hardness of materials by using Brinell Hardness Machine **1.4: Practical 4: Study the Brinell Hardness Machine and to determine the Brinell hardness of the given material.** 1.4.1 Explain Brinell's Hardness Testing 1.4.2 Explain and demonstrate the procedure 1.4.3 Determine the Brinell hardness of the given material. 1.4.4 Complete write up with diagrams, observations, calculations and results and graphs	2
A5 Specific Learning Objectives: (IMO 7.04,2014: 3.1.3.1) Demonstrate a knowledge and understanding of hardness of materials by using Rockwell Hardness Machine **1.5:** Practical 5: Study the Rockwell Hardness Testing Machine and to determine the Rockwell Hardness of the given material 1.5.1 Explain Rockwell Hardness Testing 1.5.2 Explain and demonstrate the procedure 1.5.3 Determine the Rockwell hardness of the given material 1.5.4 Complete write up with diagrams, observations, calculations and results and graphs	2

B. Stress and strain. (IMO 7.02,2014: 1.2.3) **General Learning Objective:** Demonstrate a knowledge and understanding of fundamental concept related to stresses, strains and strain energy **Topic 2: Stress and strain.** **Sub-Topics:** **2.1:** Practical 6: Conduct Izod impact test on Impact testing machine and calculate value of energy absorbed **2.2:** Practical 7: Conduct Charpy impact test on Impact testing machine and calculate value of energy absorbed **2.3:** Practical 8: Study and determine the stresses developed in thin cylindrical shell with schematic diagrams	**6**
B1 Specific Learning Objectives: (IMO 7.02,2014: 1.2.3) Demonstrate a knowledge and understanding of fundamental concept related to strain energy due to impact loading by using Izod impact test **2.1:** Practical 6: Conduct Izod impact test on Impact testing machine and calculate value of energy absorbed 2.1.1 Explain impact testing and energy absorbed 2.1.2 Explain apparatus and demonstrate procedure 2.1.3 Perform experiment 2.1.4 Complete write up with diagrams, observations, calculations and results and graphs	2
B2 Specific Learning Objectives: (IMO 7.02,2014: 1.2.3) Demonstrate a knowledge and understanding of fundamental concept related to strain energy due to impact loading by using Charpy impact test **2.2:** Practical 7: Conduct Charpy impact test on Impact testing machine and calculate value of energy absorbed. 2.2.1 Explain impact testing and energy absorbed 2.2.2 Explain apparatus and demonstrate procedure 2.2.3 Perform experiment 2.2.4 Complete write up with diagrams, observations, calculations and results and graphs	2
B3 Specific Learning Objectives: (IMO 7.02,2014: 1.2.3) Demonstrate a knowledge and understanding of fundamental concept related to stresses and strains in thin cylindrical shell **2.3:** Practical 8: Study and determine the stresses developed in thin cylindrical shell with schematic diagrams 2.3.1 Understand the concept of failure in thin cylindrical shell due to internal fluid pressure 2.3.2 Explain with schematic diagrams 2.3.3 Derive the stresses and strains for the thin cylindrical shell	2
C1 Specific Learning Objectives: (IMO 7.02,2014: 1.2.5) Demonstrate a knowledge and understanding of fundamental concept of combined stresses in structural element by using graphical (Mohr's stress circle) and analytical method **3.1:** Practical 9: Study and determine the principal stresses for a given combined stress condition through graphical (Mohr's stress circle) and analytical method 1.3.3 Draw and elaborate the case on oblique section of body with combined stress condition 1.3.4 Determine and explain the principle stresses by analytical method 1.3.5 Draw and explain the procedure for calculating the principle stresses by graphical (Mohr's stress circle) method 1.3.6 Compare the results by both the methods	**2**

D. Torsion (IMO 7.02,2014: 1.2.4) **General Learning Objective:** Demonstrate knowledge and understanding the concept of torsional moment in structural elements **Topic 4: Torsion** **Sub-Topics:** **4.1:** Practical 10: Conduct torsion test on ductile circular bar and determine the modulus of rigidity. Also plot a curve of angle of twist vs torque **4.2:** Practical 11: Determine the stiffness and modulus of rigidity of the material of given close coiled helical the spring	**4**
D1: Specific Learning Objective: (IMO 7.02,2014: 1.2.4) Demonstrate knowledge and understanding the concept of torsional moment in ductile circular bar **Sub-Topics:** **4.1:** Practical 10: Conduct torsion test on ductile circular bar and determine the modulus of rigidity. Also plot a curve of angle of twist vs torque 4.1.1 Explain torsion stress and modulus of rigidity 4.1.2 Explain apparatus and demonstrate procedure 4.1.3 Perform experiment 4.1.4 Complete write up with diagrams, observations, calculations and results and graphs	2
D2: Specific Learning Objective: (IMO 7.02,2014: 1.2.4) Demonstrate knowledge and understanding the concept of torsional moment in close coiled helical the spring **Sub-Topics:** **4.2:** Practical 11: Determine the stiffness and modulus of rigidity of the material of given close coiled helical the spring 4.2.1 Explain stiffness of spring for round section wire 4.2.2 Explain apparatus and demonstrate procedure 4.2.3 Perform experiment 4.2.4 Complete write up with diagrams, observations, calculations and results and graphs	2
E. Simple Harmonic motion (IMO 7.02,2014: 1.2.2) **General Learning Objective:** Demonstrate a knowledge and understanding of the concept and application of simple harmonic motion **Topic 5: Simple Harmonic motion** **Sub-Topics:** **5.1:** Practical 12*:* Investigate simple harmonic motion using a simple pendulum and plot a graph between square of time period versus length of the pendulum **5.2:** Practical 13*:* Investigate simple harmonic motion using a compound pendulum and plot a graph between square of time period versus length of the pendulum **5.3:** Practical 14: Investigate simple harmonic motion using an oscillating spring; to determine the spring constant of a spring **5.4:** Practical 15: Determine the natural frequency of free torsional vibrations of flywheel	**8**

E1: Specific Learning Objective: **(IMO 7.02,2014: 1.2.2)** Demonstrate a knowledge and understanding of the concept and application of simple harmonic motion by using simple pendulum **Sub-Topics:** **5.1:** Practical 12*:* Investigate simple harmonic motion using a simple pendulum and plot a graph between square of time period versus length of the pendulum 5.1.1 Explain apparatus and demonstrate procedure 5.1.2 Perform experiment 5.1.3 Determine the time period in case of a simple pendulum and to plot the graph square of time period versus length of the pendulum 5.1.4 Complete write up with diagrams, observations, calculations and results	2
E2: Specific Learning Objective: **(IMO 7.02,2014: 1.2.2)** Demonstrate a knowledge and understanding of the concept and application of simple harmonic motion by using compound pendulum **Sub-Topics:** **5.2:** Practical 13*:* Investigate simple harmonic motion using a compound pendulum. Also find the radius of gyration and equivalent length of compound pendulum 5.2.1 Explain apparatus and demonstrate procedure 5.2.2 Perform experiment 5.2.3 Determine the time period in case of a compound pendulum 5.2.4 Find the radius of gyration and equivalent length of compound pendulum. 5.2.5 Complete write up with diagrams, observations, calculations and results	2
E3: Specific Learning Objective: **(IMO 7.02,2014: 1.2.2)** Demonstrate a knowledge and understanding of the concept and application of simple harmonic motion using an oscillating spring **Sub-Topics:** **5.3:** Practical 14: Investigate simple harmonic motion using an oscillating spring; to determine the spring constant of a spring 5.3.1 Explain apparatus and demonstrate procedure 5.3.2 Perform experiment 5.3.3 Determine the time period in case of a helical spring 5.3.4 Determine the spring constant of a spring 5.3.5 Complete write up with diagrams, observations, calculations and results	2
E4: Specific Learning Objective: **(IMO 7.02,2014: 1.2.2)** Demonstrate a knowledge and understanding of the concept and application of simple harmonic motion using free torsional vibration of flywheel **Sub-Topics:** **5.4:** Practical 15: Determine the natural frequency of free torsional vibrations of flywheel 5.4.1 Understand the natural frequency of free torsional vibrations of flywheel 5.4.2 Explain apparatus and demonstrate procedure 5.4.3 Perform experiment 5.4.4 Complete write up with diagrams, observations, calculations and results	2

Subject Name/Code: Fluid Mechanics (P)/311

Instructional hours:

Practical	: 30 hours
Total contact hours	: 30 hours
Credits	: 1

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Additional Information on Subject:

Pre-requisites: Class 12 Physics, Chemistry, Maths.

Recommended Text:

1. Fluid Mechanics and Hydraulics R K Bansal.
2. Hydraulics and Fluid Mechanics – P. N. Modi and S. M. Seth.

Reference:

1. Fluid Mechanics and Hydraulic Machines – R. K. Rajput.
2. Fluid Mechanics (Part 1 and Part 2) – J. F. Douglas.
3. Mechanics of Fluids – Bernard Massey and John Ward Smith.
4. Fundamentals of Fluid Mechanics – G. S. Sawhney.

Table of Topics

Section	Topics	Hours (P)
A	**Fluid Properties** A1 – Specific gravity A2 – Viscosity	4
B	**Pressure Measurement** B1 – Pressure measuring devices	2
C	**Hydrostatics** C1 – Hydraulic lifting machine	4
D	**Fluid Flow** D1 – Venturimeter D2 – Orifice meter D3 – Notches D4 – Losses in pipe	8
E	**Centrifugal Pumps** E1 – Characteristics curve E2 – Design of centrifugal pump	6
F	**Fluid Flow and Characteristics of Major Systems** F1 – Hydraulic system	6
	Total	**30**

Learning Objectives	L
General Learning Objective: To demonstrate knowledge and understanding of fluid mechanics concepts, hydraulic machines and systems.	
A. Fluid Properties **(Ref: IMO 7.04 Appendix 1 Section 1.4 Page 244)** **General Learning Objective:** To demonstrate a knowledge and understanding of fluid properties like density, specific gravity, viscosity etc.	
A1. Specific Gravity **(Ref: IMO 7.04 Appendix 1 Section 1.4 Page 244)** **Specific Learning Objective:** To experimentally obtain specific gravity of a given liquid 1.1. Obtain specific gravity of given liquid/s experimentally	2
A2. Viscosity **(Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47)** **Specific Learning Objective:** To experimentally obtain viscosity a given liquid 2.1. Obtain viscosity of given liquid using experimental setup	2
B. Pressure Measurement **(Ref: IMO 7.04 Appendix 1 Section 1.4 Page 244)** **General Learning Objective:** To demonstrate knowledge and understanding of pressure measuring devices like manometer, pressure gauge	

B1. Pressure Measuring Devices (Ref: IMO 7.04 Appendix 1 Section 1.4 Page 244) **Specific Learning Objective:** To obtain pressure reading at specific points in a fluid flow using pressure measuring device 1.1. Determine pressure/pressure difference in a given pipe flow using manometer and/or pressure gauges	2
C. Hydrostatics (Ref: IMO 7.04 Appendix 4 Section 1.3 page 255) **General Learning Objective:** To demonstrate knowledge and understanding of pressure exerted by fluid on different surfaces	
C1. Hydraulic Lifting Machine (Ref: IMO 7.04 Appendix 4 Section 1.3 page 255) **Specific Learning Objective:** To demonstrate knowledge and working of hydraulic lifting machine. 1.1. Study design and working of a hydraulic lifting machine	4
D. Fluid Flow (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **General Learning Objective:** To demonstrate knowledge and understanding of loss of energy in fluid flow due to major and minor losses	
D1. Venturimeter (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** To experimentally determine coefficient of discharge of a venturimeter 1.1. Determine coefficient of discharge of a given venturi meter using experimental setup	2
D2. Orifice meter (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** To experimentally determine coefficient of discharge of a orifice meter 2.1. Determine coefficient of discharge of a given orifice meter using experimental setup	2
D3. Notches (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objectives:** To experimentally determine coefficient of discharge of notches of different shapes 3.1. Determine coefficient of discharge of notches of different shapes (e.g., V notch, rectangular notch) using experimental setup	2
D4. Losses in Pipe (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **Specific Learning Objective:** To experimentally determine losses occurring in flow through pipes 4.1. Determine coefficient of friction of given pipe using experimental setup	2
E. Centrifugal pumps (Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47) **General Learning Objective:** To demonstrate knowledge and understanding of centrifugal pump	

E1. Characteristics Curve **(Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47)** **Specific Learning Objective:** To demonstrate knowledge and understanding of centrifugal pump characteristics 1.1. Determine operational characteristics of a given centrifugal pump using experimental setup	2
E2. Design of centrifugal pump **(Ref: IMO 7.02 Competence 1.2 section 2.6 Page 47)** **Specific Learning Objective:** To demonstrate knowledge and understanding of centrifugal pump design 2.1 Study design of centrifugal pump considering important parts like impeller, vanes, casing etc.	4
F. Fluid flow and characteristics of major systems **(Ref: IMO 7.04 Competence 1.4 Section 1.9 Page 54-55)** **General Learning Objective:** To demonstrate knowledge and working of different components of major systems like diesel engine propulsion plant, steam turbine propulsion plant such as valves, piping etc.	
F1. Hydraulic System **(Ref: IMO 7.04 Competence 1.4 Section 1.9 Page 54-55)** **Specific Learning Objective:** To demonstrate knowledge and working of a complete hydraulic system 1. 1 Study design and performance of any one hydraulic system considering its important components, pipes and fittings, valves, hydraulic power etc.	6

Subject Name/Code: Applied Thermodynamics and Industrial Chemistry (P)/312

Instructional hours:

Practical	: 30 hours
Total contact hours	: 30 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. McConkey, A., Eastop, T. D. (1983). Applied Thermodynamics for Engineering Technologist: SI Units. United Kingdom: Longman.

Reference:

1. IS 3025 (Part 44):1993 Methods of sampling and test (Physical and Chemical) for water and waste water – Biological Oxygen Demand (BOD).
2. IS 3025 (Part 58):2006 Indian Standard Methods of Sampling and test (Physical and Chemical) for water and waste water – Chemical Oxygen Demand (COD).
3. IS:10496 -1983 Indian Standard – Specification for feed water, boiler water and condensate for high pressure boilers.
4. IS 1448 [P:20]:1998 Indian Standard Methods of Test for Petroleum and its products – Determination of flash point by Abel Apparatus.
5. IS:1448[P:6] – 1984, Indian standard Methods of test for Petroleum and its products – Heat of combustion of liquid hydro carbon fuels by bomb calorimeter method.
6. IS:1448[P:7] – 2004, Indian standard Methods of test for Petroleum and its products – Determination of Calorific Value by Calculation.
7. IS 5456:2006, Indian standard Testing of positive displacement type air compressors and exhausters – code of practice.

Books that can be referred to on internet (Free sources):

1. Keenan, J.H., Hatsopoulos, G.N. (1965). Principles of general thermodynamics. United Kingdom: Wiley. - www.archive.org.
2. Karamchandani, C.J., Patel, R.C.(1963).Elements of Heat Engines.(n.p.):Acharya Book Depot [1962-63, vol 1 - 3 - http://thermodynamicsheatengines.com/downloads.html.
3. The Dynamics and Thermodynamics of Compressible Fluid Flow. (1953). United State: Ronald Press. Vols I and II - www.archive.org.

Table of Topics

Section	Topics	Hours (P)
A	Tests regarding Sewage Treatment Plant	2
B	Boiler Water Tests	10
C	Fuels and Combustion	6
D	Air Compressor	4
E	Rankine Cycle - Steam Plant	4
F	Brayton Cycle – Turbine Plant	4
	Total	**30**

Learning Objectives	P
A Tests regarding Sewage Treatment Plant: **General Learning Objectives** • **Understand Chemical Oxygen Demand (COD) for sewage effluent** • **Understand the Biological Oxygen Demand (BOD) for aerobic process** **Sub-Topics:** 1.1 Test a sample for COD 1.2 Test a sample for BOD	
A1 Specific Learning Objectives: (IMO 7.02:2014: 1.3, 1.4, 4.2) (IMO 7.04:2014, 1.5, 4.1) **1.1 COD** 1.1.1 Sampling and sample preservation shall be done as prescribed in IS 3025 (Part 1) (A sample is refluxed with a known amount of potassium bichromate in sulphuric acid medium and the excess of bichromate is titrated against ferrous ammonium sulphate. The amount of bichromate consumed is proportional to the oxygen required to oxidize the oxidizable organic matter)	1
A2 Specific Learning Objectives: (IMO 7.02,2014: 1.3, 1.4, 4.2) (IMO 7.04:2014, 1.5, 4.1) **1.1 BOD** 1.1.1 Sampling and sample preservation shall be done as prescribed in IS 3025 (Part 1) (The standard test condition includes incubating the sample in an air tight bottle, in dark at a specified temperature for specific time)	1

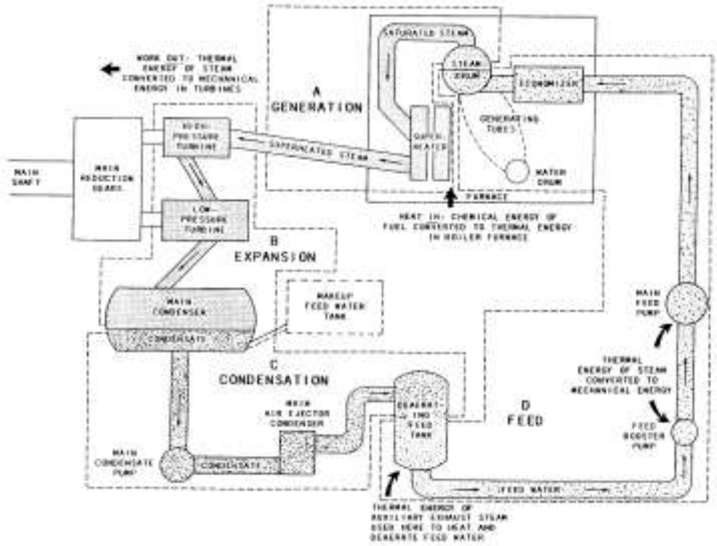
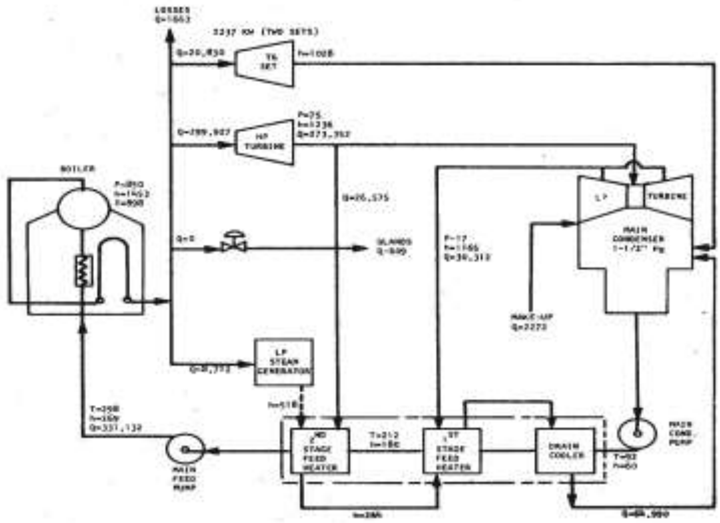
Learning Objectives	P
B Boiler Water Tests **General Learning Objectives** Understand the condition of Boiler Water to take appropriate maintenance measures	
B1 Standard Shipboard tests **Specific Learning Objectives:** **(IMO 7.04,2014: 1.4, Appendix 5 – 1.3) (IMO 7.02,2014: 1.3, 3.16, 3.19,3.20)** 1.1.1 Explain the significance of following tests: - Colour / Turbidity - pH Value - Electrical Conductance - Specific Gravity - Dissolved Solids - Alkalinity - Total Hardness - Sulphates - Sulphites - Phosphates	1

- Chlorides - Silica - Dissolved Oxygen - Nitrite - Calcium - Iron 1.1.2 Demonstrate the method of estimating the above water parameters using standard test kits	
B2 Specific Learning Objectives: **(IMO 7.04,2014: 1.4, Appendix 5 – 1.3) (IMO 7.02,2014: 1.3, 3.16, 3.19,3.20)** **1.1 Determination of Iron** 1.1.1 Explain the Determination by photometric anthralin method	1
B3 Specific Learning Objectives: **(IMO 7.04,2014: 1.4, Appendix 5 – 1.3) (IMO 7.02,2014: 1.3, 3.16, 3.19,3.20)** **1.1 Determination of Copper** 1.1.1 Explain the Determination by Neocuproine method	1
B4 Specific Learning Objectives: **(IMO 7.04,2014: 1.4, Appendix 5 – 1.3) (IMO 7.02,2014: 1.3, 3.16, 3.19,3.20)** **1.1 Determination of Silica** 1.1.1 Explain the Determination by Colorimetric – Molybdate Reactive Silica	1
B5 Specific Learning Objectives: **(IMO 7.04,2014: 1.4, Appendix 5 – 1.3) (IMO 7.02,2014: 1.3, 3.16, 3.19,3.20)** **1.1 Determination of Dissolved Solids** 1.1.1 Explain the Determination by Electrical Conductivity Methods	1
B6 Specific Learning Objectives: **(IMO 7.04,2014: 1.4, Appendix 5 – 1.3) (IMO 7.02,2014: 1.3, 3.16, 3.19,3.20)** **1.1 Determination of Chlorides (Low Range)** 1.1.1 Explain the Determination by Colorimetric method	1
B7 Specific Learning Objectives: **(IMO 7.04,2014: 1.4, Appendix 5 – 1.3) (IMO 7.02,2014: 1.3, 3.16, 3.19,3.20)** **1.1 Determination of Sodium** 1.1.1 Explain the action: When a solution containing dissolved sodium is aspirated into a flame, a characteristic yellow-orange colour will result. The intensity of this flame is a function of concentration. Flame filter photometer apparatus is used for measuring the intensity of this emitted light	1
B8 Specific Learning Objectives: **(IMO 7.04,2014: 1.4, Appendix 5 – 1.3) (IMO 7.02,2014: 1.3, 3.16, 3.19,3.20)** **1.1 Determination of Hardness** 1.1.1 Explain the action: When a solution containing dissolved sodium is aspirated into a flame, a characteristic yellow-orange colour will result. The intensity of this flame is a function of concentration 1.1.2 Flame filter photometer apparatus is used for measuring the intensity of this emitted light	1
B9 Specific Learning Objectives: **(IMO 7.04,2014: 1.4, Appendix 5 – 1.3) (IMO 7.02,2014: 1.3, 3.16, 3.19,3.20)** **1.1 Determination of Total Phosphate and Emergency pH** 1.1.1 Explain the action: Conversion of all of the phosphate ions to hydrogen phosphate ions by adding H+. Then, the concentration of hydrogen phosphate ions can be determined. Both processes are most easily done by performing a titration with nitric acid	1
B10 Specific Learning Objectives: **(IMO 7.04,2014: 1.4, Appendix 5 – 1.3) (IMO 7.02,2014: 1.3, 3.16, 3.19,3.20)** **1.1 Determination of Dissolved Oxygen**	1

1.1.1 Explain the action: Dissolved oxygen oxidizes iodide, I-, to iodine, I2, in the presence of manganese(II) salts. In basic solution, manganese(II) hydroxide, Mn(OH)2, is oxidized to hydrated manganese(IV) oxide, MnO2 1.1.2 This compound in acidic solution oxidizes iodide ion to free iodine and the manganese(IV) oxide is reduced to the original Mn2+. Since the manganese(II) ions are present at both the beginning and the end of the process in the same valence state, Mn2+, they can be regarded as catalysts and are omitted when writing the overall equations 1.1.3 The iodine produced can be determined by titration with a standard sodium thiosulfate solution, Na2S2O3, using starch as an indicator. Starch forms a dark blue/violet complex with iodine, and the end point of the titration is indicated by the disappearance of the blue colour 1.1.4 From the volume of the thiosulfate solution used, the amount of iodine generated can be determined 1.1.5 This can be related to the amount of oxygen in the original sample	

Learning Objectives	P
C Tests regarding Fuels: **General Learning Objectives** • **Understand Flash point of fuels** • **Understand Calorific value of fuels** **Sub-Topics:** 1.1 Test a sample for Flash point 1.2 Test a sample for Higher Calorific Value 1.3 Test a sample for Lower Calorific Value	
C1 Specific Learning Objectives: (IMO 7.02:2014: 1.5) (IMO 7.04:2014, 1.5, 4.1) **1.1 Flash Point of Fuels** 1.1.1 Explain the action: The lowest temperature of the sample, corrected to a barometric pressure of 101.3 kPa, at which, application of a test flame causes the vapour of the sample to ignite under the specified conditions of test 1.1.2 Explain the action: The sample, suitably cooled, is placed in the cup of the Abel apparatus and heated at a prescribed rate. A small test flame is directed into the cup at regular intervals, and the flash point is taken as the lowest temperature at which application of the test flame causes the vapour above the sample to ignite with a distinct flash inside the cup	2
C2 Specific Learning Objectives: (IMO 7.02,2014: 1.5) (IMO 7.04:2014, 1.5, 4.1) **1.1 Higher Calorific Value of Fuels** 1.1.1 Explain the action: The gross heat of combustion of a fuel at constant volume is the number of heat units measured as being liberated at 25°C when unit mass of the fuel is burned in oxygen saturated with water vapour in a bomb under standard conditions. The resultant materials in the bomb are considered. as being gaseous oxygen, carbon dioxide, sulphur dioxide, nitrogen, liquid water in equilibrium with its vapour and saturated with carbon dioxide, other compounds in solution, and solid ash	2
C3 Specific Learning Objectives: (IMO 7.02,2014: 1.5) (IMO 7.04:2014, 1.5, 4.1) **1.1 Lower Calorific Value of Fuels** 1.1.1 Explain the action: The net heat of combustion of a fuel at constant pressure is the number of heat units measured as being liberated at 25°C when unit mass of fuel is burned in oxygen at constant pressure such that the heat released is equal to the gross heat of combustion of the fuel at constant pressure less than latent heat of evaporation at 25°C and constant pressure of the water both originally contained in the fuel and formed by its combustion	2

Learning Objectives	P
D Reciprocating type Air Compressor **General Learning Objectives** • **Carry out performance analysis of reciprocating air compressor** **Sub-Topics:** 1.1 Capacity (Free Air Delivery) Tests 1.2 Volumetric and Overall Efficiency of Machine	
D1 Specific Learning Objectives: (IMO 7.02,2014: 1.3) (IMO 7.04:2014, 1.3, 1.4) **1.1 Free Air Delivery (FAD)** 1.1.1 Explain that the flow rate should be calculated on the basis of charging a receiver of known capacity 1.1.2 Explain that the charging flow rate of the cubic meters per minute is calculated as per Appendix C of IS 5456:2006 Testing of positive displacement type air compressors and exhausters	2
D2 Specific Learning Objectives: (IMO 7.02:2014: 1.3) (IMO 7.04:2014, 1.3, 1.4) **1.1 Overall Efficiency of the compressor** 1.1.1 Explain that the overall efficiency is the ratio of theoretical power required to compress the amount of air actually delivered to input power to the compressor. 1.1.2 Explain that to determine the overall efficiency of the compressor, the following procedure should be followed: • Measure the output of the compressor (FAD) • Measure the suction and delivery pressure and input power to the compressor • Find out swept and clearance volume from the bore, stroke and total volume of the cylinder • By drawing the PV diagram work done per swept volume of air shall be found out. Multiply it by the ratio of output capacity to swept volume. This shall give theoretical power required to compress the amount of air actually delivered. • Ratio of this to the input power to compressor shall give overall efficiency of the compressor	2

Learning Objectives	P
E Rankine Cycle Steam Plant **General Learning Objectives** • **Identify, label and describe the components of a Steam plant and carry out heat balance for the system** **Sub-Topics:** 1.1 Components identification and tracing 1.2 Heat Balance Diagram to prepare	
E1 Specific Learning Objectives: **(IMO 7.02,2014: 1.2, 1.2.4.2) (IMO 7.04:2014, 1.2,1.4)** **1.1 Steam Plant Layout:** Identify all the components and trace them in the workshop / laboratory  (courtesy: NAVEDTRA / USCG)	2
E2 Specific Learning Objectives: **(IMO 7.02,2014: 1.2, 1.2.4.2) (IMO 7.04:2014, 1.2, 1.4)** **1.1** Identify the power / ratings of individual components and draw heat balance diagram  (courtesy: Woodward / UMICH)	2

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F Gas Turbine Plant (Brayton cycle based)

General Learning Objectives

- **Identify, label and describe the components of a Gas Turbine plant and carry out heat balance for the system**

Sub-Topics:

1.1 Components identification and tracing

1.2 Heat Balance Diagram to prepare

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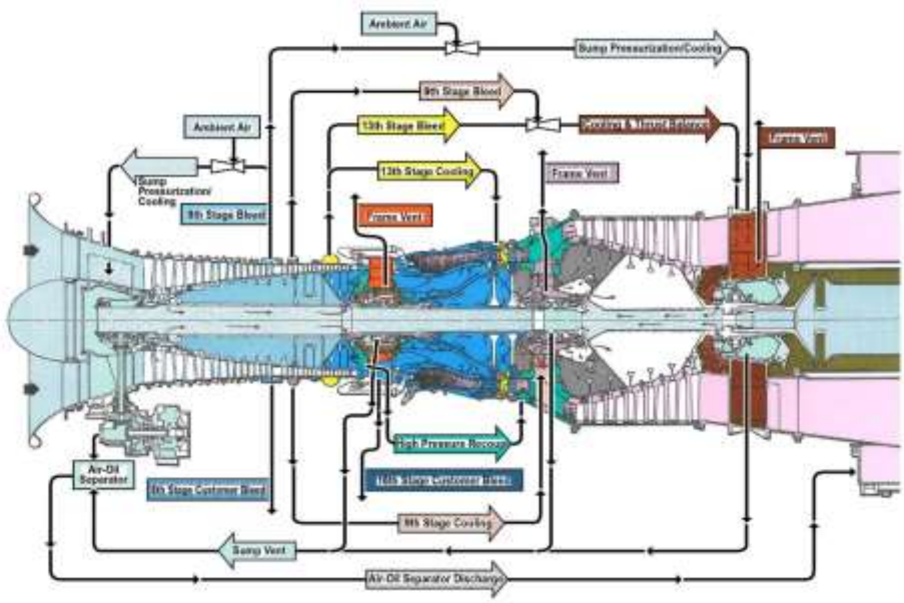
F1 Specific Learning Objectives: (IMO 7.02,2014: 1.1,1.2.4.3, 1.3) (IMO 7.04:2014, 1.2,1.4)

1.1 Steam Plant Layout: Identify all the components and trace them in the workshop / laboratory



(Courtesy: NAVEDTRA / USCG)

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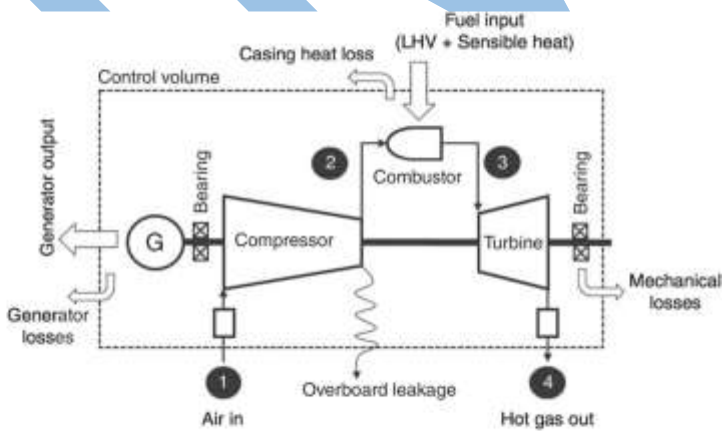
F2 Specific Learning Objectives: (IMO 7.02,2014: 1.1,1.2.4.3, 1.3) (IMO 7.04:2014, 1.2,1.4)

1.1 Identify the power / ratings of individual components and draw heat balance diagram



(Courtesy: S Can Gulen (https://doi.org/10.1017/9781108241625.008)

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Subject Name/Code: Marine Workshop (Electrical Safety, Maintenance and Repair) (P)/313

Instructional hours:

Practical	: 45 hours
Total contact hours	: 45 hours
Credits	: 1.5

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Practical assessment Hands on skills	: 50%
Viva voce	: 50%

Recommended Text:

1. Practical Course Handout Marine Machinery Systems.
2. Practical Hand out Electrical Knowledge.
3. Electrical Machinery, P.S. Bimbhara, Khanna Publishers.

Reference:

1. Practical Marine Electrical Knowledge by Dennis T. Hall.
2. Ship's Equipment Manual and Drawings.

Table of Topics

Section	Topics	Hours P
A1 - 2	**Workshop layout and system tracing of Diesel Generator of Ship in campus** **sub topics/SLO**: sea water system, fresh water system, fuel oil system, lube oil system, starting air system.	3
B1 - 6	**Dismantling, maintenance checks, Assembly of Valves** **Sub topics**: overhauling of Gate valve, Globe valve, Butterfly valve, Boiler safety valve, Gasket cutting, gland packing	9
C1 - 2	**Power tools and filters** **Sub topics**: bearing removal by extractor, stud extractor, other power tools like pneumatic chipping gun Different types of filters	6
D1 -4	**Dismantling, maintenance checks, Assembly of Pumps**. **Sub topics**: Overhauling of centrifugal pump, Reciprocating pump, screw pump, Gear pump	8
E1	**Reciprocating Air compressor** Dismantling, maintenance checks, Assembly of Reciprocating Air compressor	3
F1	**Basic Electrical Knowledge** **Sub topics**: Performance analysis of single phase A.C. series and parallel circuits and 3 phase circuits, measurement of power and energy.	8
G1	**Transformers in Electrical Machines** **Sub Topics:** OC & SC tests of 1 phase transformer, Polarity tests of 1 phase transformer, Parallel operation of single-phase transformers, single phase transformers connections as Y-Y, Y-D, D-Y and D-D.	8
	Total	**45**

Learning Objectives	P
(IMO 7.04,2014: B3.2.2.5), (IMO 7.04,2014: B3 .1.6, 7), **(IMO 7.04,2014: B 3.2.3.2, 3, 4), (IMO 7.04,2014: B 3.2.3.6)**	
A.1 Workshop Layout and system tracing of Diesel Generator of Ship in campus **General Learning Objective** 1.1 Understand the various sections and Machines in workshop and their applications 1.2 Understand the function of Freshwater, Sea Water, Lube oil, Fuel Oil System and Air System of auxiliary Engine	**3**
1.1 Specific Learning Objectives 1.1.1 Familiarize the layout of machineries in the ship on campus/plant in campus 1.1.2 Understand the importance of the machinery and its purpose	1
A.2: System tracing of Diesel Generator 1.2.1 Evaluate various components fitted in Freshwater, Sea Water, Lube oil, Fuel 1.2.2 Evaluate Oil System and Air System of auxiliary Engine 1.2.3 Evaluate the understanding of logic behind locating various components in the system with its purpose 1.2.4 Evaluate the understanding of tracing of various shipboard pipelines 1.2.5 Evaluate the understanding of Functions of various components fitted in Freshwater, Sea Water, Lube oil, Fuel Oil System and Air System of auxiliary Engine	2
B. Dismantling, maintenance checks, Assembly of Valves (IMO 7.04,2014: B3.2.2.5) **General Learning Objective`** 2.1 Identify a Gate valve 2.2 Globe valve 2.3 Butterfly valve 2.4 Boiler safety valve and its components along with Assembly/disassembly	**9**

2.5 Safe working practices to be followed while cutting the gasket joints 2.6 Gland packing	
Specific Learning Objectives	
B.1: Gate valve 2.1.1 Identify a Gate valve from its appearance 2.1.2 Give examples of on-board applications 2.1.3 Demonstrate dismantling of a Gate valve 2.1.4 Identify all the components and their function 2.1.5 Differentiate between Rising stem and Non-rising stem type Gate valve 2.1.6 Describe seat insertion and removal procedure (No demonstration required) 2.1.7 Describe how fluid tightness is achieved 2.1.8 Demonstrate assembling of a gate valve 2.1.9 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools; 2.1.10 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations;	1.5
B.2: Globe valve 2.2.1 Identify a Globe valve from its appearance and be Able to describe the stamping 2.2.2 Identify correct flow direction w.r.t. pipeline mounting 2.2.3 Give examples of on-board applications 2.2.4 Demonstrate dismantling of a Globe valve 2.2.5 Identify all the components, their functions and possible defects 2.2.6 Differentiate between SDNR (Screw down Non-Return) and SDR (Screw Down Return) type Globe valve 2.2.7 Describe how fluid tightness is achieved 2.2.8 Demonstrate cutting of appropriate joints prior assembling 2.2.9 Demonstrate assembling of a globe valve 2.2.10 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools 2.2.11 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	1.5
B.3: Butterfly valve 2.3.1 Identify a butterfly valve from outside 2.3.2 Describe the purpose of the butterfly valve 2.3.3 Demonstrate dismantling of a butterfly valve 2.3.4 Identify all components and their function 2.3.5 Demonstrate assembling of butterfly valves 2.3.6 Describe how fluid tightness is achieved 2.3.7 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools 2.3.8 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	1.5
B.4: Boiler safety valve 2.4.1 Identify a Boiler safety valve from its appearance 2.4.2 Give examples of on-board applications 2.4.3 Demonstrate dismantling of a Boiler safety valve 2.4.4 Identify all the components, their functions and possible defects 2.4.5 How the setting of the Boiler safety valve is done 2.4.6 Describe how fluid tightness is achieved 2.4.7 Demonstrate cutting of appropriate joints prior assembling 2.4.8 Demonstrate assembling of a Boiler safety valve 2.4.9 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools 2.4.10 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	1.5
B.5: Gasket cutting 2.5.1 Describe the function of gaskets 2.5.2 Give examples of materials used for gaskets 2.5.3 Describe the selection of the appropriate material and thickness of gasket sheet as per the requirement 2.5.4 Describe/demonstrate following procedure for accurately marking of joint sheets:	1.5

From previously used joints used as template 2.5.5 Taking exact dimensions of ID & OD, cutting out the same and then marking for the hole 2.5.6 By using chalk, grease or some other paste by applying it on sealing flange and taking impression on the joint sheet 2.5.7 Using the flange or spare flange and marking dimensions on the joint sheet 2.5.8 Demonstrate the procedure of cleaning the surface prior installation of new gaskets 2.5.9 Describe the do's & don'ts for the entire process 2.5.10 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	
B.6: Gland Packing 2.6.1 Describe the function of Gland packing 2.6.2 Give examples of materials used for gland packing 2.6.3 Describe the selection of the appropriate material and thickness of gland packing as per the requirement 2.6.4 Describe the procedure of taking out the old gland packing and replacing a new one 2.6.5 Describe the do's & don'ts for the entire process 2.6.6 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	1.5
C. Power tools and filters (IMO 7.04,2014: B3 .1.6, 7**)** **General Learning Objective** Identify bearing removal by extractor, stud extractor, other power tools like pneumatic chipping gun etc. Identify different types of filters used on ships	**6**
Specific Learning Objectives	
C.1: Power tools 3.1.1 Demonstrate use of stud remover for removing a broken stud 3.1.2 Demonstrate bearing extraction from pump / motor shaft using bearing puller 3.1.3 Able to use power tools following safe working practices 3.1.4 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools 3.1.5 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	3
C.2: Filters 3.2.1 Identify different type of filters used on ships 3.2.2 Describe the purpose of filter 3.2.3 Demonstrate dismantling of a filters 3.2.4 Identify all components and their function 3.2.5 Demonstrate assembling of filter 3.2.6 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools 3.2.7 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	3
D. Dismantling, maintenance checks, Assembly of Pumps. **(IMO 7.04,2014: B 3.2.3.2, 3,)** **General Learning Objective** Identify and distinguish the various parts of centrifugal pump, reciprocating pump, screw pump and Gear pump and understand the maintenance required to be carried out on centrifugal pump, reciprocating pump, screw pump and Gear pump and Will be Able to follow all safety precautions	**8**
Specific Learning Objectives	
D.1: Centrifugal Pump 4.1.1 Demonstrate briefly the principle of operation of a centrifugal pump 4.1.2 Give examples of on-board applications 4.1.3 Demonstrate briefly types of centrifugal pumps and their classification 4.1.4 Enumerate safety precautions & isolation prior overhauling 4.1.5 Demonstrate dismantling of a centrifugal pump 4.1.6 Identify all the components and their functions 4.1.7 Demonstrate the movement of liquid inside the pump from suction to discharge 4.1.8 Identify the direction of rotation of pump with respect to curvature of impeller vanes and direction of volute	3

4.1.9 Identify the possible defects and their rectification – wear ring clearance, cavitation, erosion, corrosion, scoring of Shaft sleeve, scaling and deposits etc. 4.1.10 Demonstrate Assembling of a centrifugal pump 4.1.11 Demonstrate working of mechanical seal and identification of parts 4.1.12 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools 4.1.13 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	
D.2: Reciprocating Pump 4.2.1 Give examples of on-board applications of reciprocating pumps 4.2.2 Enumerate safety precautions & isolation prior overhauling 4.2.3 Demonstrate complete dismantling of a reciprocating pump 4.2.4 Identify all the components and their function 4.2.5 Demonstrate the significance of suction/discharge valves 4.2.6 Identify positioning and significance of relief valves 4.2.7 Identify the positioning & function of the accumulator on the pump discharge side 4.2.8 Demonstrate how lubrication of crosshead/guides/con-rod takes place. (wick lubrication) 4.2.9 Demonstrate the double acting function of the reciprocating pump 4.2.10 Demonstrate the movement of liquid inside the pump from suction to discharge & be able to reason the direction of flow in case the direction of rotation of prime mover is reversed 4.2.11 Identify possible defects of the pump and their rectification 4.2.12 Demonstrate Assembling of a reciprocating piston pump 4.2.13 Demonstrate operation of a reciprocating piston pump in a ship on campus 4.2.14 Demonstrate the significance of reading and interpreting the suction and discharge pressure gauges for troubleshooting 1.4.4 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools 1.4.5 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	3
D.3: Screw Pump 4.3.1 Demonstrate briefly the principle of operation of a screw pump 4.3.2 Give examples of on-board applications 4.3.3 Demonstrate briefly types of screw pumps ` 4.3.4 Enumerate safety precautions & isolation prior overhauling 4.3.5 Identify positioning and significance of relief valve 4.3.6 Demonstrate dismantling of a screw pump 4.3.7 Identify all the components and their functions 4.3.8 Demonstrate the movement of liquid inside the pump from suction to discharge 4.3.9 Identify the possible defects and their rectification 4.3.10 Demonstrate Assembling a screw pump 4.3.11 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools 4.3.12 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	1
D.4: Gear Pump 4.4.1 Demonstrate briefly the principle of operation of Gear pump 4.4.2 Give examples of on-board applications 4.4.3 Demonstrate briefly types of Gear pumps 4.4.4 Enumerate safety precautions & isolation prior overhauling 4.4.5 Identify positioning and significance of relief valve 4.4.6 Demonstrate dismantling of a Gear pump 4.4.7 Identify all the components and their functions 4.4.8 Demonstrate the movement of liquid inside the pump from suction to discharge 4.4.9 Identify the possible defects and their rectification 4.4.10 Demonstrate Assembling a Gear pump 4.4.11 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools 4.4.12 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations .	1

E Dismantling, maintenance checks, Assembly of Reciprocating Air compressor **(IMO 7.04,2014: B 3.2.3.6)** **General Learning Objective** Identify and distinguish the various parts of the Air compressor and understand the maintenance required to be carried out on the Air compressor and Will be Able to follow all safety precautions	**3**
Specific Learning Objectives	
E.1: Reciprocating Air Compressor. 5.1.1 Identify a reciprocating air compressor and different stages of the same 5.1.2 Enumerate safety precautions/isolation prior dismantling of the compressor 5.1.3 Demonstrate the dismantling of valve assembly, identify all components and assemble the same correctly 5.1.4 Identify all the major components and their functions 5.1.5 Identify and demonstrate the functions of the following fittings and attachments: Lube oil pump & L.O. filter, cooling water pump, unloader, drain valve, intercooler, after cooler, non-return valve (2nd stage discharge), bursting disc, 1st & 2nd stage relief valve, Suction filter & silence, crankcase breather 5.1.6 Dismantle the unloader and demonstrate its function 5.1.7 Remove crank-case cover and be Able to identify and demonstrate the major components 5.1.8 Demonstrate the method of cylinder lubrication 5.1.9 Read & interpret technical parameters/documentation, plan and organize work processes, identify necessary materials and tools 5.1.10 Perform tasks with due consideration to safety rules, accident prevention regulations and environmental protection stipulations	3
F. Basic Electrical Knowledge	
General Learning Objective Understand the operation and working principle of various electrical equipment & Performance analysis of single phase A.C. series and parallel circuits **F1. Sub Topic: Basics of Electricity IMO (7.04,2014: F2/2.1.1)** **Sub-sub topics & SLOs** 1.1 Explain performance analysis of single phase A.C. series and parallel circuits with R-L-C combination with Phasor diagram 1.2 Measure power in a three phase circuit by the two-wattmeter method 1.3 Explain verification of voltage & current in three phase balanced star & delta network 1.4 Explain measurement of energy in a single phase circuit using analogue and digital energy meters	**8**
Specific Learning Objectives: (7.04,2014: F2/2.1.1) **1.1 Performance analysis of single phase A.C. series and parallel circuits with R-L-C combination with Phasor diagram** 1.1.1 Explain the meaning of inductive and capacitive reactance 1.1.2 Explain the variation of reactance with frequency 1.1.3 Develop the condition for resonance in a series RLC circuit 1.1.4 Develop the condition for resonance in parallel RLC circuits 1.1.5 Explain the phasor relationship between voltage and current in a series circuit 1.1.6 Explain the phasor relationship between voltage and current in a parallel circuit 1.1.7 Draw phasor diagram	2
Specific Learning Objectives: (7.04,2014: F2/2.1.1) **1.2 Measure power in a three phase circuit by two-wattmeter method** 1.2.1 Explain measurement of active and reactive power 1.2.2 Explain power triangles 1.2.3 Draw a power triangle.	2
Specific Learning Objectives: (7.04,2014: F2/2.1.1) **1.3 Verification of voltage & current in three phase balanced star & delta network** 1.3.1 Show the relationship between line current and phase current in star and delta connection 1.3.2 Show the relationship between line voltage and phase voltage in star and delta connection 1.3.3 Draw the phasor diagram	2
Specific Learning Objectives: (7.04,2014: F2/2.1.1) **1.4 Measurement of energy in single phase circuit using analogue and digital energy meter**	2

1.4.1 Describe the connection of the energy meter in a single phase circuit ` 1.4.2 Describe the working of an energy meter 1.4.3 Verify the actual consumed energy and energy shown by the meter	
G Transformers in Electrical Machines	
General Learning Objective Understand the concept of OC and SC of transformers and identify polarities, learn the parallel operation of transformers and different connections of transformer windings G1. **Sub Topic: Transformers IMO 7.02, 2014: F2/2.1.3, 3.8, (IMO 7.04,2014: F2/1.3(3);** **Sub-sub topics & SLOs** 2.1 Explain OC & SC tests of 1 phase transformer 2.2 Explain Polarity tests of 1 phase transformer 2.3 Explain Parallel operation of single-phase transformers. 2.4 Explain to connect single phase transformers (3 pcs) in the following ways a) Y-Y b) Y-D c) D-Y d) D-D 2.5 Explain the advantages of D-D transformers	**8**
Specific Learning Objectives: **2.1 OC & SC tests of 1 phase transformer** 2.1.1 Explain different losses in transformer like iron loss and copper loss 2.1.2 Calculate winding parameters and regulation of transformer 2.1.3 Explain the purpose of OC and SC test	2
Specific Learning Objectives: **2.2 Polarity tests of 1 phase transformer** 2.2.1 Identify voltage polarity of windings of single phase transformer 2.2.2 Explain additive polarity and subtractive polarity 2.2.3 Explain connection of polarity test	2
Specific Learning Objectives: **2.3 Parallel operation of single-phase transformers.** 2.3.1 Show the conditions for parallel operation of transformer 2.3.2 Connect two transformers in parallel and understand load sharing	2
Specific Learning Objectives: **2.4 To connect single phase transformers (3 pcs) in the following ways a) Y-Y b) Y-D c) D-Y d) D-D and advantages of D-D transformers.** 2.4.1 Describe the connections of transformer as Y-Y 2.4.2 Describe the connections of transformer as Y-D 2.4.3 Describe the connections of transformer as D-D 2.4.4 Describe the connections of transformer as D-Y 2.4.5 Describe the applications of different type of connections 2.4.6 Describe the concept of neutral in the phase arrangement	2

SEMESTER 4

Subject Name/Code: Strength of Materials/401

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisites: Fundamentals of engineering mechanics and solid mechanics.

Recommended Text:

1. Reed Volume 2: Applied Mechanics for Engineers; By William Embleton; Revised by J.T. Gunn; Publisher Sunderland Tyne and Wear) Thomas Reed.1983: ISBN0900335874.
2. Strength of Materials, R S Khurmi, S. Chand.

Reference:

1. Strength of Materials, G. H. Ryder, Macmillan Pub, India.
2. Strength of Materials, Ramamrutham S, Dhanpat Rai Publishing, New Delhi.
3. Strength of Materials, Rajput R.K, S. Chand Publishing, New Delhi.
4. NPTEL online course: strength of material by Prof. Sriman Kumar Bhattacharyya.
5. https://onlinecourses.nptel.ac.in/noc20_ce34/preview.

Table of Topics

Section	Topics	Hours (L)
A	Shear force and Bending Moment	8
B	Bending stresses in beams	8
C	Deflection of Beams	9
D	Fixed and Continuous Beams	8
E	Thin curved Bars	5
F	Stability of Columns	7
	Total	**45**

Learning Objectives	**L**
General Learning Objective: Understand the concept of shear forces, bending moments and their effect on stresses, Slopes and deflections in beams, stresses and deformation in thick cylindrical shell and buckling of columns. **Specific Learning Objectives: (IMO 7.02,2014:1.2.5, NPTEL Sway am)** **A. Shearing force and Bending Moment (NPTEL Sway am)** **Specific Learning Objective:** Understand principles of statics to determine reactions & internal forces in statically determinate beams. 1.1 Types of loads, supports and beams 1.2 Concept of shearing force and bending moment 1.3 Relationship between loading intensity, shear Force and bending moment 1.4 Shear force and bending moment diagrams for statically determinate beams subjected to points load, uniformly distributed loads, uniformly varying loads, couple and their combinations 1.5 Numerical with different loading condition	**8**
1.1 Types of loads, supports and beams (NPTEL Sway am) 1.1.1 Define types of loads 1.1.2 Define types of supports 1.1.3 Define types of beams	1
1.2 Concept of shearing force and bending moment (NPTEL Sway am) 1.2.1 Define shear force and bending moment 1.2.2 Define convention	1
1.3 Relationship between loading intensity, shear Force and bending moment (NPTEL Sway am) 1.3.1 Apply derivation	1
1.4 Shear force and bending moment diagrams for statically determinate beams subjected to points load, uniformly distributed loads, uniformly varying loads, couple and their combinations. (NPTEL Sway am) 1.4.1 Apply derivation for different loading condition 1.4.2 Define point of contra-flexure	2
1.5 Numerical with different loading condition	3

B. 2.0 Bending stresses in beams (NPTEL Sway am) **Specific Learning Objectives:** Understand different types of stresses developed in the member subjected to bending effects. 2.1 Theory of simple bending 2.2 Assumptions in theory of bending 2.3 Derivation of flexural formula 2.4 Second moment of area of common cross sections (rectangular, I, T, C) with respect to centroid and parallel axes, bending stress distribution diagrams, moment of resistance and section modulus 2.5 Numerical on bending stress 2.6 Axial and bending stress **(IMO 7.02,2014:1.2.5)** 2.7 Combined bending and twisting **(IMO 7.02,2014:1.2.5)**	**8**
2.1 Theory of simple bending (NPTEL Sway am) 2.1.1 Explain bending equation **2.2 Assumptions in theory of bending (NPTEL Sway am)**	1
2.3 Derivation of flexural formula (NPTEL Sway am) 2.3.1 Explain with diagram	1
2.4 Second moment of area of common cross sections (rectangular, I, T, C) with respect to centroid and parallel axes, bending stress distribution diagrams, moment of resistance and section modulus. (NPTEL Sway am) 2.4.1 Explain Calculation of second moment of area for common cross section 2.4.2 Explain Diagrams showing bending stress distribution 2.4.3 Explain Calculation of moment of resistance 2.4.4 Explain Calculation of section modulus	2
2.5 Numerical on bending stress	2
2.6 Axial and bending stress (IMO 7.02,2014:1.2.5) 2.6.1 Apply derivation on axial and bending stress	1
2.7 Combined bending and twisting (IMO 7.02,2014:1.2.5) 2.7.1 Apply derivation on Combined bending and twisting	1
C. 3.0 Deflection of Beams (NPTEL Sway am) **Specific Learning Objective:** Understand Slopes and deflections in beams and determine parameters by various methods. 3.1 Beam deflection 3.2 Slope, deflection and radius of curvature 3.3 Types of methods 3.1 Double integration and Macaulay's methods 3.2Determination of Slope and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, uniformly varying load and couple 3.3 Moment area method	**9**
3.1 Beam deflection (NPTEL Sway am) 3.1.1 Explain with diagram the deflection phenomenon	1
3.2 Slope, deflection and radius of curvature (NPTEL Sway am) 3.2.1 Explain Relationship between slope, deflection and radius of curvature 3.2.2 Explain Sign conventions	1
3.3 Types of methods (NPTEL Sway am) 3.3.1 Explain types of different methods to determine values 3.3.2 Explain the significance of methods	1
3.4 Double integration and Macaulay's methods (NPTEL Sway am) 3.4.1 Explain of stepwise procedure	2

3.5 Determination of sloped and deflection for cantilever and simply supported beams subjected to point loads, U.D.L, uniformly varying load and couple (NPTEL Sway am) 3.5.1 Derive each load condition using suitable method 3.5.2 Derive by Numerical calculations etc.	2
3.6 Moment area method (NPTEL Sway am) 3.6.1 Define Mohr's Theorem 3.6.2 Define Application to simple cases	2
D. 4.0 Fixed and Continuous Beams **Specific Learning Objective:** Understand Slopes and deflections infixed and continuous Beams. 4.1 Fixed beam subjected to central load 4.2 Fixed beam subjected to eccentric point load 4.3 Fixed beam subjected to uniformly distributed load 4.4 Continuous Beam 4.5 Clapeyron's Theorem of three moment 4.6 Numerical on fixed beam and continuous beam	**8**
4.1 Fixed beam subjected to central load 4.1.1 Explain Derivation 4.1.2 Perform Numerical	1
4.2 Fixed beam subjected to eccentric point load 4.2.1 Explain Derivation 4.2.2 Perform Numerical	2
4.3 Fixed beam subjected to uniformly distributed load 4.3.1 Explain Derivation 4.3.2 Perform Numerical	1
4.4 Continuous Beam 4.4.1 Explain Definition 4.4.2 Perform Numerical	1
4.5 Clapeyron's Theorem of three moment 4.5.1 Explain statement 4.5.2 Explain derivation 4.5.3 Perform numerical	3
E. 5.0 Thin curved Bars **Specific Learning Objective:** Understand deflections in curved bar subjected to bending 5.1 Strain energy due to bending 5.2 Castigliano's Theorem 5.3 Numerical Exercises	**5**
5.1 Strain energy due to bending 5.1.1 Define derivation 5.1.2 Perform numerical	2
5.2 Castigliano's Theorem 5.2.1 Define statement 5.2.2 Define derivation 5.2.3 Perform numerical	3
F. 6.0 Stability of Columns (NPTEL Sway am) **Specific Learning Objective:** Understand the concept of buckling of columns using different theories available for the analysis with various end conditions 6.1 Classification of columns 6.2 Concept of buckling of column	**7**

6.3 Assumptions in Euler's theory 6.4 Derivation for Euler's Buckling load for different end conditions 6.5 Limitations of Euler's theory 6.6 Rankine-Gordon's formula for columns 6.7 Numerical based on Euler's and Rankine's formulae	
6.1 Classification of columns (NPTEL Sway am) 6.1.1 Definition 6.1.2 Column stability 6.1.3 Classification **6.2 Concept of buckling of column (NPTEL Sway am)** 6.2.1 Explain Axial loaded compression members 6.2.2 Explain Axial loaded long columns	1
6.3 Assumptions in Euler's theory (NPTEL Sway am) **Derivation for Euler's Buckling load for different end conditions (NPTEL Sway am)** 6.3.1 State End conditions of loaded column 6.3.2 State Effective length of the column 6.3.3 State Sign convention for bending moment 6.3.4 State Derivation of Euler's formula for different end condition	2
6.4 Limitations of Euler's theory. (NPTEL Sway am) **Rankine-Gordon's formula for columns (NPTEL Sway am)** 6.4.1 Derivation	1
6.5 Numerical based on Euler's and Rankine's formulae	3

Subject Name/Code: Marine Turbo Machinery/402

Instructional hours:

Lecture	: 30 hours
Tutorial	: 15 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

Pre-requisites: Class 10, + 1 and +2 scheme (MPC Group) / Basic and Applied Thermodynamics.

Recommended Text:

1. Operations of Machinery in Ships: Steam Turbines, Boilers and Auxiliary Plant (Part 15-IME) (Part 18 - IME) Institute of Marine Engineers, IME.
2. Elements of Gas Turbine Propulsion. By Jack D Mattingly (2005). India: McGraw Hill Education (India) Pvt Limited. - Chapter 9 Turbomachinery.
3. Kearton, W. J. (2011). Steam Turbine Theory and Practice - a Textbook for Engineering Students. (n.p.): Read Books.

Reference:

1. McBirnie, S. C. (2013). Marine, Steam Engines, and Turbines. United Kingdom: Elsevier Science.
2. Marine Gas Turbines by John B Woodward, Wiley-interscience publication, a volume in Ocean Engineering (1975), ISBN 0-471-95962-6, John Wiley & Sons, Inc.
3. Lilly, L. R. C. (1984). Diesel Engine Reference Book. United Kingdom: Butterworth.
4. Fluid Mechanics and Thermodynamics of Turbomachinery by SL Dixon, CA Hall, Elsevier – Butterworth-Heinemann (2010), ISBN 978-1-85617-793-1.
5. For Sketch of Gas Turbine: Rolls – Royce – The jet Engine (1996), ISBN 0902121 235 or Industrial catalogues.
6. Marine Engineering – by group of authorities, Editor: Roy L Harrington, ISBN: 0-939773-10-4, SNAME (USA).

Free Resources on Web:

1. Introduction to Marine Gas Turbines. (1978). United States: Naval Education and Training Support Command. https://www.google.co.in/books/edition/Introduction_to_Marine_Gas_Turbines/QGbZAAAAMAAJ?hl=en&gbpv=0.
2. Principles of Naval Engineering (Revised 1970) Prepared by BUREAU OF NAVAL PERSONNEL, NAVPERS 10788-B - https://archive.org/details/principlesofnava00unit.

Table of Topics

Section	Topics	Hours (L:T)
A	Steam Turbines	0:15
B	Dimensional analysis: similitude for Turbo-machinery	6: 0
C	Turbo-compressor	4: 0
D	Gas Turbines	15:0
E	Marine Turbocharger	5: 0
Total		**30:15**

Learning Objectives	L: T
General Learning Objective: Understand fundamental theory of turbo-machines. Understand design, construction and operation of Steam Turbines, Gas Turbines, Turbo-compressor and Turbo-charger. Analyse issues in matching compressor and turbine or compressor and diesel engine. Perform calculations of forces, efficiencies, power required or output from to the turbo-machinery and assess their performance.	
Sub-sub topics **A Marine Steam Turbines:** **Specific Learning Objective: (IMO Model Course 7.04 – 1.4.1.2, 1.4.1.3, 1.4.3.1, 1.4.3.3) (IMO Model Course 7.02 – 1.1.2, 1.2.4, 1.3.3.21, 1.3.3.23, 1.3.4.2)** Explain/Discuss the following: 1.1 Introduction and Classification of Steam Turbines: Construction and description of the individual parts 1.2 The guiding devices: Nozzles with enlarged cross-section, Guide channels, Guide vanes, Attachment 1.3 Sealing: Diffuser or hub sealing, blade sealing, intermediate seals (radial turbine) 1.4 Construction of the disks 1.5 Blades: constant pressure blades, high pressure guide and rotor blade, manufacture and design of blades, buckets and locking, the sealing and stiffening of the blades, materials, the strength concept, blade erosion, blade fastening, special methods for changing angles, vibration 1.6 Nozzles, Diaphragms and Stationary blading: Nozzles, diaphragms, intermediate blades, The rim, wheel disc, wheel hub, materials, design and attachment of wheels 1.7 Drums: Arrangement and fastening, compensation of the axial thrust 1.8 Rotor: Construction, material and design 1.9 Couplings, stuffing boxes: labyrinth stuffing boxes, lid type stuffing boxes, stuffing boxes with water seal, steam feed to the stuffing boxes 1.10 Bearings: Support bearing – arrangement of bearings, bearing housing / support and design; Thrust bearing – Design of the bearings and housing 1.11 Turbine housing / casing – shape, thickness, material, Foundation frame, Oil pumps 1.12 Present steam turbines available for marine market 1.13 Axial Impulse Turbines: Description – De Laval Turbine, velocity triangles, axial thrust, Energy output and performance, efficiency, efficiency – blade speed ratio plot, utilizing exit speed, efficiency when utilizing exhaust energy 1.14 Axial Reaction Turbines: Description, velocity triangles, axial thrust, enthalpy - entropy diagram, Energy output and performance, efficiency, efficiency – blade speed ratio plot 1.15 Radial turbines: Description, velocity triangles 1.16 Compounding in Turbines: Velocity compounding with Curtis stage and Curtis Turbine, schematic and velocity triangles, Efficiency – blade speed ratio plots for single row, two row and three row of blades, implementation schematic for radial and axial turbines. Definition of stage and row 1.17 Pressure compounding with axial turbines – with pure impulse stages (Zoelly Turbines) and Rateau Turbine, schematic for pressure – velocity variation across the turbine, h-s plot	0: 15

1.18 Pressure velocity compounding with axial turbines – Curtis stages, illustration of schematic, pressure – velocity variation 1.19 Pressure compounding with Parson's reaction turbine, schematic with pressure – velocity variation and relative velocity variation across the turbine, degree of reaction, conditioning curve 1.20 Pressure compounding with Curtis stage and multi-stage Parson's turbine, schematic with pressure – velocity variation and relative velocity variation across the turbine 1.21 The losses in the steam turbines and the efficiencies: Nozzle losses, blade losses, exit losses, the wheel friction, loss by exhaust, Gland steam losses, pressure loss across labyrinth seals – pressure gradient, the mechanical losses, energy losses due to heat transfer, effect of wetness and elimination. Turbine calculations for nozzle, areas, blade length, enthalpy, speeds, angle and efficiencies for various turbines including multi-wheel and multi-stage turbines 1.22 Arrangement and Cycles, machinery arrangement, reheat turbine, reheat, steam and moisture considerations 1.23 Turbine performance – steam conditions, exhaust vacuum, extraction of steam, expansion line, turbine stage design – impulse and reaction stages, number of stages, velocity – compounded stages, stage efficiency features. Description of Main Propulsion Turbine, Auxiliary Turbines 1.24 Operation of Steam Turbines: Warming through; run up to speed etc.	
B Dimensional analysis: similitude for Turbo-machinery: **Specific Learning Objective: (IMO Model Course 7.02 – 1.3.3 – 3.1, 3.5)** Explain/Discuss the following: 1.1 Dimensional analysis and performance laws 1.2 In-compressible fluid analysis 1.3 Performance characteristics for low-speed machines 1.4 Compressible fluid analysis 1.5 Flow coefficient and stage loading 1.6 Performance characteristics for high-speed machines – compressors, turbines 1.7 Specific speed and specific diameter 1.8 Contours of specific speed showing characteristics of various pump types 1.9 Range of specific speeds for various types of turbo-machines (plot only) 1.10The Cordier diagram, compressible specific speed, cavitation and cavitation limits	6: 0
C Turbo-compressor: **Specific Learning Objective:(IMO Model Course 7.04 – 1.4.1.2, 1.4.1.3, 1.4.3.1, 1.4.3.3)** **(IMO Model Course 7.02 – 1.3.3 – 3.1, 3.5)** Explain/Discuss the following: 3.1 Compressor Design: Euler's turbo-machinery equations 3.2 Axial flow compressor analysis – through flow field 3.3 The cascade field, the secondary field 3.4 Two-dimensional flow through blade rows - Euler's equations, velocity diagrams, flow annulus area 3.5 Stage parameters – efficiencies, degree of reaction 3.6 Stage loading and flow coefficients, stage pressure ratio, blade Mach number, stage efficiency 3.7 Repeating-stage, Repeating-row, Mean-line design 3.8 Flow path dimensions, axial dimensions, number of blades, blade profile, radial variation, radial equilibrium, free-vortex variation of swirl, swirl distribution, selection of number of stages, compressor performance, compressor map, compressor starting problems 3.9 Centrifugal flow compressor analysis – general equations, velocity diagrams, slip factor 3.10 Axial flow compressor analysis – stage parameters – adiabatic efficiency, exit swirl angle, stage loading and flow coefficients, degree of reaction, zero reaction, 50% reaction, general zero swirl case	4: 0
D Marine Gas Turbines: **Specific Learning Objective: (IMO Model Course 7.04 – 1.4.1.3, 1.4.3.1)** **(IMO Model Course 7.02 – 1.1.3, 1.2.1, 1.2.4, 1.3.4)** Explain/Discuss the following: 4.1 Gas turbine working cycle and airflow, with plots of Temperature, Velocity, Mass flow rate along the length of the machine for various configuration	15: 0

4.2 Construction of rotors, rotor drum, rotor blades, stator vanes, methods of securing vanes to compressor casing, variable stator vanes 4.3 Combustion chambers, apportioning the airflow, flame tube cooling methods, types of combustion chambers 4.4 Turbines – triple stage single shaft, twin turbine, free power turbine, nozzle guide vanes, turbine blades - various, methods of attaching blades to turbine discs, free power contra rotating turbine, 4.5 Exhaust system, exhaust gas flow 4.6 Accessory drives – gear boxes and drives, internal gear box, radial driveshaft, direct drive, gear train drive, intermediate gear box, external gearbox, auxiliary gear box 4.7 Lubrication system circuit & description 4.8 Intermediate air system – cooling, internal airflow pattern, nozzle guide vale and turbine blade cooling arrangement 4.9 Typical seals 4.10 Fuel system – description using circuit and control circuit 4.11 Starting and ignition, methods of starting – electric, cartridge, air, hydraulic, air starter motor 4.12 Noise suppression arrangement 4.13 Gas turbines for ship propulsion overview describing complete layout – general arrangement, air intake, exhaust uptake, environment ambient conditions and duct losses on performance, load requirements, service requirements, considerations 4.14 Classification of cycles and illustration of engines, structural arrangement, intercoolers and recuperators, reduction gearing, starting and reversing, accessories – pumps and drives, fuel system, intake filters, inlet and exhaust silencers 4.15 Compressor design – centrifugal compressor – impeller, diffuser, rotor, the axial flow compressor, blading design and cooling, rotor design, stator design, casing design, nozzle design and construction, combustion systems – combustion chamber configurations 4.16 Design parameters, design objectives, mechanical details and construction, fuel nozzles, ignition systems, bearings, shaft seals, lubrication system, Predicting performance, multiple comparisons	
E Marine Turbocharger: **(IMO Model Course 7.04 – 3.2.3.9, 3.2.3.2.3)** **(IMO Model Course 7.02 – 1.1.1.1.1, 1.3.2.3.1)** Explain/Discuss the following: **Specific Learning Objective:** 5.1 Compressor, turbine 5.2 Bearings and casing 5.3 Compressor and turbine efficiency 5.4 Non-dimensional representation of compressor and turbine characteristics 5.5 Turbocharger compressor performance map 5.6 Compressor performance 5.7 Turbine performance and map 5.8 The energy in the exhaust system, constant pressure turbocharging – four stroke diesels / two stroke diesels 5.9 Principles of pulse turbocharging, pulse turbocharging – four stroke diesels / two stroke diesels, pulse converters – principles	5: 0

Subject Name/Code: Marine Internal Combustion Engines and Technology 1/403

Instructional hours:

Lecture	: 60 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Marine Diesel Engine, D. K. Sanyal, Bhandarkar Publication.
2. Pounder C.C. (2000): Marine Diesel Engines, Newnes-Butterworths, London.
3. Christensen, Stanley G: Lamb's Questions & Answers on The Marine Diesel Engine, Butterworth Heinemann.
4. Jackson L & Morton T.D: General Engineering Knowledge for Marine Engineers, Thomas Reed Publications.

Reference:

1. Cowley J.K. (1992), The Running and Maintenance of Marine Machinery, Institute of Marine Engineers.
2. H D McGeorge: General Engineering Knowledge, Butterworth-Heinemann.
3. Doug Woodyard: Pounder's Marine Diesel Engines and Gas Turbines, Butterworth Heinemann.
4. Griffiths, Denis (2004): Marine Low Speed Diesel Engines, IMarEST Publication.
5. Griffiths, Denis (2004): Marine Medium Speed Diesel Engines, MEP Series, Vol. 1, Part 3, IMarEST Publication.

Table of Topics

Section	Topics	Hours (L)
A1.1 - A1.4	Heat-engine cycle	10
B1.1 - B1.6	Ideal gas cycles	6
C1.1 - C1.6	Diesel engine fuel atomization and combustion	6
D1.1 - D1.3	Classification of engines	4
E1.1 - E1.21	Basic construction -large-bore (two-stroke) engine	23
F1.1 - F1.8	Scavenging, supercharging and exhaust systems	11
Total		**60**

Learning Objectives	**L**
A General Learning Objective: Heat Engine Cycles-(IMO 7.04,2014: F1/1.4.1.1) **Specific Learning Objectives:** Understand the design features and the operative mechanism of the Marine Diesel Engine and associated auxiliaries so that the related machinery is maintained and operated in a safe, economical and efficient manner on board	
Note: A 1.1 – 1.4: Some elements of this Section may be treated as a recap for learners. Students may be asked to review the fundamentals learnt in Thermodynamics and Industrial Chemistry Subjects.	
1.1 Heat Engine Cycle 1.1.1 Define 'heat-engine cycle' as a number of thermodynamic processes arranged in a given sequence and repealed over constant intervals of time 1.1.2 State those real practical cycles are based on 'ideal' theoretical cycles 1.1.3 State that most ideal cycles involve the following thermodynamic processes: 1.1.4 Explain Heating or cooling, at constant pressure 1.1.5 Explain Heating or cooling, at constant volume 1.1.6 Explain Adiabatic compression or expansion	2
1.2 Ideal and Actual cycle 1.2.1 State that the cycle of thermodynamic processes (or operations) is called out on a 'working fluid' 1.2.2 State that ideally the working fluid is 'perfect', with its physical properties and structure remaining constant throughout the cycle 1.2.3 State that working fluids used in practical engines change during the cycle of processes 1.2.4 State that the function of a heat-engine cycle is to produce the maximum possible output of useful work from a given quantity of energy supplied to the working fluid	2
1.3 Cycle Efficiency 1.3.1 State that, in the majority of practical heat-engine cycles the energy input is obtained from the energy released by the combustion of a fuel with air 1.3.2 State that the 'efficiency' of the cycle is measured by the energy output obtained per unit of energy supplied to the working fluid 1.3.3 State that, in the 'ideal' case, the energy output will be the difference between the energy supplied during the cycle and the energy remaining and rejected at the end of the cycle 1.3.4 Deduce from the above objective that ideally the output energy is the difference between the energy supplied and the energy rejected	2
1.4 Numerical Questions Deduce from the above objective that the cycle efficiency is given by the ratio: – μ = (Energy supplied – Energy rejected)/Energy supplied – Solve simple numerical problems related to the equation in the above objective	4

B General Learning Objective: Ideal Gas Cycles **Specific Learning Objectives:** Understand how heat energy is produced, converted and dissipated by differentiating the actions in a cycle; to have knowledge of the basic engine cycles	
1.1 Otto Cycle a. Define ideal-gas cycle as those which use a perfect (or ideal) gaseous working fluid b. Define the Otto cycle as a sketch on a plane of pressure-volume: Indicating where the thermodynamic processes given in the above objective have been used in Otto cycle c. Name the practical engines whose cycle is modelled on the Otto cycle, internal- combustion reciprocating engine, using gas or petrol as a fuel; ignition of fuel is by spark	1
1.2 Diesel Cycle a. Define the Diesel cycle as a sketch on a plane of pressure-volume Indicating where the thermodynamic processes of ideal cycle are used in Diesel cycle. b. Name the practical engine whose cycle is modelled on the Diesel cycle, Diesel, compression-ignition reciprocating engine, using diesel or heavier fuel oil; ignition is by transfer of heat energy from compressed air	1
1.3 Dual Cycle a. Define the Dual cycle as a sketch on a plane of pressure-volume: Indicating where the thermodynamic processes in ideal cycle are used in Dual cycle b. Name the practical engines whose cycle is modelled on the Otto cycle with reference to modern development of the diesel cycle	1
1.4 Joule Cycle a. Define the Joule cycle as a sketch on a plane of pressure-volume: indicating where the thermodynamic processes in ideal cycle are used in Joule cycle b. Explain the practical engines whose cycle is modelled on the Joule cycle, namely, rotary turbine, using gaseous or light to medium fuels (‘gas turbine’)	1
1.5 Two stroke Valve Timing Diagram 1.5.1 Explain the meaning of ‘single-and double-acting’ as applied to reciprocating engines 1.5.2 Describe the processes which take place in each stroke of the two-stroke engine 1.5.3 List the usual maximum temperatures and pressures for the cycle employed 1.5.4 Sketch a diagram showing typical crank angles at which air and exhaust valves or ports open and close and the periods of air inlet, compression, combustion, expansion and exhaust in the above objective	1
1.6 Four stroke Valve Timing Diagram a. Describe the processes which take place in each stroke of the Four-stroke engine b. List the usual maximum temperatures and pressures for the cycle employed c. Sketch a diagram showing typical crank angles at which air and exhaust valves or ports open and close and the periods of air inlet, compression, combustion, expansion and exhaust in the above objective	1
C General Learning Objective: Diesel Engine Fuel Atomization and Combustion **Specific Learning Objectives:** Understand the concepts of atomization, fuel combustion and related knowledge	
1.1Combustion of Fuel 1.1.1 Describe the combustion process in an engine cylinder 1.1.2 Describe the chemical reaction in combustion as being between combustible materials such as hydrocarbon in fuels and the oxygen contained in atmospheric air 1.1.3 State that, as a result of combustion, heat energy become available, enabling thermodynamic operations to be carried out	1
1.2 Calorific Value of Fuel a. State that the heat released during the combustion of a unit of a substance is termed calorific value (CV) b. State that calorific values for fuels are usually stated with respect to unit mass in the case of solid and liquid fuels and unit volume in the case of gaseous fuels c. State that the main combustible elements in marine fuels are carbon, hydrogen and sulphur d. State the appropriate calorific values of the elements given in the above objective	1
1.3 Constituents of Fuel a. State that sulphur is usually present in marine fuels b. State that the salts of sodium and vanadium are usually present in marine fuels c. State that sulphur, although combustible, is an undesirable element in a fuel	1

d. State that sodium and vanadium are also undesirable elements in a fuel e. State typical percentages of carbon, hydrogen and sulphur for fuel oil marine diesel fuel	
1.4 Calorific Value of Different Grades of Fuel a. State typical calorific values for marine fuels used on board a ship b. State the average proportions, by percentage, of oxygen and nitrogen in atmospheric air	1
1.5 Injector Nozzle 1.5.1 Sketch a section through a typical injector nozzle assembly 1.5.2 Describe the care necessary with injector nozzle holes	1
1.6 Injector Nozzle Function 1.6.1 Explain how atomization is produced by the injector nozzle 1.6.2 Explain why swirl and penetration are important to the ignition and combustion of the fuel/air mixture	1
D General Learning Objective: Classification of Engines **Specific Learning Objectives:** Understand how engines are classified based on different features and characteristics	
1.1 Bore Size 1.1.1 State that marine diesel engines are normally described in broad categories by the bore of the cylinders and their rotational speed 1.1.2 State that large-bore engines are normally fitted with piston rods and crossheads 1.1.3 State that smaller diesel engines normally have trunk pistons and gudgeon pin in the place of piston rods and crossheads 1.1.4 State that large-bore engines are normally directly connected to the propeller and therefore rotated at low speed	1
1.2 Speed 1.2.1 State that other diesel engines may run at medium speed or high speed, depending upon their duty 1.2.2 State that medium-speed and high-speed engines are often used as direct drives for generation of electrical power 1.2.3 State that medium-speed engines (and occasionally high-speed engines) are used, through some form of speed reduction, as main propulsion engines 1.2.4 State the approximate speed ranges related to the following engines: • low-speed • medium-speed • high-speed	1
1.3 Other Parameters State the classification of engines based on the following parameters according to: • Ignition System • Operating Cycles • Strokes/Cycle • Piston Action • Piston Connection • Cylinder Arrangement • Method of Fuel Injection • method of Charging • Fuel Used • Bore/Stroke Ratio • Use	2
E Basic Construction -Large-bore (two-stroke) engine details **General Learning Objective** **Specific Learning Objectives:** Understand the construction and component arrangements of large marine diesel engines.	
1.1 Structure of the bedplate 1.1.1 Describe the structure of the bedplate 1.1.2 Describe the basic construction of bedplate 1.1.3 Explain where cracks in bedplates sometimes occur 1.1.4 Explain the possible causes of cracking in a bedplate 1.1.5 Name the materials of engine bedplate construction	1

1.2 Bedplate connection to tank top 1.2.1 Explain that bedplate is connected to the tank top using holding down bolts 1.2.2 Explain the types of chocks used in connection with bedplate 1.2.3 Sketch and explain how the bedplate rests on the tank top with the aid of chocking & holding down bolts arrangement	1
1.3 Arrangement of holding down arrangement 1.3.1 Explain the purpose of holding down bolts and side chocking 1.3.2 Describe the attention necessary to holding down bolts and chocks 1.3.3 Explain the source of transverse forces which cause lateral movement and tend to rock the engine 1.3.4 Explain the inspection carried out on the holding bolts arrangement 1.3.5 Explain the consequences running engine with slack holding down bolts 1.3.6 Explain the consequences of over tightening for the holding down bolts	1
1.4 Structure of A-frame and column 1.4.1 Describe the basic construction of the A-Frame 1.4.2 Explain the purpose of the A-frame 1.4.3 List the materials used for the A-frame construction 1.4.4 Identify the location of defects normally found on an engine A-frame 1.4.5 Identify with reasons the weak points in an A-frame	1
1.5 Arrangement of tie- bolts 1.5.1 Explain the purpose of tie-bolts installed in modern diesel engines 1.5.2 Describe the procedure of tightening the tie-bolts 1.5.3 Name the materials used for construction for the tie-bolts 1.5.4 Explain the causes of tie-bolts failure during in service 1.5.5 Describe the methods of fitting tie-bolts	1
1.6 Cylinder block and entablature 1.6.1 Explain the functional purpose of a cylinder block 1.6.2 Name the materials from which the cylinder is made 1.6.3 Describe the basic construction of the cylinder block and entablature 1.6.4 Explain the reasons for manufacturing the liner separately from the cylinder block 1.6.5 Sketch and describe the type of an engine cylinder block that may be used on the modern diesel engine 1.6.6 Identify the location of defects normally found on an engine cylinder block	1
1.7 Arrangement of main bearing caps 1.7.1 Sketch and describe the arrangement of main bearing caps 1.7.2 Describe the methods of tightening the jack bolts for the main bearing caps 1.7.3 Identify the common defects normally found on the main bearing caps& jack bolts 1.7.4 Explain the maintenance carried out for the main bearing caps arrangement	1
1.8 Arrangement of piston rod gland assembly 1.8.1 Sketch and label the various parts of the piston rod gland assembly 1.8.2 Explain the functional purpose of the piston rod gland assembly 1.8.3 Name the materials used for construction for the piston rod gland assembly 1.8.4 Describe the stresses that act during operation 1.8.5 Describe the clearances to be taken 1.8.6 Identify the consequences in running of an engine with improper clearances in the piston rod assembly 1.8.7 Explain the causes of excessive wear of the piston rod gland assembly 1.8.8 Explain why replaceable lamellae are used in some of the modern diesel engines in the stuffing box glands	1
1.9 Cylinder Cover 1.9.1 Sketch and describe the cylinder cover of a typical 2-stroke propulsion engine 1.9.2 Name the materials used for construction 1.9.3 Define the stresses the cylinder cover is subjected to	1
1.10 Crankshaft 1.10.1 Explain the functional purpose of the crankshaft 1.10.2 Name the materials used for construction for the manufacture of the crankshaft 1.10.3 Sketch and describe the type of crankshaft that may be used on modern marine diesel engines 1.10.4 Define the stresses that act on the crankshaft during operation 1.10.5 Identify the location of defects normally found on a crankshaft 1.10.6 Describe the procedure in taking crankshaft deflection	1

1.10.7 Explain the factors affecting crankshaft deflection reading 1.10.8 Explain the reasons for crankshaft misalignment 1.10.9 Identify the critical areas for crankshaft inspection	
1.11 Main bearing 1.11.1 Sketch a cross section through main bearing assembly and its structural support 1.11.2 Identify types of forces acting on the main bearing 1.11.3 Explain the procedure of renewal main bearing shell and bearing clearance 1.11.4 Explain what inspection is made to ensure adequate main bearing clearance 1.11.5 Describe the causes of main bearing failures as follows 1.11.6 Wiping 1.11.7 Fatigue 1.11.8 Tin Oxide Corrosion 1.11.9 Cavitation Erosion 1.11.10 Electrical Potential 1.11.11 Fretting 1.11.12 Thermal ratchetting in white metal 1.11.13 Scratching 1.11.14 Identify with reasons the points of weakness in main bearing 1.11.15 Name the materials used for construction and its properties for manufacture of main bearing 1.11.16 Explain why bearing keeps are sometimes secured by jack bolts rather that holding down bolts	2
1.12 Thrust block and bearing 1.12.1 Sketch a cross-section through thrust block and bearing assembly and its structural support 1.12.2 Explain the factors affecting the load carrying capacity of lubrication of thrust bearing 1.12.3 Name the materials used for construction for the manufacture of tilting pad thrust bearing 1.12.4 Explain the advantages of using tilting pad journal bearing for marine diesel engine	1
1.13 Bottom end bearing 1.13.1 Sketch a cross-section of bottom end bearing assembly showing the flow of lubricating oil 1.13.2 Name the materials used for construction for construction 1.13.3 Describe the procedures for checking alignment, and the bearing clearance 1.13.4 Identify with reasons the points of weakness in the bottom end bearing 1.13.5 Explain the causes of the bottom end bearing failures 1.13.6 Identify types of forces acting on the bottom end bearing 1.13.7 Identify the location of defects normally found on the bottom end bearing.	1
1.14 Connecting Rod 1.14.1 Sketch a cross-section of a connecting rod and showing the flow of lubricating oil 1.14.2 Name the materials used for construction1 1.14.3 Describe the procedure of hydraulic method of tightening connecting rod bolts 1.14.4 Identify the location of defects normally found on the connecting rod 1.14.5 Identify the design consideration for the manufacture of connecting rod	1
1.15 Crosshead and Bearings 1.15.1 Sketch a cross-section of a crosshead bearing and label the various parts 1.15.2 List the materials used for construction 1.15.3 Explain the common problems associated with crosshead and bearing 1.15.4 Explain why the lubrication of the crosshead bearing is difficult 1.15.5 Describe the design changes adopted in modern diesel engines to overcome the problems 1.15.6 Explain types of forces acting on the crosshead bearings 1.15.7 Explain the causes of distortion of crosshead pin and con-rod flange 1.15.8 Describe with Sketch one arrangement whereby lubricant is fed to top end bearings, slippers and guide	2
1.16 Guides and guides shoes 1.16.1 Sketch a cross-section of a guide and guide shoe and label all the parts 1.16.2 Name the materials used for construction 1.16.3 Explain types of forces acting on the guides and guide shoes 1.16.4 Explain the causes of guide and guide shoes failure 1.16.5 Identify the common defects found at the guide and guides shoes 1.16.6 Describe how the alignment is checked for guides and guide shoes	1
1.17 Camshaft drive arrangement 1.17.1 Sketch and describe the camshaft drive arrangement for modern marine diesel engine 1.17.2 Explain the functional purpose of the camshaft drive arrangement 1.17.3 Name the materials used for construction 1.17.4 Explain the common defects found in the camshaft drive arrangement	1

1.17.5 Explain inspection and maintenance carried out on Camshaft drive arrangement	
1.18 Gear wheel transmission 1.18.1 Sketch and explain the gear wheel transmission and label all parts 1.18.2 Name the materials used for construction 1.18.3 Identify the common defects found on the gear wheel transmission 1.18.4 Explain the causes of defect gear wheel profile 1.18.5 Identify types of inspection on gear wheel transmission	1
1.19 Chain wheel transmission 1.19.1 Sketch and explain the Chain Wheel Transmission 1.19.2 Explain the functional purpose of the chain wheel transmission 1.19.3 Name the materials used for construction 1.19.4 Explain the procedure of tightening of the chain wheel 1.19.5 Explain the causes of having a slack chain wheel during engine running 1.19.6 Identify the common defects found on the chain wheel transmission	1
1.20 Camshaft bearing arrangement 1.20.1 Sketch and describe the camshaft bearing arrangement 1.20.2 Name the materials used for construction 1.20.3 Identify the common defects found on the camshaft bearing 1.20.4 Explain types of inspection carried out on the camshaft bearing 1.20.5 Explain the consequences of running the engine with defective camshaft bearing	1
1.21 Exhaust Valve 1.21.1 Sketch and explain the Exhaust valve fitted on a typical 2-stroke propulsion engine 1.21.2 Name the materials used for construction 1.21.3 Define the method of cooling for the exhaust valve 1.21.4 State the importance of Spring air in the operation of the exhaust valve	1
F General Learning Objective: Scavenging, Supercharging and Exhaust Systems **Specific Learning Objectives:** Understand the functions and types of ancillary systems aiding in engine performance	
1.1 Scavenging 1.1.1 Explain the purpose of scavenging, supercharging and exhaust in diesel engine 1.1.2 Explain the stages in scavenging process 1.1.3 Explain types of scavenging used in diesel engine	2
1.2 Constant Pressure Supercharging 1.2.1 Explain the meaning of supercharging 1.2.2 Explain the advantages of supercharging 1.2.3 Identify the methods of supercharging 1.2.4 Explain the types of equipment used for supercharging 1.2.5 Sketch and explain the constant pressure turbo charging system	1
1.3 Pulse Type Supercharging 1.3.1 Sketch and explain the pulse system of turbo charging 1.3.2 Explain the advantages and disadvantages for pulse and constant pressure exhaust systems	1
1.4 Turbocharger 1.4.1 Sketch and explain the turbochargers of a Marine Engine 1.4.2 Explain the methods of Turbocharger washing when in operation	2
1.5 Turbocharger Function 1.5.1 Explain lubrication and cooling requirements of turbochargers 1.5.2 Identify typical faults and identify appropriate actions to be undertaken with defective or damaged turbochargers 1.5.3 Explain what is meant by turbocharger surging 1.5.4 Identify the symptoms of turbocharger surging 1.5.5 Explain the causes of turbocharger surging 1.5.6 Explain the operation of Propulsion engine with turbocharger out of operation	2
1.6 Latest trends in turbocharging 1.6.1 Explain the latest developments in turbocharging/turbochargers (e.g., hybrid; VGT etc.) 1.6.2 Sketch and explain 2-stage turbocharging 1.6.3 Explain the Mixed Pulse Converter turbocharging concept 1.6.4 Sketch and explain a Hybrid turbocharger	1

1.7 Air Cooler 1.7.1 Explain the function of charge air cooler in marine diesel engine 1.7.2 Explain the causes for fouling of air cooler on the water and air side 1.7.3 Explain the methods employed for cleaning of air cooler on the water and air side	1
1.8 Auxiliary Blower 1.8.1 State the importance of Auxiliary Blower in the operation of Main Engine 1.8.2 State the operation of auxiliary blower and how is it controlled 1.8.3 Sketch a line diagram showing the positioning of the auxiliary blower in the scavenge system	1

Subject Name/Code: Marine Pollution Prevention and Safety /404

Instructional hours:

Lecture	: 60 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Safety of Ship Marine Environment Protection, A S Tambwekar.
2. Textbook of Environmental Studies for Undergraduate courses, Erach Bharucha.
3. A text book on environmental studies for undergraduate students, Asthana and Asthana, S. Chand Publishers.
4. Environmental Science, S. K. Tiwari Volume 1, Atlantic Publishers and Distributers.
5. Environmental Sciences for Engineering Under Graduates – Dr. Sushmita Baskar, Dr. R Baskar, Unicorn Books, (ISBN:978-8-1780-6125-2).
6. Renewal Energy Resources, 3ed. John Twidell.
7. Textbook of Environmental Studies for Undergraduate courses, Erach Bharucha.
8. A text book on environmental studies for undergraduate students, Asthana and Asthana, S. Chand Publishers.
9. Environmental Science, S. K. Tiwari Volume 1, Atlantic Publishers and Distributers.

Reference:

1. International Convention for the safety of life at sea (SOLAS), as amended (IMO).
2. Regulations for the prevention of pollution by oil – Annex 1, MARPOL 73/78 (IMO).
3. International safety management code (ISM code).
4. Marine Auxiliary machinery -H.D. McGeorge.

Table of Topics

Section	Topics	Hours (L)
A1.1 - A1.7	Marpol 73/78	14
B1.1 - B1.4	Convention and legislations adopted by various countries	4
C1.1 - C1.7	Anti – pollution procedures and all associated equipment	4
D1.1 – D1.2	Proactive measures to protect the marine environment	2
E1.1	Oily water separator/similar equipment requirements and operation	8
F1.1	Sewage treatment plant	4
G1.1	Incinerator	4
H1.1	Safety measures to be taken for repair and maintenance	10
I1.1	Safe working practices	10
Total		**60**

Learning Objectives	L
General learning objective **Understand the precautions to be taken to prevent pollution of the marine environment, anti-pollution procedures and all associated equipment and proactive measures to protect the marine environment.** **Specific Learning Objectives**: Various Annexes to Marpol (IMO 7.04,2014: F4/4.1.1, 4.1.2, 4.1.3)	
A Marpol 73/78 (IMO 7.04,2014: F4/4.1.1/1.1)	
A 1.1 Introduction to Marpol 1.1.1 Define, for the purpose of MARPOL 73/78: a) Harmful substance b) Discharge c) Ship d) Incident 1.1.2 State that violations of the Convention are prohibited and that sanctions should be established for violations, wherever they occur by the Administration of the ship concerned	1
1.1.3 Describe the inspections which may be made by port State authorities and outlines actions which they may take 1.1.4 Describe the provisions for the detection of violations and enforcement of the Convention 1.1.5 State that reports on incidents involving harmful substances must be made without delay	1
A 1.2 Annex I-Oil 1.2.1 Define for the purposes of Annex I: 1.2.1.1 Oil 1.2.1.2 Oily mixture 1.2.1.3 Oil fuel 1.2.1.4 Oil tanker 1.2.1.5 Combination carrier 1.2.1.6 Nearest land 1.2.1.7 Special area 1.2.1.8 Instantaneous rate of discharge of oil content 1.2.1.9 Wing tank 1.2.1.10 Centre tank 1.2.1.11 Slop tank 1.2.1.12 Clean ballast 1.2.1.13 Segregated ballast 1.2.2 Describe the surveys and inspections required under the provisions of MARPOL73/78	1

1.2.3 Describe the steps which may be taken if a surveyor finds that the Condition of the ship or its equipment is unsatisfactory 1.2.4 State that the IOPP Certificate should be available on board the ship at all times	
1.2.5 State that the condition of the ship and its equipment should be maintained to conform with the provisions of the Convention 1.2.6 State that the certificate issued after survey is the International Oil Pollution Prevention (IOPP) Certificate 1.2.7 Ensure Compliance with Pollution-Prevention Requirements 1.2.8 List the conditions under which oily mixtures may be discharged into the Sea from an oil tanker 1.2.9 List the conditions under which oily mixtures from machinery-space bilges may be discharged into the sea State that the provisions do not apply to the discharge of clean or segregated ballast 1.2.10 Describe the conditions under which the provisions do not apply to the discharge of oily mixtures from machinery spaces where the oil content without dilution does not exceed 15 parts per million 1.2.11 State that residues which cannot be discharged into the sea in compliance with the regulations must be retained on board or discharged to reception facilities 1.2.12 State that the special areas for the purposes of Annex I as the Antarctic area, the Baltic Sea area, Mediterranean Sea area, Black Sea area, The Gulf area, Gulf of Aden area, Red Sea area and north-west European waters 1.2.13 State that any discharge into the sea of oil or oily mixtures from an oil tanker or other ships of 400 tons' gross tonnage and above is prohibited while in a special area 1.2.14 Describe the conditions under which an oil tanker may discharge oily mixtures through ODMCS 1.2.15 Describe the conditions under which a ship, other than an oil tanker, may discharge oily mixtures in a special area 1.2.16 State that the regulation does not apply to the discharge of clean or segregated ballast	1
1.2.17 Describe conditions in which processed bilge water from machinery spaces may be discharged in a special area 1.2.18 Describe the exceptional circumstances in which the regulations on the discharge of oil or oily mixtures do not apply 1.2.19 State that ballast water should not normally be carried in cargo tanks of tankers provided with segregated ballast tanks 1.2.20 Explain the exceptions in which ballast may be carried in cargo tanks 1.2.21 State that every oil tanker operating with crude oil washing systems should be provided with an Operations and Equipment Manual 1.2.22 State that, in new ships of 4,000 tons' gross tonnage and above and in new oil tankers of 150 tons' gross tonnage and above, no ballast water should normally be carried in any oil fuel tank 1.2.23 Explain that a new chapter 8 – STS operations has been added to MARPOL Annex 1 to prevent marine pollution during some ship-to-ship (STS) oil transfer operations 1.2.24 State that as per the above amendment to Annex I of MARPOL, Tankers of 150 GT and above involved in STS operations are required to have on board by the date of the first periodical survey after 1st January 2011 (but not later than 1st April 2012) an STS operations plan approved by the ship flag administration, describing how STS operations are to be conducted	1
A1.3 Annex II - Noxious Liquid Substances in Bulk 1.3.1 Describe the requirements of Annex II apply to all ships carrying noxious liquid substances in bulk 1.3.2 State that noxious liquid chemicals are divided into four categories, X, Y, Z and OS such that substances in category X pose the greatest threat to the marine environment and those in category Z the least 1.3.3 State that the conditions for the discharge of any effluent containing substances falling in those categories are specified 1.3.4 State that more stringent requirements apply in special areas, which for the purposes of Annex II are the Antarctic area 1.3.5 State that pumping and piping arrangements are to be such that, after unloading, the tanks designated for the carriage of liquids of categories Z do not retain more than certain stipulated quantities of residue	1

1.3.6 State that the discharge operations of certain cargo residues and certain tank cleaning and ventilation, operations may only be carried out in accordance with approved procedures and arrangements based on standards developed by IMO 1.3.7 State that each ship which is certified for the carriage of noxious liquid substances in bulk should be provided with a Procedures and Arrangements Manual	
1.3.8 State that the Manual highlights the arrangements and equipment needed to comply with Annex II and specifies the operational procedures with respect to cargo handling, tank cleaning, Slop's handling, residue discharging, ballasting and de-ballasting which must be followed in order to comply with the requirements of Annex II 1.3.9 State that each ship should be provided with a Cargo Record Book which should be completed, on a tank-by-tank basis, whenever any operations with respect to a noxious liquid substance take place 1.3.10 State that a surveyor appointed or authorized by the Government of a Party to the Convention to supervise any operations under this Annex should make an appropriate entry in the Cargo Record Book 1.3.11 Describe the surveys required for ships carrying noxious liquid substances in bulk 1.3.12 State that the certificate issued on satisfactory completion of the survey is an international Pollution Prevention Certificate for the Carriage of Noxious Liquid Substances in Bulk	1
A1.4 Annex III-Harmful Substances Carried by Sea in Packaged Forms, or in Freight Containers, Portable Tanks or Road and Rail Tank Wagons 1.4.1 State that for the purpose of this annex, empty receptacles, freight containers 1.4.2 State the purpose includes portable road and rail tank wagons which have been used previously for the carriage of harmful substances are treated as harmful substances themselves unless precautions have been taken to ensure that they contain no residue that is hazardous to the marine environment 1.4.3 State that packaging, containers and tanks should be adequate to minimize Hazard to the marine environment 1.4.4 Describe the requirements for marking and labelling packages, freight containers, tanks and wagons	1
1.4.5 Describe the notification procedures for loading/unloading harmful substances as per MARPOL Annex III 1.4.6 Describe the documentation relating to the carriage or harmful substances by sea 1.4.7 State that certain harmful substances may be prohibited for carriage or limited as to the quantity which may be carried aboard any one ship 1.4.8 State that jettisoning of harmful substances is prohibited except for the purpose of securing the safety of the ship or saving life at sea	1
A 1.5 Annex IV – Sewage 1.5.1 State that Annex IV contains a set of regulations regarding the discharge of sewage into the sea, ships' equipment and systems for the control of sewage discharge, the provision of facilities at ports and terminals for the reception of sewage, and requirements for survey and certification 1.5.2 Describe the provisions regarding the discharge of sewage into the sea 1.5.3 State that an International Sewage Pollution Prevention Certificate is issued by national shipping administrations to ships under their jurisdiction showing compliance 1.5.4 State that the Annex requires ships to be equipped with either a sewage treatment plant or a sewage comminution and disinfecting system or a sewage holding tank 1.5.5 State that the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or is discharging comminute and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; or is discharging sewage which is not comminuted or disinfected at a distance of more than 12 nautical miles from the nearest land	1
A1.6 Annex V – Garbage 1.6.1 Define, for the purposes of Annex V: 1.6.1.1 Garbage 1.6.1.2 Nearest land 1.6.1.3 Special area 1.6.2 State that the provisions of Annex V apply to all ships 1.6.3 State that the disposal into the sea of all plastics is prohibited 1.6.4 State the regulations concerning the disposal of other garbage	1

1.6.5 State that the special areas for the purposes of Annex V as the Mediterranean Sea, Baltic Sea, Black Sea, Red Sea, 'Gulfs' area, North Sea, Antarctic area (south of latitude 60 degrees south, Wider Caribbean region including the Gulf of Mexico and the Caribbean Sea	
A1.7 Annex VI – Air Pollution 1.7.1 Define, for the purposes of Annex VI: 1.7.1.1 Continuous feeding 1.7.1.2 Emission control area (ECA) 1.7.1.3 New installations 1.7.1.4 Nitrogen Oxide (NOX) technical code 1.7.1.5 Ozone depleting substances 1.7.1.6 Sludge oil 1.7.1.7 Shipboard incineration 1.7.1.8 Shipboard incinerator 1.7.1.9 Emission control area 1.7.1.10 Particular matter (PM) 1.7.1.11 Volatile organic compounds (VOCs)	1
1.7.2 Describe the types of inspection required under Annex VI 1.7.3 Describe the provision for the issuance of International Air Pollution Prevention certificate 1.7.4 Describe the duration of validity of the certificate	1
1.7.5 Describe the regulation regarding NOX in Regulation 13 of Annex VI 1.7.6 Describe the requirement for SOX emission control area (SECA) 1.7.7 Describe the requirement for fuel oil quality in Regulation 18 of Annex VI 1.7.8 State that the special areas for the purposes of Annex VI as the Baltic Sea(SOx), North Sea(SOx), North American (SOx, NOx and PM), United State Caribbean Sea ECA (SOx, NOx and PM) 1.7.9 Discuss current developments in Alternate Fuels aiming to reduce emissions	1
General learning objective: Understand the various conventions enacted to prevent Pollution **B Convention and legislations adopted by various countries** **Specific Learning Objectives: Understanding LDC, OPA and other acts (IMO 7.04,2014: F4/4.1.1/1.2)**	
B1.1 Convention of the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention) (LDC) 1.1.1 Explain the aims of the Convention 1.1.2 Define, for the purpose of the Convention: i. Dumping ii. Wastes or other matter iii. Special permit iv. General permit 1.1.3 State that the dumping of wastes or other matter in whatever form or condition, as listed in annex I, is prohibited 1.1.4 State that the dumping of wastes or other matter listed in annex II requires a prior special permit 1.1.5 State that the dumping of all other wastes or matter requires a prior general permit 1.1.6 State that the provisions of Article IV do not apply when it is necessary to secure the safety of human life or of vessels in cases of *force majeure* caused by stress of weather, or in any case which constitutes a danger to human life or a real threat to vessels 1.1.7 State that such dumping should be done so as to minimize the likelihood of damage to human or marine life and must be reported immediately 1.1.8 State that the Addendum to Annex I contain regulations on the incineration of wastes at sea 1.1.9 State that the appropriate authority of a Contracting Party should issue prior special or general permits in respect of matter intended for dumping: • Loaded in its territory • Loaded by a vessel flying its flag when the loading occurs in the territory of a State not party to the Convention	1
B 1.2 International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969 International Convention on Civil Liability for Oil Pollution Damage, 1969(CLC 1969) 1.1.1 Describe the rights of Parties to the Convention to intervene on the high seas following a maritime casualty 1.1.2 Define, for the purposes of the Convention **(CLC 1969)**: • Ship	1

• Owner • Oil • Pollution damage • Preventive measures • Incident 1.1.3 Describe the occurrences to which the Convention **(CLC 1969)** applies 1.1.4 State that the owner of a ship is strictly liable for any oil pollution damage caused by the ship as the result of an incident lists the exceptions to liability	
B1.3 Oil Pollution Preparedness, Response & Cooperation Convention (OPRC) as amended (OPRCHNS Protocol) 1.3.1 State that the Protocol on Preparedness, Response and Cooperation to Pollution Incidents by Hazardous and Noxious Substances (HNS), 2000 or the OPRC-HNS Protocol, aims to provide a global framework for international co-operation establishing systems for preparedness and response in combating incidents or threats of marine pollution involving HNS at the national, regional and global levels; in improving scientific and technological understanding and knowledge in this field; in promoting technical cooperation in response techniques; and in developing specialized training programmes 1.3.2 State that the OPRC-HNS Protocol was adopted to expand the scope of the 1990 International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC Convention 1990), which entered into force on 13 May 1995, to apply, in whole or in part, to pollution incidents by hazardous substances other than oil 1.3.3 State that the OPRC-HNS Protocol entered into force on 14 June 2000 1.3.4 State that parties to the HNS Protocol will be required to establish measures for dealing with pollution incidents, either nationally or in cooperation with other countries 1.3.5 State that ships are required to carry a shipboard pollution emergency plan to deal specifically with incidents involving HNS 1.3.6 State that under the OPRC-HNS Protocol 2000, hazardous and noxious substances or HNS are Defined as ‘any substance other than oil which, if introduced into the marine environment, is likely to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea’, and include: • oil derivatives • liquid substances which are noxious or dangerous • liquefied gases • liquids with flashpoints not exceeding 60°C • packaged dangerous, harmful and hazardous materials and • solid bulk material with associated chemical hazards 1.3.7 State that the Protocol covers pollution incidents or a threat of a pollution incident from Hazardous and Noxious Substances (HNS), such as a discharge, release or emission of HNS including those from fire or explosions, which pose or may pose a threat to the marine environment, or coastline, and therefore, require emergency action or an immediate response	1
B1.4 OPA – 90 & other U.S legislations 1.4.1 Explain the contents and purpose of OPA – 90 1.4.2 Explain National Pollutant Discharge Elimination system (NPDES) of the U.S. Clean Water Act 1.4.3 Explain the Ocean Dumping Act (ODA)	1
C General learning objective: Understand the antipollution procedures and all associated equipment on board a ship **Specific Learning Objectives: Understand Oil Record Book, SOPEP, VRP, VOCMP and others. (IMO 7.04,2014: F4/4.1.2/2.1, 2.2, 2.3)**	
C1.1 Control of discharge of oil (IMO 7.04,2014: F4/4.1.2/2.1) 1.1.1 Explain the control of discharge of oil as stated in Regulation 9 of MARPOL 73/78. 1.1.2 Explain Particularly Sensitive Sea Areas (PSSA) 1.1.3 Explain methods for prevention of oil pollution and discharge provisions for oil and oily waste from machinery spaces outside special areas and within special areas 1.1.4 Explain bilge water holding tank	0.5
	0.5

1.1.5 Explain principle of operation of Oily water separator 1.1.6 Explain Oil discharge monitoring and control system and oil filtering Equipment as stated in Regulation 16 of MARPOL 73/78 1.1.7 Explain in brief the prevention of oil pollution as stated in Regulation 13F in the event of collision or stranding and Regulation 13G in the event of collision or stranding Measure for existing tankers of MARPOL 73/78 1.1.8 Explain the retention of oil on board as stated in Regulation 15 of MARPOL 73/78	
C1.2 Oil Record Book (Part I - Machinery Space Operations and Part II – Cargo/Ballast Operations) **(IMO 7.04,2014: F4/4.1.2/2.2)** 1.2.1 Describe the requirements for the provision of Oil Record Books, which is, Oil tankers of 150 tons GT and every ship of 400 tons of GT and above other than an oil tanker to carry an Oil Record Book Part I (Machinery Space Operations) 1.2.2 Describe that every oil tanker of 150 tons GT and above shall also be provided with an Oil Record Book Part II (Cargo/Ballast Operations) 1.2.3 Describe the various operation to be carried out to complete Oil Record Book 1.2.4 List the various entries that need to be made in the Oil Record Book with respect to above for following operations: a. for machinery space operations (all ships) b. for cargo/ballast operations (oil tankers) 1.2.5 Describe the entries required for accidental or other exceptional Discharge of oil 1.2.6 Explain that each completed operation shall be signed by the officer or officers in charge of the operations concerned and each completed page shall be signed by the master of ship 1.2.7 State that the Oil Record Book should be kept on board readily available for inspection and should be preserved for a period of three years after the last entry has been made 1.2.8 Explain that the competent authority of the Government of a Party to the Convention may inspect the Oil Record Book on board any ship to which Annex I applies while the ship is in its port or offshore terminals and may Make a copy of any entry in that book and may require the master of the ship to certify that the copy is a true copy of such entry	0.5
C1.3 Shipboard Oil Pollution Emergency Plan (SOPEP) including Shipboard Marine Pollution Emergency Plans (SMPEP) for Oil and/or Noxious Liquid Substances and Vessel Response Plan (VRP) **(IMO 7.04,2014: F4/4.1.2/2.3)** 1.3.1 Explain that the Shipboard Oil Pollution Emergency Plan ('SOPEP') is to be seen as an information from the owners to the Master of a particular ship 1.3.2 Explain and advice to the Master how to react in case of an oil spill to prevent or at least mitigate negative effects on the environment 1.3.3 Explain that the Plan contains operational aspects for various oil spill scenarios and Lists communication information that to be used in case of such incidents 1.3.4 State that it is compulsory for all ships of more than 400 Gross Tons (Oil tankers of more than 150 GT) to carry a SOPEP on board 1.3.5 State that the required contents is described in MARPOL Convention Annex I Reg. 26. 1.3.6 Explain that 'Guidelines for the Development of a Shipboard Oil Pollution Emergency Plan' are published by IMO under MEPC.54(32) 1992 as amended by MEPC.86(44) 2000 1.3.7 Explain that the SOPEP forms an integral part of the IOPP certificate and its existence is verified in the Supplement to the IOPP Certificate 1.3.8 Describe that the Plan consists generally of 4 Sections with the mandatory contents and its Appendices with additional information as contact addresses and data plus a set of certain drawings for easy reference for the Master, data abt. charterer, insurance, P&I Club, etc.) 1.3.9 Explain IMO has adopted a requirement for ships above 150 GRT certified to carry noxious liquid substances in bulk and that these ships shall carry an additional emergency plan called 'Shipboard Marine Pollution Emergency Plan (SMPEP) for noxious liquid substances' 1.3.10 Explain that this plan, is to be seen as an information from the owners to the Master of a particular ship advising the Master how to react in case of a spill of noxious liquid substances to prevent or at least mitigate negative effects on the environment 1.3.11 Explain that the Plan is compulsory since 1st January 2003 1.3.12 Describe that the Plan contains operational aspects for various spill scenarios and Lists communication information are to be used in case of such incidents 1.3.13 Explain that as the contents is mainly similar to the contents of the Shipboard Oil Pollution Emergency Plan (SOPEP) which is compulsory, IMO recommends to prepare a combined plan called 'Shipboard Marine Pollution Emergency Plan' ('SMPEP')	0.5

1.3.14 Explain that such plan has to fulfil the requirements for the SOPEP and additionally for the Shipboard Marine Pollution Emergency Plan for noxious liquid substances according to the IMO Guideline 1.3.15 State that the required contents is described in MARPOL 73/78 as amended Annex II Reg. 16 1.3.16 Explain that the VRP- Vessel Response Plan is a plan required for vessels trading to/from/in U.S.A and this U.S. Coast Guard's new regulations to improve pollution-response preparedness for vessels carrying or handling oil upon the navigable waters of the United State came into effect from 22nd February 2011 1.3.17 Explain that the Oil Pollution Act of 1990 (OPA-90) and the international treaty, MARPOL 73/78, require owners/operators of certain vessels to prepare Vessel Response Plans (VRP) and /or Shipboard oil Pollution Emergency Plans (SOPEP) and in addition, for certain vessels carrying noxious liquid substances a Shipboard Marine Pollution Emergency Plans (SMPEP)	
C1.4 Operating procedures of anti-pollution equipment, Sewage plant, incinerator, comminutor, ballast water treatment plant. (IMO 7.04,2014: F4/4.1.2/2.4) 1.4.1 Describe the operating procedures of anti-pollution equipment such as: • Sewage plant • Incinerator • Comminutor • ballast water treatment plant	0.5
C1.5 Volatile Organic Compound (VOC) Management Plan (IMO 7.04,2014: F4/4.1.2/2.5) 1.5.1 Describe that Volatile Organic Compounds (VOC) are organic chemicals that easily vaporize at normal conditions and enter into the atmosphere 1.5.2 Explain that VOC may include a very wide range of individual substances, such as hydrocarbons (e.g., methane, ethane, benzene, toluene, etc.), oxidized hydrocarbons (or fuel oxygenates, such as methyl tert-butyl ether (MTBE) and by-product organic compounds from chlorination in water treatment (such as chloroform) 1.5.3 Explain that VOC emissions from the fuel/petroleum industry sources occur during extraction of oil at the platform, tanker transportation of oil, loading and discharging at terminals, oil processing at refineries, tanking at filling stations and leakage from pipelines as well as oil spills 1.5.4 Explain that VOC emissions from ships can be due to incomplete combustion processes and include crankcase, exhaust and evaporation emissions 1.5.5 Explain that Tankers emit VOC during cargo loading and crude oil washing operations as well as during sea voyages 1.5.6 Explain that the amount of VOC emissions depends on many factors including the properties of the cargo oil, the degree of mixing and temperature variations during the sea voyage 1.5.7 Explain that to control this emission, there are four criteria that impact the extent and rate of evolution of gaseous non-methane VOC from crude oils and its subsequent release to the atmosphere. These are: • The volatility or vapour pressure of the crude oil • The temperature of the liquid and gas phases of the crude oil tank • The pressure setting or control of the vapour phase within the cargo tank • The size or volume of the vapour phase within the cargo tank 1.5.8 Describe that Regulation 15.6 of MARPOL requires a tanker carrying crude oil shall have on board and implement a VOC Management Plan (Management Plan) approved by the Administration in accordance with IMO Resolution MEPC.185(59) 'Guidelines for the Development of a VOC Management Plan' 1.5.9 Explain that the VOC Management Plan is specific to each ship 1.5.10 Explain that the aim of the VOC Management Plan is to identify the arrangements and equipment required to enable compliance with Regulation 15.6 of the Revised Annex VI and to identify for the ship's officers the operational procedures for VOC emission control	0.5
C1.6 Garbage Management System, Anti-fouling systems. (IMO 7.04,2014: F4/4.1.2/2.5) 1.6.1 **Garbage Management Plan** Explain that as per MARPOL 73/78, Annex V, regulation 9 every ship of 400 gross tonnages and above and every ship which is certified to carry 15 persons or more are to be required to carry a garbage management plan which the crew are required to follow Describe the content of the Garbage Management Plan 1.6.2 **Garbage Record Book** Explain that every ship of 400 gross tonnages and above and every ship which is certified to carry 15 persons or more engaged in voyages to ports or offshore terminals under the jurisdiction of other	0.5

Parties to the Convention and every fixed and floating platform engaged in exploration and exploitation of the sea-bed are to be provided with a Garbage Record Book Describe the various operation when the Garbage Record Book has to be completed List the various entries that need to be made in the Garbage Record Book Explain the disposal criteria for cargo residues/cargo hold washing water residues 1.6.3 **Anti-fouling systems** State that IMO adopted a new International Convention on the Control of Harmful Anti-Fouling Systems on Ships, on 5 October 2001 which will prohibit the use of harmful organotin in antifouling paints used on ships and will establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling system State that the convention entered into force on 17 September 2008	
C1.7 Ballast Water Management and their discharge criteria (IMO 7.04,2014: F4/4.1.2/2.5) 1.7.1 State that The International Convention for the Control and Management of Ships Ballast Water & Sediments (BWM convention) was adopted by consensus at a diplomatic Conference at IMO in London on Friday 13 February 2004 1. Define the following: 2. Ballast water 3. Ballast water management 4. Sediments 1.7.2 Describe the application of this convention 1.7.3 State that in order to show compliance with the requirements of the Convention each vessel shall have an on board valid Certificate, a Ballast Water Management Plan and a Ballast Water Record Book 1.7.4 Describe the conditions where the application of this convention may be exempted 1.7.5 Describe the management and control requirement based on Section B Regulation B1 to B6 1.7.6 Describe the Annex – Section A, B, C, D and E briefly 1.7.7 Describe the various methods of ballast exchange 1.7.8 Describe the standards that need to be observed in ballast water exchange 1.7.9 State under Regulation B-4 Ballast Water Exchange, all ships using ballast water exchange should whenever possible, conduct ballast water exchange at least 200 nautical miles from the nearest land and in water at least 200 metres in depth, taking into account Guidelines developed by IMO; In cases where the ship is unable to conduct ballast water exchange as above, this should be as far from the nearest land as possible, and in all cases at least 50 nautical miles from the nearest land and in water at least 200 metres in depth 1.7.10 State as per Annex – Section B Management and Control Requirements for Ships: 1.7.11 State that a new paragraph, 4, has been added with effect from July 1, 2010 to SOLAS Chapter V, Regulation 22 – Navigation bridge visibility. Some changes are operational and others introduce new requirements applicable to navigation records 1.7.12 State that as a consequence of this amendment, any increase in blind sectors or reduction in horizontal fields of vision resulting from ballast water exchange operations is to be taken into account by the Master before determining that it is safe to proceed with the exchange 1.7.13 State that as an additional measure, to compensate for possible increased blind sectors or reduced horizontal fields of vision, the Master must ensure that a proper lookout is maintained at all times during the exchange. Ballast water exchange must be conducted in accordance with the ship's ballast water management plan, taking into account the recommendations adopted by the IMO 1.7.14 Explain that in accordance with SOLAS Chapter V, Regulation28 – Records of navigational activities and daily reporting, the commencement and termination of the operation should be recorded 1.7.15 Explain that the navigational records generated during ballast water exchange may be reviewed during ISM Audits and port state control inspections	0.5
D General learning objective: Understand the proactive measures to protect the marine environment **Specific Learning Objectives: Understanding the various operations that can cause pollution** **(IMO 7.04,2014: F4/4.1.3/3.1)**	
1.1 Explain the need for taking proactive measures to protect the marine environment 1.2 Describe the proactive measures that can be taken on board ships to protect the marine environment for shipboard operations, including: 1.2.1 Bunkering 1.2.2 Loading / discharging Oil, Chemicals and hazardous cargoes 1.2.3 Tank cleaning	2

1.2.4 Cargo hold washing 1.2.5 Pumping out bilges (hold and engine room) 1.2.6 Ballast water exchange 1.2.7 Purging and Gas freeing 1.2.8 Disposal of other garbage **1.2.9** Discharge of sewage	
E General learning objective: Understand the operation of oily water separator/similar equipment and their requirements and operation **Specific Learning Objectives: Oily Water Separator construction and operation(IMO 7.04,2014: F1/1.5.3)**	
E1.1 OILY WATER SEPARATOR 1.1.1 Describe the requirements necessary for oily water separators/similar equipment 1.1.2 Describe the structure of oily water separators/similar equipment	1
1.1.3 Describe the oil separation principles of oily water separators/similar equipment **1.1.4** Describe the components constructing oily water separators/similar equipment	1
1.1.5 State the reasons to use positive-displacement pump for oily water separators/similar equipment **1.1.6** State the principles of oil content meter attached to oily water separators/similar equipment	1
1.1.7 Explain how to prevent oil being mixed into discharging bilge when oil content exceeds 15 ppm 1.1.8 State that fluid going through inside the pipe lines and oily-water separator/similar equipment can be correctly checked with pressure gauges	1
1.1.9 State that pollution of the sea is an offence under international law 1.1.10 State that the dumping of oil or oil-water mixtures is strictly prohibited 1.1.11 State that there is a legal maximum oil content of water to be discharged overboard	1
1.1.12 State that any discharge which could be contaminated must be passed through an oily-water separator which produces an effluent containing less than 100 p.p.m. of oil under all inlet conditions 1.1.13 State that the effluent should be further filtered to give an output containing a maximum of 15 p.p.m. of oil under all inlet conditions	1
1.1.14 Describe with the aid of a single line sketch, the operation of an automatic three-stage oily-water separator/similar equipment	1
1.2 List the information that must be entered in the Oil Record Book when pumping out bilges	1
F General learning objective: Understand the operation of Sewage Treatment Plant (IMO 7.04,2014: F1/1.5.2.2) **Specific Learning Objectives: Understand the operation of Sewage Treatment Plant and the discharge restrictions under Annex 4 of Marpol**	
F1.1 Sewage Treatment Plant 1.1 Sketch and describe a typical Biological Sewage treatment plant used on board ships	2
1.2 Explain what is meant by a coliform count in sewage systems 1.3 Explain what is meant by a sewage-retention system 1.4 Explain the purpose of a sewage comminutor 1.5 State that the effluent from a sewage plant must not be discharged in certain specified areas and that permission to discharge sewage must be obtained from the officer in charge of a navigational watch 1.6 Explain function of vacuum toilets	2
G General learning objective: Understand the operation of Incinerator (IMO 7.04,2014: F1/1.5.2.2) **Specific Learning Objectives: Understand the operation of Incinerator and the restrictions under Annex 4 and Annex 6 of Marpol for its operation.**	
G1.1 Incinerator 1.1.1 Sketch and describe a typical Incinerator with an induced draft fan for the purpose of burning sludge and sold waste as per Annex 1 and Annex 5 of MARPOL	2
1.1.2 Explain briefly the purpose and operation of an incinerator for the disposal of: • Sludge • Refuse 1.1.3 Explain the entries that need to be made in the Oil Record Book and the Garbage record Book with reference to the operation of the Incinerator	2
H General learning objective: Safety Measures To Be Taken For Repair And Maintenance on board ships	

Specific Learning Objectives: Understand the ISM Code and its application(IMO 7.04,2014: F3/3.2.1)	
H1.1 ISM Code 1.1.1 Explain the outline of ISM Code (International Safety Management) including the background and process of Establishment	2
1.1.2 Explain briefly how a SMS (Safety Management System) should be established and what sorts of documents are included	2
1.1.3 List documents, checklists and others for safety measures for fabrication and repair and explain their specific purposes	2
1.1.4 State the safety measures to be taken for repair and maintenance can be identified through proper risk assessment 1.1.5 State that safety measures based on SMS should be applied to identified risks 1.1.6 Explain that tool box talks prior to repair and maintenance are effective for taking necessary safety measures	2
1.1.7 Explain that safety measures include use of protective equipment, preparation of proper lighting, anti-slipping measures, preparation of safety procedures, setting up a safety barrier, preparation of a safe working platform, mechanical/electrical isolation of machinery to be repaired/maintained, and prior checks based on SMS 1.1.8 Explain the particular safety measures in accordance with machinery feature which may be necessary	2
I General learning objective: Safe Working Practices (IMO 7.02,2014: F3/3.3.1) **Specific Learning Objectives: Understand the Safe Working Practices under ISM Code**	
I1.1 Safe Working Practices 1.1Discuss the role of safety officials on board ship • Safety officer • Safety committee • Safety inspections • Investigation of accidents and dangerous occurrences	1
1.2 Discuss the use of safety induction procedures • Emergency procedures and fire precautions • Accidents and medical emergencies • Health and hygiene • Good housekeeping • Environmental responsibilities • Occupational health and safety	1
1.3Explain typical shipboard emergency procedures • Action in the event of fire • Muster and drills	1
1.4Discuss safe work practices when • Working aloft • Portable ladders • Lagging of steam and exhaust pipes • Unmanned machinery spaces • Refrigeration machinery	1
1.5 Identify the risks and the safety precautions and procedures for entering enclosed or confined spaces • Identifying hazards • Oxygen deficiencies • Toxicity of oil and other substances • Flammability • Other hazards • Breathing apparatus and resuscitation equipment • Preparing the space for entry • Testing atmosphere of the space • Procedures and arrangements before entry • Procedures and arrangements during entry • Procedures on completion	1
1.6 Discuss the use of permit to work systems • Work in unmanned machinery spaces	1

• Entry into enclosed or confined spaces • Hot work • Working aloft • Electrical system for other than electrical officer	
1.7 Identify safe practices for manual handling • Musculo-skeletal injuries due to an unsatisfactory working method • Appropriate steps to reduce risk of injury	1
1.8 Explain procedures for the safe use of lifting plant • Safe working load (SWL) • Register of lifting appliances, markings and certificates • Regular maintenance • Examination, inspection and testing • Safety measures	1
1.9 Discuss the procedures for undertaking hot work on board ship • Pre-use equipment test • Precautions against fire and explosion • Precautions during use of electric arc welding • Compressed gas cylinders • Gas welding and cutting	1
1.10 Discuss the procedures for working safely with hazardous substances • Carcinogens and mutagens • Asbestos dust • Use of chemical agents • Safety data sheet	1

Subject Name/Code: Electro Technology/405

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted with classroom/online lectures and self–learning.

Assessment Methods: **Refer to IMU Guidelines prior start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

Pre–requisite for this Subject: Class 12 Physics, Maths.

Recommended Text:

1. A Textbook of Electrical Technology Vol-2, B L Theraja.
2. Marine Electrical Technology 11th Edition; By Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN:9789352139514.

Reference:

1. Marine High Voltage Technology; By J. Majumder, Elstan A. Fernandez, Lakshman Singh Yadav; Publisher: Shroff Publishers and Distributors; Year: 2018; ISBN: 9788175981799.
2. Maintenance and troubleshooting of Marine Electrical Systems, Elstan Fernandez, Lakshman Singh Yadav; Publisher Zed Kuailz Publishers; Year: 2020; ISBN 9788194710608.
3. High Voltage Engineering by M.S. Naidu, V Kamaraju; Publisher Tata McGraw–Hill.
4. Marine Control Technology 4th Edition; By J. Majumder, Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN: 9789352139682.
5. Marine Electrical Equipment and Practice (Marine Engineering Series); McGeorge, H. D; Publisher: Stanford Maritime; Year: 1986; ISBN 10: 0540073601 ISBN 13: 9780540073603.
6. Practical Marine Electrical Knowledge by Dennis T. Hall.

Table of Topics

Section	Topics	Hours (L)
A1 – A2	**Electrical Safety** **Sub-Topics:** 1.1 Electrical safety 1.2 Safety Requirements for working on Electrical Systems	2
B1	**Overview of a Ship's Electrical System** **Sub-Topics:** 1.1 Design features and system configuration of equipment 1.2 Essential Services	2
C1 – C2	**Electrical Circuit Symbols and Diagrams** **Sub-Topics:** 1.1 Interpretation of circuit symbols Electrical and Simple Electronic Diagrams	4
D1 – D2	**Electrical Equipment for Hazardous Areas** **Sub-Topics:** 1.1 Design features and system configuration 1.2 Special Equipment for Tankers and Hazardous Areas	2
E1 – E4	**Emergency Power and Shore Supply** **Sub-Topics:** 1.1 Emergency Power System 1.2 Power failure (blackout) 1.3 Emergency Power Distribution Systems General Requirements for Power and Lighting	3
F1 – F3	**Isolated and Earthed Neutral Systems** **Sub-Topics:** 1.1 Electromagnetic Interference and its Suppression 1.2 Insulated and Earthed Neutral Systems Earthing and Earth-faults for High-voltage installations	2
G1 – G2	**Automatic Voltage Regulators and Exciters** **Sub-Topics:** 1.1 Need for an Automatic Voltage Regulator (AVR) 1.2 Circuit Design and Operational Features of an AVR	2
H1	**Fixed and Portable Instrumentation** **Sub-Topics:** 1.1 Basic Test Equipment and their Use on Board Ships	2
I	**Automatic Control and Paralleling of Alternators** **Sub-Topics:** 1.1 Automatic Starting, Stopping and Control of Generators Parallel Operation of AC Generators	4
J1	**Switchboards and Switchgear** **Sub-Topics:** 1.1 Switchgear for AC Power Distribution	2

Section	Topics	Hours (L)
K1 – K2	**Fault Protection Devices** **Sub-Topics:** 1.1 Detection of Electric Malfunction and measures to prevent damage (Fault Protection) 1.2 Fault location 1.3 Automatic Control mechanisms for Power Distribution Systems	4
L1 – L2	**Electric Cables** **Sub-Topics:** 1.1 Essential Requirements for Marine Electrical Cables 1.2 Fire Retardant Cables and their Installation	2
M1 – M2	**Insulation and Ingress Protection** **Sub-Topics:** 1.1 Insulating Materials and the Effects of the Environment on them 1.2 Salient Features of Insulating Materials	2
N1	**Steering Systems** **Sub-Topics:** 1.1 Operation and Control of Steering Systems in Emergency Mode	2
O1	**Deck Machinery** **Sub-Topics:** 1.1 Salient Features and Operation of Deck Machinery	2
P1	**Batteries and Battery Charging** **Sub-Topics:** 1.1 Batteries Used in the Marine Environment 1.2 Precautions while handling Batteries 1.3 Battery Charging	3
Q1	**Lighting Systems** **Sub-Topics:** 1.1 Salient Features of a Ship's Lighting Systems	2
R1	**High Voltage installations** **Sub-Topics:** 1.1 Salient Features High-voltage installations and Precaution while Working	3
	Total	**45**

Learning Objectives	L
A Electrical Safety **General Learning Objectives** • Understand the importance of existing Safety Regulations • Know the importance of adopting safety measures on-board • Understand First-aid procedures in case of electrical accidents **Topic: Electrical Safety** **Sub-Topics:** 1.1 Electrical safety 1.2 Safety Requirements for working on Electrical Systems	
A1 Specific Learning Objectives: (IMO 7.02,2014: 1.1) **1.1 Electrical safety** 1.1.1 State the safety procedures to be adopted when working on electrical installations 1.1.2 Write the effects of electric current on the human body **A2 Specific Learning Objectives: (IMO 7.04,2014: 2.2.1)** **1.2 Safety Requirements for working on Electrical Systems** 1.2.1 Describe the cause of electrical shock, giving the level of current which could be fatal 1.2.2 State the voltage range which is considered safe 1.2.3 Apply necessary safety precautions when working on electrical equipment in practice 1.2.4 State the isolation procedures required for electrical equipment 1.2.5 State the safety and isolation precautions necessary before commencing work 1.2.6 Explain the purpose of interlocks fitted to circuit breakers 1.2.7 Explain the danger associated with the spaces in the vicinity of bus bars 1.2.8 Explain the potential danger of instrument voltage / current transformer circuits and the safe procedure for working on such circuits 1.2.9 Describe the protection normally provided on the doors of switchboard cubicles 1.2.10 Explain the safety and emergency procedures are documented in the ship's safety management system	2
B Overview of a Ship's Electrical System **General Learning Objectives** • Understand the need for specially designed equipment for ships • Know the purpose of major components in a ship's electrical system • Know the importance of power management on board ships **Topic: Overview of a Ship's Electrical System** **Sub-Topics:** 1.1 Design features and system configuration of equipment 1.2 Essential Services	

B1 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 – 1.4) **1.1 Design features and system configuration of equipment** 1.1.1 State the angles of heel and trim at which machinery should be capable of operating 1.1.2 Explain the effects of temperature changes on: - electromagnetic devices - generator voltage 1.1.3 Discuss common maximum temperatures of air and sea water used for design purposes 1.1.4 Explain why the axes of a rotating machine should not be placed athwart ships unless so designed 1.1.5 Discuss requirements regarding the provision of electrical power and lighting for normal operation and for an emergency	2
B1 Specific Learning Objectives: IMO 7.04,2014: 2.1.1) **1.2 Essential Services** 1.2.1 List the essential services which are supplied by electrical power	
C Electrical Circuit Symbols and Diagrams **General Learning Objectives** • Understand the need for specially designed equipment for ships • Know the purpose of major components in a ship's electrical system • Know the importance of power management on board ships **Topic: Electrical Circuit Symbols and Diagrams** **Sub-Topics:** 1.2 Interpretation of circuit symbols 1.3 Electrical and Simple Electronic Diagrams	
C1 Specific Learning Objectives: (IMO 7.02,2014: 2.2) **1.1 Interpretation of circuit symbols** 1.1.1 Interpret, identify and trace the following: - Circuit components, functional description - Simple electrical circuits using relays, timers, contactors and other components	2
C2 Specific Learning Objectives: (IMO 7.04,2014: 2.2.6) **1.2 Electrical and Simple Electronic Diagrams** 1.2.1 Explain major electrical and electronic symbols used in their circuit diagrams 1.2.2 Describe the function of circuit elements presented by symbols in their circuit diagram 1.2.3 Explain briefly the flow of electric / electronic current and functions of their circuit diagrams taking simple circuits containing major electrical / electronic symbols as examples 1.2.4 Explain the basic differences between the following electrical diagrams - block diagram - system diagram - circuit diagram - wiring diagram 1.2.5 Sketch a circuit diagram by using a given simple wiring diagram. 1.2.6 Sketch schematic or system diagrams, using correct letter and circuit symbols from given simple circuit or wiring diagrams. 1.2.7 Use the diagrams named in the above objective	2

D Electrical Equipment for Hazardous Areas **General Learning Objectives** • Understand the dangers of hazardous areas on-board a ship • Understand the significance of special equipment for hazardous areas **Topic: Electrical Equipment for Hazardous Areas** **Sub-Topics:** 1.1 Design features and system configuration 1.2 Special Equipment for Tankers and Hazardous Areas	
D1 Specific Learning Objectives: (IMO 7.02,2014: Para 2.1.2 – 2.1) **1.1 Design features and system configuration** 1.1.1 Explain that electrical equipment designed for land use is often not suitable for ships 1.1.2 Explain that as far as possible, all materials should be non-flammable; 1.1.3 Explain where flame retardant materials may be used 1.1.4 Explain the meaning of the term flame retardant **D2 Specific Learning Objectives: (IMO 7.02,2014: 2.1.3 – 3.9)** **1.2 Special Equipment for Tankers and Hazardous Areas** 1.1.5 Explain the importance and features of electrical equipment for tankers and hazardous areas and safety systems	2
E Emergency Power and Shore Supply **General Learning Objectives** • Understand the methods of supplying emergency power and shore supply • Know the basic actions to be taken by engineers in a black-out situation • Know the detrimental effects of supplying equipment with different voltages and frequencies **Topic: Emergency Power and Shore Supply** **Sub-Topics:** **1.4 Emergency Power System** **1.5 Power failure (blackout)** **1.6 Emergency Power Distribution Systems** **1.7 General Requirements for Power and Lighting**	
E1 Specific Learning Objectives: (IMO 7.02,2014: 2.1.3 – 3.10) **1.1 Emergency Power System** 1.1.1 Explain the automatic starting arrangement for the emergency generator 1.1.2 State emergency power requirements 1.1.3 Identify essential and non-essential circuits	1

E2 Specific Learning Objectives: (IMO 7.04,2014: 1.4.2 - 2.3) **1.2 Power failure (blackout)** 1.2.1 Explain briefly power supply system on board ships and its back–up system 1.2.2 Explain the specific conditions of blackout and procedures for recovery responding to their cause taking a physical system as an example, including the following: - transient phenomenon of the plant - equipment / installations to be promptly addressed - sequential restarting auxiliaries - auxiliaries to be manually restarted - generator control system and power distributing system	1
E3 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 -1.4) **1.3 Emergency Power distribution systems** 1.3.1 Explain the purpose of interlocks fitted to circuit breakers 1.3.2 List the essential services which are supplied by electrical power 1.3.3 Explain the purpose of emergency power supply 1.3.4 State the possible sources of emergency power supply and how they are brought into use **E4 Specific Learning Objectives: (IMO 7.02,2014: Para 2.1.2 – 2.1)** **1.4 General Requirements for Power and Lighting** 1.4.1 Discuss requirements regarding the provision of electrical power and lighting for normal operation and for an emergency	1
F Isolated and Earthed Neutral Systems	
General Learning Objectives • Know the importance of electromagnetic compatibility of equipment • Understand the significance of Isolated and Earthed Neutral Systems • Understand the operating principle of earth fault indicators • Solve earth faults in a basic electrical distribution system **Topic: Isolated and Earthed Neutral Systems** **Sub-Topics:** 1.3 Electromagnetic Interference and its Suppression 1.4 Insulated and Earthed Neutral Systems 1.5 Earthing and Earth-faults for High-voltage installations	

F1 Specific Learning Objectives: (IMO 7.02,2014: 2.1 - 1.1) **1.1 Electromagnetic Interference and its Suppression** 1.1.1 Discuss the following in terms of electrical practice in ships: - electrical interference - equipment susceptible to electrical interference - common sources of interference - method of suppression of interference **F2 Specific Learning Objectives: (IMO 7.02,2014: 2.1 - 2.1.1 – 1.4)** **1.2 Insulated and Earthed Neutral Systems** 1.1.2 by means of simple sketch, show the difference between insulated systems and earthed-neutral systems **F3 Specific Learning Objectives: (IMO 7.02,2014: 2.1 - 2.1.1 – 1.7)** **1.3 Earthing and Earth-faults for High-voltage installations** 1.3.1 State that high-voltage systems are normally earthed via a resistor 1.3.2 Explain how the presence of earth faults is indicated in a high-voltage system with an earthed neutral	2
G Automatic Voltage Regulators and Exciters **General Learning Objectives** • Know the operating principle of an AVR • Understand the role of an AVR in the excitation system of a generator **Topic: Automatic Voltage Regulators and Exciters** **Sub-Topics:** 1.1 Need for an Automatic Voltage Regulator (AVR) 1.2 Circuit Design and Operational Features of an AVR	
G1 Specific Learning Objectives: (IMO 7.02,2014: 1.3 - 5.1) **1.1 Need for an Automatic Voltage Regulator (AVR)** 1.1.1 Explain the importance and fundamentals of Voltage Regulation in an alternator **G2 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 – 1.3)** **1.2 Design and Operational Features of an AVR** 1.2.1 Sketch a block diagram of an automatic voltage regulator, naming the main components and explaining the purpose of the hand trimmer 1.2.2 Adjust, or Describe how to adjust, the load sharing of two generators running in parallel 1.2.3 State that load sharing can be automatically controlled 1.2.4 Explain how excitation of the rotor is produced and supplied	2
H Fixed and Portable Instrumentation **General Learning Objectives** • Understand basic measuring system terminology and fundamentals of panel instruments • Know the purpose of instruments on a main switchboard of a ship **Topic: Fixed and Portable Instrumentation** **Sub-Topics:** 1.1 Basic Test Equipment and their Use on Board Ships	

H1 Specific Learning Objectives: (IMO 7.02,2014: 2.2) **1.1 Basic Test Equipment and their Use** 1.1.1 Operation of meggers, multimeters and CRO 1.1.2 Precautions to be followed for carrying out open, short and insulation measurement tests	2
I Automatic Control and Paralleling of Alternators **General Learning Objectives** • Understand the basic methods of synchronising two alternators • Know the importance of paralleling alternators • Understand the methods of paralleling alternators **Topic: Paralleling of Alternators** **Sub-Topics:** **1.2 Automatic Starting, Stopping and Control of Generators** **1.3 Parallel Operation of AC Generators**	
I1 Specific Learning Objectives: (IMO 7.02,2014: 1.3 Para 5.1) **1.1 Automatic Starting, Stopping and Control of Generators** 1.1.1 Describe system components and configuration for generator and distribution system automatic control 1.1.2 Describe the following functions used for generator and distribution system automatic control, including operation / control mechanisms: - fully automatic control for generator and distribution system, including starting and stopping prime mover - automatic synchronising - automatic load sharing	2
I2 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 - 1.3) **1.2 Parallel Operation of AC Generators** 1.2.1 Explain such sources of supply can be run in parallel and those which cannot 1.2.2 Perform or describe the synchronizing sequence to bring a generator into service in parallel with a running generator, using both synchroscope and lamps 1.2.3 Adjust, or describe how to adjust, the load sharing of two generators running in parallel 1.2.4 Perform the procedure, or Describe how, to reduce the load on a generator and takes it out of service 1.2.5 State that load sharing can be automatically controlled	2
J Switchboards and Switchgear **General Learning Objectives** • Understand the function and operating methodology of different components and breakers • Know the basic operation of switchboards and related switchgear **Topic: Switchboards and Switchgear** **Sub-Topics:** 1.1 Switchgear for AC Power Distribution	

J1 Specific Learning Objectives: IMO 7.04,2014: 2.1.1 – 1.4 **1.1 Switchgear for Power Distribution Systems** 1.1.1 Explain the basic purpose of switches, circuit breakers and fuse 1.1.2 Describe briefly the principle of the various types of closing mechanism of circuit breakers 1.1.3 List the way in which a circuit breaker can be tripped 1.1.4 Explain the purpose of interlocks fitted to circuit breakers	2
K Fault Protection Devices **General Learning Objectives** • Understand the fundamental reasons for faults in equipment • Know the importance of fault protection • Understand the operation of various protective devices **Topic: Fault Protection Devices** **Sub-Topics:** 1.1 Detection of Electric Malfunction and measures to prevent damage (Fault Protection) 1.2 Fault location 1.3 Automatic Control mechanisms for Power Distribution Systems	
K1 Specific Learning Objectives: (IMO 7.04,2014: 2.2.3) **1.1 Detection of Electric Malfunction and measures to prevent damage (Fault Protection)** 1.1.1 Explain why fault protection is essential 1.1.2 Name the component parts of fault–protection equipment 1.1.3 Explain why fault currents are extremely high 1.1.4 Name the protection provided against: - short circuits - small overloads 1.1.5 Describe the procedure when replacing a blown fuse 1.1.6 Explain in simple terms, preferential tripping when overload occurs 1.1.7 Explain the purpose of under voltage protection of generators and of motors 1.1.8 Explain the purpose of reverse power protection 1.1.9 Sketch the layout of a typical main switchboard, indicating the function of the main parts 1.1.10 Explain the danger associated with the spaces in the vicinity of the bus bar 1.1.11 Explain the use of transformers for switchboard instruments, stating the voltage and current produced 1.1.12 Describe the earthing of instruments 1.1.13 Explain the potential danger of instrument voltage / current transformer circuits and the safe procedure for working on such circuits 1.1.14 Explain how status indicator lamps are usually supplied with power 1.1.15 Describe the procedure if a fault develops with a miniature circuit breaker 1.1.16 Adjust, maintain and test the types of fault protection normally encountered	2
1.2 Fault location 1.2.1 Locate faults in simple control systems 1.2.2 Explain how locating fault take action to best prevent damage 1.2.3 State what is necessary to prevent damage from electrical malfunctions such as burned circuit elements, poor contacts, breaking and faulty limit / micro switches	1

K2 Specific Learning Objectives: (IMO 7.02,2014: 1.3 Para 5.1) **1.3 Automatic Control mechanisms for Power Distribution Systems** 1.3.1 Describe the following functions used for generator and distribution system automatic control, including operation / control mechanisms: - large motor start blocking - preference trip - protective / safety functions built in Automatic / Main Circuit Breaker (ACB and VCB)	1
L Electric Cables **General Learning Objectives** • Know the importance of temperature coefficients of conductors • Understand the need for cable rating and testing • Follow proper wiring procedures on board a ship **Topic: Electric Cables** **Sub-Topics:** **1.1 Essential Requirements for Marine Electrical Cables** **1.2 Fire Retardant Cables and their Installation**	
L1 Specific Learning Objectives: (IMO 7.02,2014: 2.1 - 1.1) **1.1 Essential Requirements for Marine Electrical Cables** 1.1.1 Discuss the following in terms of electrical practice in ships: - materials and conductors - sheathing of cables - cable runs in machinery spaces; cargo holds and cold storage chambers - passing of cables through bulkheads and decks **L2 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 – 1.9)** **1.2 Fire Retardant Cables and their Installation** 12.2 Describe the reaction of electric cables to a fire 12.3 Explain why cable sockets should be securely attached and locked on to the terminal	2
M Insulation and Ingress Protection **General Learning Objectives** • Know the classes and applications of insulating materials • Understand the significance of various degrees of protection and temperature ratings of electrical equipment on board ships **Topic: Insulation and Ingress Protection** **Sub-Topics:** 1.1 Insulating Materials and the Effects of the Environment on them 1.2 Salient Features of Insulating Materials (IP Notation; classification etc.)	

M1 Specific Learning Objectives: (IMO 7.02,2014: 2.1 - 1.1) **1.1 Insulating Materials and the Effects of the Environment on them** 1.1.1 Discuss the following in terms of electrical practice in ships - commonly used insulation material - effect of temperature, oxidation, fire, oil, seawater, and solvents on insulation materials **M2 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 - 1.4)** **1.2 Salient Features of Insulating Materials** 1.2.1 Explain what is meant by an insulator and the purpose of insulation 1.2.2 Describe leakage in an insulated cable 1.2.3 Explain why the insulation resistance of large installations is normally relatively lower than those of small installations 1.2.4 Describe factors which affect the value of insulation resistance 1.2.5 Explain why the current-carrying capacity of a machine is governed by its insulation 1.2.6 Describe what is meant by insulation resistance and Explain how it often deteriorates 1.2.7 Describe the materials and general physical characteristics of insulation materials and the factors and conditions which cause deterioration 1.2.8 State the maximum temperature where common insulation materials can withstand and the maximum ambient air temperature used in design 1.2.9 Explain why the ventilation and cooling of insulation is essential	2
N Steering Systems	
General Learning Objectives • Understand the fundamental modes of steering systems • Know the operating principle of rudder position indicators • Understand the basic theory of a gyroscope **Topic: Steering Systems** **Sub-Topics:** 1.1 Operation and Control of Steering Systems in Emergency Mode	
N1 Specific Learning Objectives: (IMO 7.04,2014: 1.4.2 – 2.4) **1.1 Operation and Control of Steering Systems in Emergency Mode** 1.1.1 Describe how the system can be controlled from: - a local position in the steering compartment at the rudder head - an emergency steering position on deck 1.1.2 Describe alternative systems of steering that can be used in emergency	2
O Deck Machinery	
General Learning Objectives • Understand the basic operation of windlasses and cargo winches • Be capable of tracing deck machinery control circuits **Topic: Deck Machinery** **Sub-Topics:** 1.1 Salient Features and Operation of Deck Machinery	

O1 Specific Learning Objectives: (IMO 7.02,2014: 2.1 Para 1.1) **1.1 Salient Features and Operation of Deck Machinery** 1.1.1 Discuss the following in terms of electrical practice in ships - deck machinery - fail safe brake - coil operated brake - deck winches and capstans, windlass and deck cranes	2
P Batteries and Battery Charging **General Learning Objectives** • Understand the construction and operation of secondary cells • Understand Battery charging and the safety measures to be adopted • Know the first aid measures to be adopted in case of electrolyte spillage **Topic: Batteries and Battery Charging** **Sub-Topics:** 1.3 Batteries Used in the Marine Environment 1.4 Precautions while handling Batteries 1.5 Battery Charging	
P1 Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 – 1.10) **1.1 Batteries used in the Marine Environment** 1.1.1 Describe the principle of the voltaic cell 1.1.2 Quote an example of and Explain the difference between: - primary cells - secondary 1.1.3 List the routine and emergency services normally supplied by batteries 1.1.4 State the range of voltages and /or alkaline batteries which are used 1.1.5 State that lead-acid and/or alkaline batteries are used 1.1.6 Explain the effect on current and voltage when connecting cells: - in series - in parallel 1.1.7 State that 12 lead-acid or 20 alkaline cells connected in series produce a nominal 24 volts 1.1.8 Explain how cells or batteries are connected to increase their capacity 1.1.9 Explain capacity is stated and what it means **1.2 Precautions while handling Batteries** 1.2.1 Describe the dangers which may exist in a battery compartment and Explain how they are overcome 1.2.2 Explain the topping up procedure for batteries 1.2.3 State that the appropriate first-aid equipment should be available in the place where the batteries are housed 1.2.4 Describe the first-aid necessary if parts of the body and eyes are in contact with electrolyte from: - a lead-acid battery - an alkaline battery	2

1.3 Battery Charging 1.3.1 Describe how batteries are recharged and the periods during which gassing takes place 1.3.2 Describe how a battery connected for recharging 1.3.3 Explain how the condition of an alkaline battery is determined 1.3.4 Explain the effect of the internal resistance of a battery on its terminal voltage 1.3.5 Demonstrate the above objective by means of simple examples	1
Q Lighting Systems **General Learning Objectives** • Know the fundamentals of incandescent and discharge lamps, with respect to their operating principles and areas of application • Understand the operation of various lighting circuits on-board a ship **Topic: Lighting Systems** **Sub-Topics:** 1.1 Salient Features of a Ship's Lighting Systems	
Q1 Specific Learning Objectives: IMO 7.04,2014: 2.1.1 **1.1 Salient Features of a Ship's Lighting Systems** 1.1.1 State that correct levels of lighting are vital for safety, efficiency and comfort 1.1.2 Describe the principle of the incandescent lamp 1.1.3 Explain the difference between lamps for general lighting and for rough service 1.1.4 Describe briefly the principle, application and care when handling tungsten-halogen lamps 1.1.5 Explain the principle of discharge lamps 1.1.6 Explain how florescent tubes are started up 1.1.7 Explain how the power factor of fluorescent tubes is improved 1.1.8 Explain how radio interference is suppressed in a fluorescent 1.1.9 Explain the effect of variation in voltage on both incandescent and gas-discharge lamps 1.1.10 explain how energy lights are marked 1.1.11 State which emergency lights are on the emergency switchboard system and which lights may be on the battery circuit 1.1.12 Explain why the correct power of lamps should be used	2
R High-voltage Installations **General Learning Objectives** • Know the terminology Associated with High Voltage Systems • Understand Risks and Hazards involved in High Voltage Applications • Understand Incident energy and Approach Boundaries related to Exposed HV live conductors • Understand arc prevention using arc sensors • Know Trapped Key and Key Safe Systems • Know how to avoid electrical accidents by adopting adequate safety measures **Topic: High-voltage Installations** **Sub-Topics:** 1.1 Salient Features High-voltage installations and Precaution while Working	

Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 – 1.7) **1.1 Salient Features High-voltage installations and Precaution while Working** 1.1.1 State why more than 1,000 V is usually called high voltage 1.1.2 State how and why high-voltage installations are used on board ships 1.1.3 State what voltages are mostly used as high voltage on board ships 1.1.4 Describe equipment/installations in high-voltage generator, distribution board, motors, etc. 1.1.5 State the special characteristics and features of high-voltage installations in comparison with less than 1,000 V	2
1.1.6 State safety precautions that should be strictly followed to prevent accidents when working on high-voltage electrical equipment 1.1.7 State that any operation of high-voltage installations must be carried out remotely at places where a certain distance is being kept from the installations	1

Subject Name/Code: Marine Boilers and Steam Systems/406

Instructional hours:

Lecture	: 60 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, practical in workshops and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Marine steam boilers, James H. Milton, Roy M. Leach.
2. Marine boilers - G.T.H. Flanagan.
3. Steam Engineering Knowledge for Marine Engineers - Reeds Volume:9.

Reference:

1. Running & Maintenance of Marine Machinery - Cowley, I.M.E Publication.
2. Boiler Control System - David Lindsley.
3. A Text Book of Marine Boilers – Atul Kumar Gupta.
4. Practical Boiler Operation Engineering & Power by Mallick Amiya Ranjan.

Table of Topics

Section	Topics	Hours (L)
A	Marine boiler fundamentals	9
B	Marine boiler construction	10
C	Marine boiler mountings and steam distribution	12
D	Steam boiler fuel atomization and combustion	12
E	Boiler and Associated Auxiliaries, and Steam Systems	7
F	Boiler Operation	5
G	Main Boiler Auto-shut down	2
H	Selection of Materials in Construction of Equipment	1
I	Design Characteristics	2
	Total	**60**

Learning Objectives	**L**
General Learning Objective-Understand the design features and the operative mechanism of the Marine Boiler and associated auxiliaries along with the Steam service system so that the related machinery is maintained and operated in a safe, economical and efficient manner on-board **(IMO 7.04,2014: F1/1.4.1.4)**	
A. Specific Learning Objectives: Marine boiler fundamentals 1.1 Describe with the aid of diagrams, an auxiliary boiler steam system 1.2 Identify all the services supplied by steam on all types of ship 1.3 State typical pressures of steam produced in auxiliary boilers and average system supply pressures 1.4 State the auxiliary steam boilers range for simple fire-tube boiler 1.5 State the auxiliary steam boilers range for self-contained fully automated package units 1.6 Explain simply and briefly, with the aid of diagram a fire-tube boiler 1.7 Explain simply and briefly, with the aid of diagram a water-tube boiler 1.8 Explain simply and briefly, with the aid of diagram a packaged boiler 1.9 State the principal differences between a fire-tube boiler, a water-tube boiler and a packaged boiler	9

B. Specific Learning Objectives: Marine boiler construction 1.1 Describe the material commonly used for construction in a fire-tube boiler 1.2 Describe with the aid of Sketch, the general constructional details of a fire-tube boiler, showing how the parts are connected to form a compete structure 1.3 With reference to pressure vessels explain why • shells of cylindrical form give a higher strength/weight ratio than other shapes • the cylindrical shell can be sited vertically or horizontally • dished or spherical end-plates give a higher strength than flat end-plates of similar thickness • all flat surfaces must be properly stayed to resist deformation • stays can have the form of solid bars, thick tubes or plate girders • corrugated furnaces provide higher strength and flexibility than plain furnaces of similar thickness 1.4 Explain the purpose of fitting a boiler on board diesel engine ships? 1.5 Draw the outline of a boiler system by listing associated systems including their components 1.6 Explain the relationship between a boiler and exhaust gas economizer 1.7 Explain ignition system including the function of burner control 1.8 Explain feed water system including the function of feed water control 1.9 Explain steam temperature control system usually used for main boiler 1.10Describe the principles of construction, operation and control of a packaged boiler	10
C. Specific Learning Objectives: Marine boiler mountings and steam distribution – (IMO 7.04,2014: F1/1.4.1.4) 1.1 Identify the following boiler fittings and position on boiler shell (supply shell diagram for fitting to be married/drawn and identified): • main steam outlet (or 'stop') valve • auxiliary steam stop valve • safety valves and easing gear • water level gauges • feed inlet valve • blow-down valve • scumming valve • soot blowers • connections for pressure gauges • air release valve • sampling valve • Explain the importance of boiler mounted valves 1.2 Identify the following internal boiler fitting and internal position within a boiler shell: • feed water distribution unit • scumming pan • blow-down dip pipe Explain the purpose of the valves and fittings listed above, comparing the differences, where applicable, between water-tube and fire-tube boilers 1.3 Explain the purpose of a reducing valve. Describe the operation of a reducing valve, using a single line sketch 1.4 With reference to Steam Pipes Explain how steam pipes are supported. Explain how expansion and contraction are allowed for in steam pipes Describe the different methods of joining lengths of a steam pipe Explain the purpose of drains and steam traps describing the operation of steam traps Describe the procedure for warming through a steam line and explain the cause, in simple terms, of water hammer and how water hammer can be avoided 1.5 Describe the means used to minimize the possibility of oil contaminating the boiler feed water	12

D. Specific Learning Objectives: Steam boiler fuel atomization and combustion
(IMO 7.04,2014: F1/1.4.1.4)

1.1 Explain the process by which elements carbon and hydrogen combine chemically with oxygen during combustion to form the gaseous product carbon dioxide and water vapour

- Explain the part played by nitrogen in the combustion process
- Explain the need for excess air and how it should be kept to minimum
- Explain the need for monitoring the percentage of carbon dioxide or the percentage of oxygen in the exhaust gas
- Discuss the products of combustion which is normally a gaseous mixture of carbon dioxide, sulphur dioxide, water-vapour, possibly carbon monoxide and an ash, possibly containing sodium and vanadium
- Explain how poor combustion creates smoke, which pollutes the atmosphere and wastes fuel and reduces the efficiency of the engine or boiler
- Explain the fact that the production of smoke may lead to prosecution
- Describe briefly the instruments available to indicate and record the percentage of CO_2 and O_2 in exhaust gas
- State the ranges of percentages of CO_2 which indicate good combustion, poor combustion, bad combustion

1.2 Explain the importance of atomization when it is required to mix a liquid

- fuel with air prior to combustion
- Explain why the viscosity of a fuel is important in its atomization
- Describe how the viscosity of a liquid fuel can be controlled by varying its
- temperature

1.3 State the theoretical air/fuel ratio for a typical boiler fuel

- State the actual air/fuel ratio allowing for normal excess air in the furnace of a steam boiler
- State the effect of sulphur dioxide coming into contact with a low-temperature surface, production of sulphuric acid and the corrosion it will cause
- Explain how the effect of the above objective can be minimized

1.4 Describe with a single line diagram a combustion air register identifying:

- swirl vanes
- the flame stabilizer
- air-flow control valves
- the burner
- State typical values of the pressure drop and of the velocity of combustion air in the register
- Explain why the thorough and rapid mixing of atomized fuel and combustion air is important
- Describe the furnace conditions which indicate good combustion

1.5 Sketch a section through the nozzle assembly of a pressure-jet burner

- Explain the process of atomization produced by the fuel, at high pressure, passing through a small orifice in the burner nozzle
- Describe the attention required by burner atomizer tips

1.6 Describe with the aid of sketch a steam-jet burner

1.7 Describe with the aid of sketch a rotary-cup burner

1.8 Sketch a typical Fuel oil pipeline system for an Auxiliary System burning Fuel Oil and Low Sulphur Gas Oil. Explain the process of changing over from High sulphur heavy fuel Oil to Low sulphur Gas Oil

12

E. Specific Learning Objectives: Boiler and Associated Auxiliaries, and Steam Systems - (IMO 7.04,2014: F1/1.4.3.2) 1.1 State the procedure for igniting the burner manually and automatically State the procedure to build up the steam pressure and to put boiler into service Explain the precautions and necessary measures to be taken when getting up steam Explain the benchmark for building up steam pressure 1.2 Explain operation methods of boiler and economizer when vessel under way Explain precautions for using exhaust gas economizer State the function of safety valve and how to adjust the setting point to blow 1.3 Describe the method used to ensure that all pipes, cocks, valves and other fittings used for indicating water level are clear and in good working order Describe the correct procedure for checking the water level in steaming boilers Explain the treatment of boiler water including examination of properties of boiler Water Explain surface and bottom blowing of boiler water Describe the danger of oil entering a boiler with the feed water 1.4 Explain the function/process of soot blowing 1.5 Sketch and explain the function of soot blowers. 1.6 Explain the procedure to keep boiler in cold condition while it is out of service Describe the correct procedure for operating steaming boilers in parallel on load State the precautions for opening high temperature steam valves 1.7 Explain what is meant by 'blow-back' Explain how blow-back can be avoided Explain why the temperature of boiler exhaust gases should be maintained above a minimum value	7
F. Specific Learning Objectives: Boiler Operation - (IMO 7.04,2014: F1/3.2.3.10) 1.1 Explain the need for cleaning the fire side of a boiler and the procedure to do it. 1.2 Describe the procedure to inspect the fire side of a boiler and repair/maintenance a. Explain the need of cleaning up the water side of a boiler and the procedure to do it 1.3 Describe the procedure to inspect the water side of a boiler and the repair/ maintenance. 1.4 Describe the flashing up of boiler up from cold after cleaning up the fire/water side. Describe the procedure to repair the firebrick wall of a furnace	5
G Specific Learning Objectives: Main Boiler Auto-shut down - (IMO 7.04,2014: F1/1.4.2.2) 1.1 Explain main boiler auto-shut down taking a typical system as an example in terms of the following: • specific conditions • processes appearing until shut down • impact on the plant when vessel under way and in port • procedures for recovery (eliminating causes, reigniting burner, etc.,) • main boiler control system (changeover of control system, position, etc.,)	2
H Specific Learning Objectives: Selection of Materials in Construction of Equipment – (IMO 7.04,2014: F1/3.2.5.1) 1.1 State the materials used for constructing major parts of the following equipment on boilers • water tube • furnace • steam drum • water drum • superheater	1
I Specific Learning Objectives: Design Characteristics -(IMO 7.04,2014: F1/3.2.5.2 1.1 Explain and design characteristics developed to improve performance in construction of boiler	2
Total	**60**

Subject Name/Code: Automation, Control Engineering and Safety Devices/407

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, practical in workshops and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Modern Control Engineering D Roy Choudhury PHI.
2. Instrumentation and Control System, Boyd G & Jackson, Bloomsbury.
3. Marine Control Technology 4h Edition; By J. Majumder, Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN: 9789352139682.
4. Applied Marine Control and Automation; By J. Majumder, Elstan A. Fernandez, Mahesh Patil; Publisher: Shroff Publishers and Distributors; Year: 2019; ISBN: 9789352139194.

Reference:

1. Digital Control System and State Variable; By Gopal M; Publisher Tata McGraw Hill.
2. Digital Control System by Kuo B.C.; Publisher Oxford University Press, London.
3. Marine Control Practice by D.A. Taylor, Publisher Butterworth and Co. Ltd. London.

Table of Topics

Section	Topics	Hours (L)
A1	**Automatic Control Systems** **Sub-Topics:** Basic Construction and Operation Principles of Machinery Systems	14
B1	**Monitoring Systems** **Sub-Topics:** Function, Performance Test and Configuration of Monitoring Systems	3
C1	**Automatic Control Devices** **Sub-Topics:** Function, Performance Test and Configuration of Automatic Control Devices	5
D1	**Protective Devices** **Sub-Topics:** Function, Performance Test and Configuration of Protective Devices	5
E1	**Automatic Control Equipment and Safety Devices for the Main Engine** **Sub-Topics:** Design Features and System Configuration of Automatic Control Equipment and Safety Devices for The Main Engine	10
F1	**Automatic Control Equipment and Safety Devices for the Generator and Distribution System** **Sub-Topics:** Design Features and System Configuration of Automatic Control Equipment and Safety Devices for The Generator and distribution system	2
G1	**Automatic Control Equipment and Safety Devices for the Steam Boiler** **Sub-Topics:** Design Features and System Configuration of Automatic Control Equipment and Safety Devices for the Steam Boiler	2
H1	**Troubleshooting of Monitoring Systems** **Sub-Topics:** Test and calibration of sensors and transducers of monitoring system	4
	Total	**45**

Learning Objectives	L
A Automatic Control Systems **General Learning Objectives** • Understand the various modes of control • Identify the various sensors and physical components in a control loop • Understand the operation of basic controllers **Topic: Automatic Control Systems** **Sub-Topics:** 1.1 Basic Construction and Operation Principles of Machinery Systems	

A1 Specific Learning Objectives: (IMO 7.04, 2014, 1.4.1 – 1.8) **1.1 Basic Construction and Operation Principles of Machinery Systems** 1.1.1 Name and Describe each component constructing the following control methodologies: - ON-OFF control - sequential control - PID control - program control	2
1.1.2 Describe what control methodologies can be applied to which control systems taking examples such as automatic motor start/stop for ON-OFF control, automatic generator start/stop for sequential control	2
1.1.3 Describe what control methodologies can be applied to which control systems taking examples such as level/temperature/pressure control for PID control and main engine speed multiplication/reducing program control	2
1.1.4 Describe in simple words, the construction and the functions of each component for control systems	2
1.1.5 Describe operation principles of each component constructing automatic control systems taking examples such as: - pressure switch - temperature switch - resistance bulb	2
1.1.6 Describe operation principles of each component constructing automatic control systems taking examples such as: - electric-pneumatic converter - electromechanical transducer - valve positioner - control valve - relay	2
1.1.7 Describe operation principles of each component constructing automatic control systems taking examples such as: - pneumatic/electronic PID controller	2

B Monitoring Systems **General Learning Objectives** • Understand the configuration of a monitoring system • Identify the units incorporated in a monitoring system • Know how to set / change values in a monitoring system **Topic: Monitoring Systems** **Sub-Topics:** 1.1 Function, Performance Test and Configuration of Monitoring Systems	
B1 Specific Learning Objectives: (IMO 7.04, 2014, 2.2.5 – 5.1) **1.1 Function, Performance Test and Configuration of Monitoring Systems** 1.1.1 State what a monitoring system or data logger is 1.1.2 Explain how a monitoring system is constructed showing its system configuration 1.1.3 Explain functions of the following system components for a monitoring system: - CPU unit - I/O interface - monitoring display - log printer - alarm printer - lamp driver - extension alarm system	2
1.1.4 Explain briefly how each system component works and its operation mechanism 1.1.5 Explain how measured/monitored values can be confirmed if it is correct 1.1.6 Explain how alarm setting value in a monitoring system can be changed 1.1.7 Explain how function/performance tests can be carried out taking a typical system as an example	1
C Automatic Control Devices **General Learning Objectives** • Know the functions of components in a control loop • Know the use of testing equipment for systems on board a ship, that are **Topic: Automatic Control Devices** **Sub-Topics:** 1.1 Function, Performance Test and Configuration of Automatic Control Devices	

C1 Specific Learning Objectives: (IMO 7.04, 2014, 2.2.5 – 5.2) **1.1 Function, Performance Test and Configuration of Automatic Control Devices** 1.1.1 State what components are compromised in various automatic control systems showing their system configurations 1.1.2 Explain briefly the functions of the following components and their operation mechanism: - sensor - controller - transducer/converter - positioner - regulator - control valve - actuator - relay - servomotor	2
1.1.3 Explain how function/performance tests for each component cited above can be carried out 1.1.4 Describe testing equipment for function/performance of each component cited above 1.1.5 Explain what is meant by mechatronics and how it is utilized in automatic control systems	1
1.1.6 Describe how functions/performances of automatic control systems incorporated in the following operation systems can be tested: - main engine - power generation and distribution - boiler - auxiliary machinery	2
D Protective Devices **General Learning Objectives** • Understand the working principle of safety devices • Understand the correlation and functions of safety devices in a control system **Topic: Protective Devices** **Sub-Topics:** 1.1 Function, Performance Test and Configuration of Protective Devices	
D1 Specific Learning Objectives: (IMO 7.04, 2014, 2.2.5 – 5.3) **1.1 Function, Performance Test and Configuration of Protective Devices** 1.1.1 State what is meant by protective/safety devices and how they work in simple terms 1.1.2 Explain how protective/safety devices are incorporated in each system in a ship's propulsion machinery stating that protective/safety devices are isolated from their control systems	2
1.1.3 Explain briefly the following protective/safety devices and operation mechanism - main engine shut down such as over speed, lubricating oil low pressure, etc. - prime mover of generator shut down - boiler shut down such as low water, non-detect flame eye etc. - purifier shut down	2
1.1.4 Describe briefly how functions/performances of protective/safety devices can be tested 1.1.5 Explain the need for testing functions/performances of protective/safety devices in the ship's statutory survey	1

E Automatic Control Equipment and Safety Devices for the Main Engine **General Learning Objectives** • Understand the correlation of components for the automatic control of the main engine • Understand the methods of tuning control systems especially for a main engine • Understand the concept and requirements of UMS systems **Topic: Automatic Control Equipment and Safety Devices for the Main Engine Sub-Topics:** 1.1 Design Features and System Configuration of Automatic Control Equipment and Safety Devices for The Main Engine	
E1 Specific Learning Objectives: (IMO 7.02, 2014, 2.1.2 – 2.3) **1.1 Design Features and System Configuration of Automatic Control Equipment and Safety Devices for The Main Engine** 1.1.1 Explain control theory - changing set points - basic control system design - first order and second order systems - transfer functions - control system stability - natural frequency and control systems - time lag and time constant - system response	2
1.1.2 Explain tuning - system response - control loop tuning - Ziegler-Nichols, Cohen-Coon tuning methods	1
1.1.3 Explain signal transmission systems - digital communication bus and fibre topic signal transmission systems	1
1.1.4 Describe final control elements - control valve trim - selecting control valves and their actuators - valve sizing	1
1.1.5 Explain electronic PID Controllers - single loop digital controllers - manual and automatic tuning of electronic controllers	1
1.1.6 Explain the following monitoring and control systems - boiler water level control - advanced boiler combustion control - diesel engine cooling control - main engine control for FP and CP propellers - alarms and monitoring systems	1

1.1.7 State the general requirements of automatic control equipment and safety devices - monitoring system - safety system - system independence - local control - failure mode and effect analysis - power supply	1
1.1.8 Explain remote control – diesel propulsion - control – electronic, electro-pneumatic, electro-hydraulic or pneumatic - malfunctions – alarms, engine slow down, engine stop	1
1.1.9 Highlight the importance of the following for UMS systems: - concept of unattended machinery spaces (UMS) - requirements of UMS - bridge control - testing regime for UMS	1
F Automatic Control Equipment and Safety Devices for the Generator and Distribution System **General Learning Objectives** • Understand the instrumentation and safety units for the automatic control of the generator and distribution system • Know the list of alarms and safeties for a generator and distributions system • Understand the auto starting of propulsion auxiliaries **Topic: Automatic Control Equipment and Safety Devices for the Generator and Distribution** **Sub-Topics:** 1.1 Design Features and System Configuration of Automatic Control Equipment and Safety Devices for The Generator and distribution system	
F1 Specific Learning Objectives: (IMO 7.02, 2014, 2.1.2 – 2.3) **1.1 Design Features and System Configuration of Automatic Control Equipment and Safety Devices for The Generator and distribution system** 1.1.1 Describe the features of instrumentation and safety in generator and distribution system 1.1.2 Explain auxiliary diesel generator alarm and shutdown 1.1.3 Explain automatic starting of propulsion auxiliaries	2
G Automatic Control Equipment and Safety Devices for the Steam Boiler **General Learning Objectives** • Know the list of alarms and safeties in a boiler • Understand the functioning of the alarm and safety components in a boiler system **Topic: Automatic Control Equipment and Safety Devices for the Steam Boiler** **Sub-Topics:** 1.1 Design Features and System Configuration of Automatic Control Equipment and Safety Devices for The Steam Boiler	
G1 Specific Learning Objectives: (IMO 7.02, 2014, 2.1.2 – 2.4) **1.1 Design Features and System Configuration of Automatic Control Equipment and Safety Devices for The Steam Boiler** 1.1.1 List the following failures will have alarms and display: - feed water high salinity, high water level, boiler pressure high and low, superheater outlet temperature high, fuel pump low outlet pressure, heavy fuel temperature high and low (or high and low viscosity), uptake high gas temperature, control system power failure, atomization steam/air pressure low 1.1.2 List the following failures that will have alarms, display and automatic shutdown of the boiler:	2

G Automatic Control Equipment and Safety Devices for the Steam Boiler **General Learning Objectives** • Know the list of alarms and safeties in a boiler • Understand the functioning of the alarm and safety components in a boiler system **Topic: Automatic Control Equipment and Safety Devices for the Steam Boiler** **Sub-Topics:** 1.1 Design Features and System Configuration of Automatic Control Equipment and Safety Devices for The Steam Boiler	
- low water level, supply air pressure failure, ignition or flame failure	
H Troubleshooting of Monitoring Systems **General Learning Objectives** • Understand the importance of testing and calibration of sensors and transducers • Know the various methods of testing and calibration of sensors and transducers **Topic: Troubleshooting of Monitoring Systems** **Sub-Topics:** 1.1 Test and calibration of sensors and transducers of monitoring system	
H 1 Specific Learning Objectives: (IMO 7.02, 2014, 2.2.3 – 3.1) **1.1 Test and calibration of sensors and transducers of monitoring system** 1.1.1 testing and calibration of pressure sensor and transducer 1.1.2 testing and calibration of temperature sensor and transducer 1.1.3 testing and calibration of flow sensor and transducer	2
1.1.4 testing and calibration of level sensor and transducer 1.1.5 testing and calibration of tachometer sensor and transducer 1.1.6 testing and calibration of viscometer sensor and transducer	2

Subject Name/Code: Refrigeration and Air Conditioning /408

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisites: 10, + 1 and +2 scheme (MPC Group) / Basic and Applied Thermodynamics.

Recommended Text:

1. Cowley J.K. (1992), The Running and Maintenance of Marine Machinery, Institute of Marine Engineers.
2. Johnson, B., Whitman, B., Silberstein, E., Tomczyk, J. (2012). Refrigeration and Air Conditioning Technology. United States: Cengage Learning.
3. Horan, T. J., Dossat, R. J. (2002). Principles of Refrigeration. Prentice Hall India.

Reference:

1. Turnquist, C. H., Althouse, A. D. (1956). Modern Refrigeration and Air Conditioning. United States: Goodheart-Willcox. - https://archive.org/details/modernrefrigerat00alth/mode/2up.
2. Container Refrigeration, 1st Ed., 2008, ISBN 13: 978-1-905331-25-3 (9781905331253), 2008, Chilukuri Maheshwar.
3. 1997 ASHRAE Handbook: Fundamentals. (1997). United State: ASHRAE. (SI).
4. Refrigeration units in marine vessels: Alternatives to HCFCs and high GWP HFCs. (2019). Denmark: Nordic Council of Ministers. - Freely downloadable from www.books.google.com
5. Harbach, J. A. (2005). Marine Refrigeration and Air-conditioning. United State: Cornell Maritime Press.

Free resources online:

1. Turnquist, C. H., Althouse, A. D. (1956). Modern Refrigeration and Air Conditioning. United State: Goodheart-Willcox. - https://archive.org/details/modernrefrigerat00alth/mode/2up
2. Refrigeration units in marine vessels: Alternatives to HCFCs and high GWP HFCs. (2019). Denmark: Nordic Council of Ministers. https://www.google.co.in/books/edition/Refrigeration_units_in_marine_vessels/_OaVDwAAQBAJ?hl=en&gbpv=0

Table of Topics

Section	Topics	Hours (L)
A	Shipboard Refrigeration Systems – Introduction:	1
B	Refrigeration and Refrigerants:	2
c	Plotting the refrigerant cycle and calculations of cooling load, COP	4
D	Description of marine type systems:	4
E	Refrigerant Oils and applications:	2
F	Refrigerant Retrofitting:	2
G	Leak Detection, System Evacuation, and System Clean-up:	3
H	System Charging:	3
I	Automation and control components and applications:	5
J	Special Refrigeration System Components:	3
K	Description of marine type Ammonia refrigerant system and calculations	4
L	Air Conditioning: Description and layout of the ships Accommodation Air conditioning system:	2
M	Air Conditioning: Concepts of thermodynamics:	5
N	Air Conditioning basics and design calculations	5
	Total	**45**

Learning Objectives	L
General Learning Objective: Introduce applications of refrigeration and air conditioning on ships; To understand thermodynamics of refrigeration, vapour compression cycles, vapour absorption cycle, gas mixtures, psychrometric; To formulate conservation of energy in refrigeration and air conditioning; To understand the working fluid (refrigerants), types, properties, lubricating oil compatibility, recovery and storage; To learn about marine refrigeration and air conditioning plants, working and automation, maintenance procedures on refrigeration circuits – leak detection, repair, charging and retrofitting on board plants; To understand human comfort, ventilation and air conditioning requirements; To understand properties of air that affect the human comfort; To learn about heat load calculations for spaces	
A Shipboard Refrigeration and Air Conditioning Systems – overview: **Specific Learning Objective:** 1.1 Explain the use of refrigeration on board ships 1.2 Explain Systems overview – Provision refrigeration, Cargo refrigeration, Chilled water systems, cooling coils, compressors, condensers and related components; Refrigeration plants and piping systems, Brine secondary cooling systems; refrigerated storage spaces and reefer ships; 1.3 Explain Systems overview – Air conditioning system functions on ships, its systems and arrangements. 1.4 Explain Electronic component cooling applications of self-contained modules. 1.5 Explain Container refrigeration	1
B Refrigeration and Refrigerants: **Specific Learning Objective: (IMO Model Course 7.04 – 1.4.1.2, 1.4.2)** 2.1 Introduction to refrigeration 2.2 Explain Rating of refrigeration equipment 2.3 Explain the refrigeration process 2.4 Explain Temperature and pressure relationship 2.5 Describe refrigeration components – the evaporator the compressor condenser refrigerant metering device – TEV 2.6 Match refrigeration systems and components: Discuss	2

C Plotting the refrigerant cycle and calculations of cooling load, COP: **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.1.4)** **(IMO Model Course 7.04 – 1.4.2)** 3.1 Explain Pressure – Enthalpy diagram 3.2 Discuss on the scales and reference point 3.3 Explain in detail the thermodynamic chart. 3.4 Explain the refrigerant cycle on the P-h diagram 3.5 Explain Component level drawings and explanation	4
D Description of marine type systems: **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.1.4,1.2.5.1, 1.3.5.4)** 4.1 Explain Refrigeration, temperature ranges of refrigeration 4.2 Explain Evaporator - Boiling and condensation, the evaporator and boiling temperature, Removing moisture, Heat exchange characteristics of the evaporator 4.3 Explain Types of evaporators, evaporator evaluation, latent heat in the evaporator, the flooded evaporator, dry type evaporators performance, evaporator superheat, hot pull down, pressure drop in evaporators, liquid cooling evaporators (chillers), evaporators for low temperature applications, defrost of accumulated moisture 4.4 Explain Condensers – condenser evaluation, function of reservoir 4.5 Explain Compressors – types of compressors, reciprocating, belt-driven, hermetic, semi-hermetic, rotary, scroll, discus valve design, liquid in the compressor cylinder, system maintenance and compressor efficiency 4.6 Explain Expansion devices – TEV, TXV components, the valve body, the diaphragm, needle and seat, the spring, the sensing bulb and transmission tube, types of bulb charge, the liquid charge bulb, the cross-liquid charge bulb, the vapour charge bulb, TXV functioning with an internal equalizer, TXV functioning with external equalizers, TXV response to load changes, selection of TXV Valves, balanced port TXV, dual port TXV, the pressure limiting TXV, servicing the TXV, installing the sensing bulb	4
E Refrigerant Oils and applications: **Specific Learning Objective: (IMO Model Course 7.04 – 1.2.1.4)** 5.1 Classify Oil groups 5.2 Explain Regulations, recover, recycle or reclaim – procedures – methods of recovery, mechanical recovery systems	2
F Refrigerant Retrofitting: **Specific Learning Objective: (IMO Model Course 7.04 – 1.2.1.4)** 6.1 Demonstrate Methods 6.2 Explain Compatible refrigerants 6.3 Explain Design considerations.	2
G Leak Detection, System Evacuation, and System Clean-up: **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.1.4)** 3.1 Mend Leaks, exposing the leak site 3.2 Explain Types of leaks – standing, pressure dependent, temperature dependent, vibration dependent, combination dependent, cumulative micro leaks 3.3 Explain Basic Refrigerant Leak detection: Spotting refrigerant oil residue, testing evaporator coil for leaks, testing condensing suction for leaks, testing suction and liquid line leaks, advanced leak detection, testing for various types of leaks; standing pressure test, leak detection methods, repairing leaks, system evacuation – the purpose, evacuation theory, measuring the vacuum, recovering the refrigerant, the vacuum pump, multiple or triple evacuation, leak detection, removing moisture, evacuation procedure; use of nitrogen, cleaning a dirty system	3
H System Charging: **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.1.4)** 2.1 Explain Charging a refrigeration system 2.2 Explain Vapour refrigerant charging 2.3 Explain Liquid refrigerant charging 2.4 Illustrate with explanation, fittings, equipment used in the procedures	3

2.5 Explain Weighing the refrigerant, using charging devices, using charts	
I Automation and control components and applications: **Specific Learning Objective: (IMO Model Course 7.02 – 1.3.5.4)** Explain the following: 9.1 Temperature controls 9.2 High pressure controls 9.3 Low pressure controls 9.4 Oil pressure safety controls 9.5 Gas pressure switches pressure 9.6 Temperature traducers	5
J Special Refrigeration System Components: **Specific Learning Objective: (IMO Model Course 7.02 – 1.3.5.4)** **(IMO Model Course 7.04 – 1.4.2)** Explain the following: 4.1 Two temperature controls 4.2 Evaporator pressure control 4.3 Multiple evaporators, electric evaporator 4.4 Pressure regulating valve 4.5 Crankcase pressure regulator, relief valves 4.6 Fan-cycling 4.7 Low pressure control applied as thermostat 4.8 Automatic pump down 4.9 De-Frost cycle, Random or Off-Cycle defrost, planned defrost, Low-temperature evaporator defrosting, internal heat defrosting – hot gas / cool gas defrosting, external heat defrosting, defrost termination and fan delay control, 4.10 Receivers, filter driers, refrigerant check valves, refrigerant sight glasses 4.11 Liquid refrigerant distributors 4.12 Heat exchangers 4.13 Suction line accumulators, suction line filter driers 4.14 Discharge service valves, refrigeration line service valves 4.15 Oil separators 4.16 Ball valves 4.17 Crankcase heating	3
K Description of marine type Ammonia refrigerant system and calculations: **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.1.4, 1.3.5.4)** **(IMO Model Course 7.04 – 1.4.2)** Explain the following: 11.1 Description, label of parts, component 11.2 Thermodynamics schematics 11.3 Calculations 11.4 Automation and control 11.5 Safety	4
L Air Conditioning: Description and layout of the ships Accommodation Air conditioning system: **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.1.7, 1.2.5.1, 1.2.1.7,1.2.5.1)** **(IMO Model Course 7.04 – 1.4.3)** Explain the following: 12.1 Air quality 12.2 Location of the intake vent 12.3 Ducting and dampers 12.4 Air Handling Unit – schematic and description 12.5 Duct work to the accommodation 12.6 Return of the air, mixing 12.7 Fire dampers 12.8 Ventilation, air cleaning 12.9 Detection for flammable or toxic gases 12.10 Air humidification, sizing humidifiers	2

12.11 Cooling air, de-humidification, drainage of the condensate 12.12 Heating of the air, thermostat and controls	
M Air Conditioning: Concepts of thermodynamics: **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.1.7, 1.2.5.1, 1.2.1.7,1.2.5.1)** **(IMO Model Course 7.04 – 1.4.3)** Explain the following: 1.1 Dry and atmospheric air 1.2 Enthalpy 1.3 Specific and relative humidity of air 1.4 Expressions for the properties	5
N Air Conditioning basics and design calculations: **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.1.7, 1.2.5.1, 1.2.1.7,1.2.5.1)** **(IMO Model Course 7.04 – 1.4.3)** Explain the following: 4.1 Objectives, comfort 4.2 Food energy and the body, heat transfer to and from the body, the comfort chart 4.3 Psychrometric 4.4 Moisture in the air 4.5 Absolute and relative humidity 4.6 Superheated gases in air 4.7 Dry-bulb and wet bulb temperatures, dew point temperature 4.8 Enthalpy 4.9 The psychrometry chart, plotting on the psychrometric chart 4.10 Fresh air, infiltration and ventilation. 4.11 Air conditioning processes – simple heating and cooling, heating with humidification, cooling with de-humidification 4.12 Evaporative cooling, adiabatic mixing of air streams 4.13 Heating and cooling Load estimation 4.14 Numerical exercises involving air conditioning problems	5

Subject Name/Code: Automation, Control Engineering and Safety Devices (P)/409

Instructional Hours:

Practical	: 25 hours
Total contact hours	: 25 hours
Credits	: 1

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods **Refer to IMU Guidelines prior to the start of the Session for actual allocations**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

1. Instrumentation and Control System, Boyd G & Jackson, Bloomsbury.
2. Marine Control Technology 4h Edition; By J. Majumder, Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN: 9789352139682.
3. Applied Marine Control and Automation; By J. Majumder, Elstan A. Fernandez, Mahesh Patil; Publisher: Shroff Publishers and Distributors; Year: 2019; ISBN: 9789352139194.

Reference:

1. Digital Control System and State Variable; By Gopal M; Publisher Tata McGraw Hill.

Recommended Text:

4. Modern Control Engineering, D. Roy Choudhury, PHI.
2. Digital Control System by Kuo B.C.; Publisher Oxford University Press, London.
3. Marine Control Practice by D.A. Taylor, Publisher Butterworth and Co. Ltd. London.

Table of Topics

Section	Topics	Hours P
A1	**Practical for Automation, Control Engineering and Safety Devices** **Subtopics**: Temperature control system using PID controller; Level control system using PID controller; Study of SCADA system, PLC and ladder programming; Use programmable relay for start/stop electrical motor; Application of PLC controller; Study the working of Synchro; PID controller trainer; Fuzzy logic trainer; Study of MATLAB; PID tuning using MATLAB; Generate root locus, Bode plot, Nyquist plot in MATLAB; Microprocessor controlled DC/AC machines; Study of electro-hydraulic control.	25
	Total	**25**

Learning Objectives	P
A: Practical for Automation, Control Engineering and Safety Devices	
1.0 General Learning Objective To provide practical knowledge about advanced control theory of automation and control engineering in ships. **A1 Sub Topic:** Practical for Automation, Control Engineering and Safety Devices **Sub-sub topics & SLOs** 1.1 Temperature control system using PID controller 1.2 Level control system using PID controller 1.3 Study of SCADA system, PLC and ladder programming 1.4 Use programmable relay for start/stop electrical motor 1.5 Application of PLC controller 1.6 Study the working of Synchro 1.7 PID controller trainer 1.8 Fuzzy logic trainer 1.9 Study of MATLAB 1.10PID tuning using MATLAB 1.11Generate root locus, bode plot, Nyquist plot in MATLAB 1.12Microprocessor controlled DC/AC machines 1.13Study of electro-hydraulic control	**25**
Specific Learning Objectives: (IMO 7.02, 2014: F2/2.1.1.3, 2.1.2.2, 2.2.3.1) /(IMO 7.04,2014: F2/2.1.3.5, 2.1.2.3, 2.1.3.2) 1.1 Temperature control system using PID controller	2
Specific Learning Objectives: (IMO 7.02, 2014: F2/2.1.1.3, 2.1.2.2, 2.2.3.1) / (IMO 7.04,2014: F2/2.1.3.5, 2.1.2.3, 2.1.3.2) 1.2 Level control system using PID controller	2
Specific Learning Objectives: (IMO 7.02, 2014: F2/2.1.3.4, 2.2.4.1)/ IMO 7.04,2014: F2/2.1.2.3, 2.1.3.1, 2.1.3.2) / 1.3 Study of SCADA system, PLC and ladder programming	2

Specific Learning Objectives: (IMO 7.02, 2014: F2/2.1.2.2) / (IMO 7.04,2014: F2/2.1.2.3, 2.1.3.1, 2.1.3.2) 1.4 Use programmable relay for start/stop electrical motor	2
Specific Learning Objectives: (IMO 7.02, 2014: F2/2.1.3.4, 2.2.4.1)/ (IMO 7.04, 2014: F2/2.1.2.3, 2.1.3.1, 2.1.3.2) 1.5 Application of PLC controller	2
Specific Learning Objectives: (IMO 7.02, 2014: F2/2.1.2.2)/(IMO 7.04, 2014: F2/2.1.2.3) 1.6 Study the working of Synchro	1
Specific Learning Objectives: (AICTE) 1.7 PID controller trainer	2
Specific Learning Objectives: (AICTE) 1.8 Fuzzy logic trainer	2
Specific Learning Objectives: (AICTE) 1.9 Study of MATLAB/SIMULINK	2
Specific Learning Objectives: (IMO 7.02, 2014: F2/2.1.2.2, 2.2.1.12) / (IMO 7.04,2014: F2/2.1.3.5) 1.10 PID tuning using MATLAB	2
Specific Learning Objectives: (AICTE) 1.11 Generate root locus, Bode plot, Nyquist plot in MATLAB	2
Specific Learning Objectives: (IMO 7.02, 2014: F2/2.1.3.4, 2.2.4.2) / (IMO 7.04,2014: F2/2.1.2.3) 1.12 Microprocessor controlled DC/AC machines	2
Specific Learning Objectives: (IMO 7.02, 2014: F2/2.1.5.1)/(IMO 7.04, 2014: F2/2.1.2.3, 2.1.3.8) 1.13 Study of electro-hydraulic control	2

Subject Name/Code: Marine Engineering Skills (P)/410

Instructional hours:

Practical	: 60 hours
Total contact hours	: 60 hours
Credits	: 2

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Internal Continual Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
External Practical Exam	: 50%

Recommended Text:

1. Practical Handouts.
2. Ship's Manuals and Drawings.

Reference:

1. MEP Series: Volume 2 Part 18: The Operation and Maintenance of Machinery in Motorships, 2020 Ed. N.J. Chell.
2. The Running &. Maintenance of Marine Machinery-J. Cowley by IMEI Publication.

Table of Topics

Section	Topics	Hours (P)
A1-A4	Marine Boiler **Sub-Topics:** Parts of boiler & Mountings, Layout of Marine Boiler system, Marine Boiler operation, Marine Boiler defects & Emergency operations	12
B1	Marine IC engine **Sub-Topics:** Engine Components, 2S & 4S engine, Main engine Bearings	12
C1-C3	Turbo charger **Sub-Topics:** Parts of a Turbocharger, Gas flow passages & sealing, Lubrication & Bearing	4
D1-D2	Refrigeration & Air conditioning **Sub-Topics**: Refrigeration & air conditioning system, Operation, safety cut-outs & Trouble shooting of Faults.	4
E1-2	Prevention of Marine pollution at sea **Subtopics:** Oily Water Separator, Marine Incinerator	8
F	**Electrical Technology** **Sub-Topics/SLOs:** Electrical machines, applications of alternators for load sharing, speed control of induction motor, overhauling of induction motor	20
	Total	**60**

Learning Objectives	P
A. Marine Boiler **General Learning Objective:** Familiarization with Marine boiler & associated system	
A1 Subtopic: Parts of Marine Boiler & Mountings **Sub Topics & SLOs** 1.1 Construction of a water tube boiler 1.2 Arrangement of boiler Furnace 1.3 Arrangement of Boiler Burner 1.4 Arrangement of water drums 1.5 Arrangement of steam drum 1.6 Arrangement of water tubes/down comers/ stay tubes 1.7 Boiler Mountings	
Specific Learning Objectives: **1.1 Construction of water Tube Boiler** 1.1.1 Identify a Water tube boiler 1.1.2 Identify difference Between Water Tube & smoke tube Boiler	0.5
Specific Learning Objectives: **1.2 Arrangement of Boiler Furnace** 1.2.1 Identify the Location of boiler Furnace 1.2.2 Explain the importance of furnace refractory & Material of refractory	0.5
Specific Learning Objectives: **1.3 Arrangement of Boiler Burner** 1.3.1 Identify the Location of boiler Burner 1.3.2 Explain the different types of boiler Burners 1.3.3 Demonstrate by identifying/explaining the sequence of operation happen in the Boiler burner after getting start signal	1
Specific Learning Objectives: **1.4 Arrangement of water Drum** 1.4.1 Identify the Location of water Drum 1.4.2 Explain the purpose of water Drum	0.5
Specific Learning Objectives: **1.5 Arrangement of steam Drum**	0.5

1.5.1 Identify the Location of steam Drum 1.5.2 Explain the purpose of Steam Drum	
Specific Learning Objectives: **1.6 Arrangement of water Tubes, down comers, Stay Tubes** 1.5.1 Identify the Location of water tubes, Downcomers, Stay tubes 1.5.2 Explain the purpose of Water tubes, Downcomers, Stay Tubes	0.5
Specific Learning Objectives: **1.5 Boiler Mountings** 1.5.1 Identify the Location of Boiler Mountings (Main steam stop valve, Safety Valve, Vent Valve, Blow down valve, Pressure Gauge, Feed water valve, Scum valve) 1.5.2 Explain the purpose of boiler Mountings	0.5
A.2 Sub Topic: Layout of Marine Boiler System. **Sub Topics & SLOs** 2.1 Feed Water System 2.2 Steam distribution system 2.3 Fuel oil system 2.4 Chemical dosing & sampling system	
Specific Learning Objectives: **2.1 Feed Water System** 2.1.1 Trace the feed water system 2.1.2 Explain the purpose of each component in the Boiler feed water system	1
Specific Learning Objectives: **2.2 Steam Distribution System** 2.2.1 Trace the Steam Distribution system 2.2.2 Explain the purpose of each component in the Boiler steam distribution system	1
Specific Learning Objectives: **2.3 Fuel Oil system** 2.3.1 Trace the Fuel Oil system 2.3.2 Explain the purpose of each component in the fuel oil system	1
Specific Learning Objectives: **2.4 Chemical dosing & sampling system** 2.4.1 Trace the Chemical Dosing & sampling system 2.4.2 Explain the purpose of each component in the Chemical Dosing & sampling system	1
A3: Sub Topic: Marine Boiler operations. **Sub Topic & SLOs** 3.1 Starting boiler from cold 3.2 boiler operation in parallel 3.3 Putting the boiler out of operation 3.4 Preparing Boiler for survey	
Specific Learning Objective: **3.1 Starting Boiler from Cold** 3.1.1 Start the Boiler from cold condition	0.5
Specific Learning Objective: **3.2 Boiler Operation in parallel** 3.2.1 Demonstrate by identifying/explaining how to run the boiler in parallel with exhaust gas boiler	0.5
Specific Learning Objective: **3.3 Putting Boiler in out of operation** 3.3.1 Demonstrate by identifying/explaining how to put boiler out of operation	0.5
Specific Learning Objective: **3.4 Preparing Boiler for Survey** 3.4.1 Demonstrate by identifying/explaining preparation of boiler for survey	0.5
A.4 Sub Topic: Marine Boiler defects & Emergency operations **Sub Topics & SLOs** 4.1 Plugging of water tubes	

4.2 Setting of safety valve 4.3 Inspection & maintenance of boiler mountings	
Specific Learning Objectives: **4.1 Plugging of water Tubes** **4.1.1** Identify & Plug leaky water Tube	1
Specific Learning Objectives: **4.2 Setting of safety Valve** **4.2.1** Demonstrate by identifying/explaining the setting of safety valve	0.5
Specific Learning Objectives: **4.3 Inspection & Maintenance of Boiler Mountings** **4.2.1** Demonstrate by identifying/explaining the inspection procedure of Boiler Mountings	0.5
B. Marine IC Engine	
General Learning Objective: Identify the IC engine Components **B1 Sub Topics: Diesel Engine Components** **Sub Topics & SLOs** **1.1 Piston** **1.2 Liner** **1.3 Cylinder Head & Mountings** **1.4 A frame** **1.5 Crankcase** **1.6 Bedplate** **1.7 Entablature** **1.8 Crankshaft** **1.9 Camshaft** **2.0 Flywheel** **2.1 Rocker Arm**	
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **1.1 Piston** 1.1.1 Identify the Piston & its location in the Engine 1.1.2 Demonstrate by identifying/explaining the Purpose of the Piston	0.5
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **1.2 Liner** 1.2.1 Identify the liner & its location in the Engine 1.2.2 Demonstrate by identifying/explaining the Purpose of the liner	0.5
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **1.3 Cylinder Head & Mountings** 1.3.1 Identify the Cylinder head & Its Mountings 1.3.2 Demonstrate by identifying/explaining the Purpose of cylinder head & Mountings	1
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **1.4 A frame** 1.4.1 Identify the A frame 1.4.2 Explain the purpose of A frame	0.25
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **1.5 Crankcase** 1.5.1 Identify the Crankcase 1.5.2 Explain the purpose of Crankcase	0.25
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **1.6 Bedplate** 1.6.1 Identify the Bedplate 1.6.2 Explain the purpose of Bedplate	0 .25
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **1.7 Entablature** 1.7.1 Identify the Entablature 1.7.2 Explain the purpose of Entablature	0 .25
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **1.8 Crankshaft**	0 .25

1.8.1 Identify the Crankshaft 1.8.2 Explain the purpose of Crankshaft	
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **1.9 Camshaft** 1.9.1 Identify the Camshaft 1.9 .2 Explain the purpose of Camshaft	0 .25
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **2.0 Flywheel** 2.0.1 Identify the Flywheel 2.0 .2 Explain the purpose of Flywheel	0 .25
Specific Learning Objectives: (7.04-p37-6, 7.04-p146-3.8, 7.02-p56-3.7) **2.1 Rocker arm** 1.9.1 Identify the Rocker Arm 1.9.2 Explain the purpose of Rocker Arm	0 .25
B 2 Sub Topic: 2S & 4 S engine **Sub Topic & SLOs** **2.1 2-Stroke Diesel Engine** **2.2 4-Stroke Diesel Engine**	
Specific Learning Objective: **2.1 2-Stroke Diesel Engine** 2.1.1 Demonstrate by identifying/explaining the Difference between 2S & 4S engine 2.1.2 Trace & demonstrate lube oil system of 2 stroke engine 2.1.3 Identify all the parts of the 2 stroke engine	3
Specific Learning Objective: **2.2 4-Stroke Diesel Engine** 2.2.1 Demonstrate by identifying/explaining the Difference between 2S & 4S engine 2.2.2 Trace & demonstrate lube oil system of 4 stroke engine 2.2.3 Identify all the parts of the 4 stroke engine	3
B3 Sub Topic: Main engine Bearings **Sub Topics & SLOs** 3.1 Journal bearing/Main Bearing 3.2 Cam shaft bearings 3.3 Crankpin bearing 3.4 Cross Head Bearing 3.5 Piston Pin bearing 3.6 Thrust Bearing 3.7 Turbocharger Bearing 3.8 Intermediate Bearing	
Specific Learning Objective: **3.1 Journal Bearing** 3.1.1 Identify the location of journal bearing & explain its purpose	0 .25
Specific Learning Objective: **3.2 Cam shaft Bearing** 3.2.1 Identify the location of Cam shaft bearing & explain its purpose	0 .25
Specific Learning Objective: **3.3 Crank pin Bearing** 3.3.1 Identify the location of journal bearing & explain its purpose	0 .25
Specific Learning Objective: **3.4 Cross head bearing** 3.4.1 Identify the location of Cross bearing & explain its purpose	0 .25
Specific Learning Objective: **3.5 Piston Pin bearing** 3.5.1 Identify the location of piston pin bearing & explain its purpose	0 .25
Specific Learning Objective: **3.6 Thrust bearing** 3.6.1 Identify the location of Thrust bearing & explain its purpose	0 .25
Specific Learning Objective: **3.7 Turbocharger** 3.7.1 Identify the location of Turbocharger bearing & explain its purpose	0 .25

Specific Learning Objective: **3.8 Intermediate Bearing** 3.8.1 Identify the location of Intermediate bearing & explain its purpose	0 .25
C. Turbo Charger	
General Learning Objective. Identify the parts & its purpose of an exhaust gas Turbo Charger. **C1 Sub Topic: Parts of Turbocharger** **Sub Topics & SLOs** 1.1 Compressor 1.2 Turbine 1.3 Turbine Blade 1.4 Nozzle 1.5 Labyrinth seal 1.6 Rotor 1.7 Suction filter 1.8 Casing	
Specific Learning Objectives: (7.04-p146- 3.8, 7.02-p55-3.5) **1.1 Compressor** 1.1.1 Identify the compressor side 1.1.2 Explain the Purpose of compressor	0.25
Specific Learning Objectives: (7.04-p146- 3.8, 7.02-p55-3.5) **1.2 Turbine** 1.2.1 Identify the Turbine Side 1.2.2 Explain the Purpose of Turbine	0.25
Specific Learning Objectives: (7.04-p146- 3.8, 7.02-p55-3.5) **1.3 Turbine Blade** 1.3.1 Identify Turbine Blades 1.3.2 Explain the Purpose of Turbine Blade	0.25
Specific Learning Objectives: (7.04-p146- 3.8, 7.02-p55-3.5) **1.4 Nozzle** 1.4.1 Identify Nozzle 1.4.2 Explain the Purpose of Nozzle	0.25
Specific Learning Objectives: (7.04-p146- 3.8, 7.02-p55-3.5) **1.5 Labyrinth Seal** 1.5.1 Identify Labyrinth Seal 1.5.2 Explain the Purpose of Labyrinth Seal	0.25
Specific Learning Objectives: (7.04-p146- 3.8, 7.02-p55-3.5) **1.6 Rotor** 1.6.1 Identify Rotor 1.6.2 Explain the Purpose of Rotor	0.25
Specific Learning Objectives: (7.04-p146- 3.8, 7.02-p55-3.5) **1.7 Suction Filter** 1.7.1 Identify Suction filter 1.7.2 Explain the Purpose of Suction filter	0.25
Specific Learning Objectives: (7.04-p146- 3.8, 7.02-p55-3.5) **1.8 Casing** 1.8.1 Identify Casing 1.8.2 Explain the Purpose of Casing	0.25
C2 Sub Topic: Gas Flow passage & sealing **2.1 Gas flow path** **2.2 Sealing system**	
Specific Learning Objective: **2.1 Gas flow path** 2.1.1 Trace the gas flow path to the Turbine Unit 2.1.2 Explain the Gas flow & temperature & pressure at various points	0.5
Specific Learning Objective: **2.2 Sealing system** 2.2.1 Explain the sealing arrangement in the Turbocharger	0.5

C3 Sub Topic Turbocharger Bearing Lubrication system **Sub Topics & SLOs** **3.1 Turbocharger Bearing Lubrication system**	
Specific Learning Objective: 3.1 Turbocharger Bearing Lubrication system 3.1.1 Trace the Lubrication system of the turbocharger 3.1.2 Explain the purpose of each component in the bearing lubrication system	1
D: Refrigeration and air conditioning	
General Learning Objective. Understand the components, isolation, flow of refrigerant, pumping down, oil charging, gas charging, starting and stopping procedure of the refrigeration and air conditioning plants **D1 Sub Topic: Refrigeration system & Air conditioning** **Sub Topics & SLOs:** 1.1 Refrigeration system 1.2 Air conditioning system	
Specific Learning Objective: **1.1 Refrigeration system** 1.1.1 Trace the Refrigeration system 1.1.2 Explain the purpose of each component in the Refrigeration system	1
Specific Learning Objective: **1.2 Air Conditioning system** 1.2.1 Trace the Air conditioning system 1.1.2 Explain the purpose of each component in the Air conditioning system	1
D2 Sub topic: Operation, safety cut outs & troubleshooting **Sub Topics & SLOs** 2.1 Operation 2.2 Safety cut out & Troubleshooting	
Specific Learning Objective: **2.1 Operation** 2.1.1 Start & stop refrigeration & air conditioning system	1
Specific Learning Objective: **2.2 Safety Cut Outs & Troubleshooting** 2.2.1 Identify the safety cut out in the refrigeration & Air conditioning system 2.2.2 Explain the purpose of safety cut out 2.2.3 Do troubleshooting in the system	1
E: Prevention of Marine pollution at sea	
General Learning Objective: Understand the basic construction, Starting, Stopping of oily water separator & Incinerator **E1 Sub Topic: Oily water Separator** **Sub Topics & SLOs:** 1.1 Construction 1.2 Working Principle 1.3 Starting 1.4 Stopping	
Specific Learning Objectives: **1.1 Construction & system** 1.1.1 Explain the construction of oily water separator 1.1.2 Trace the OWS associated system	1
Specific Learning Objectives: **1.2 Working Principle** 1.2.1 Explain the Working Principle of OWS 1.2.2 Identify components fitted on OWS	1
Specific Learning Objectives: **1.3 Starting** 1.3.1 Demonstrate by identifying/explaining starting of OWS	1
Specific Learning Objectives:	1

1.4 Stopping 1.4.1 Demonstrate by identifying/explaining Stopping Procedure of OWS	
E2 Sub Topics: Incinerator **Sub Topics & SLOs** 2.1 Construction 2.2 Working of Burner Unit 2.3 Starting 2.4 Stopping	
Specific Learning Objectives: **2.1 Construction** 2.1.1 Explain the construction of the Incinerator 2.1.2 Trace the associated system with incinerator	1
Specific Learning Objectives: **2.2 Working of Burner Unit** 2.2.1 Demonstrate by identifying/explaining the Working of Burner Unit 2.2.2 Explain the Burner unit system	1
Specific Learning Objectives: **2.3 Starting** 2.3.1 Start the Incinerator	1
Specific Learning Objectives: **2.4 Stopping** 2.4.1 Stop the Incinerator	1
F. Electrical Technology	
General Learning Objective: Understand operation of different types of electrical machines, applications of alternators for load sharing, speed control of induction motor, overhauling of induction motor and identifying different parts. **F1. Sub Topic: Electrical Motors, generators and Induction Motors** **Sub-sub topics & SLOs** 1.1 Paralleling of DC generators 1.2 Speed control of 3 phase induction Motor 1.3 Torque-slip characteristics of Induction motor 1.4 No load and blocked rotor test on Induction Motor 1.5 Squirrel cage induction motor maintenance, overhauling, salvaging, IR test, winding resistance, continuity measurement. Alternate method of checking Insulation if Insulation tester is faulty, bearing number explanation. 1.6 OC& SC tests of 3 phase Alternator 1.7 Load test of 3 phase Alternator 1.8 Synchronising of 3 phase Alternators 1.9 V & Inverted V curves of 3 Phase synchronous motor 1.10 To Study Earth fault detection by earth lamp method. Earth Fault Tracing	
Specific Learning Objectives: (IMO 7.04,2014: F2/1.3(2) **1.1 Paralleling of DC generators** 1.1.1 Understand and apply conditions for parallel operation of DC generator 1.1.2 Connect the circuit with prime mover and understand the connections 1.1.3 Explain floating condition and load sharing in between two generators	2
Specific Learning Objectives: IMO 7.02,2014: F2/2.1.3,3.3; IMO 7.02,2014: F2/2.1.3, 3.1 **1.2 Speed control of 3 phase induction Motor** 1.2.1 Explain stator side and rotor side speed control of Induction motor 1.2.2 Explain control the speed of induction motor by controlling frequency 1.2.3 Explain control the speed of induction motor by changing number of stator poles 1.2.4 Explain control the speed of induction motor by adding resistance in rotor circuit	2
Specific Learning Objectives: IMO 7.02,2014: F2/2.1.3,3.3; IMO 7.02,2014: F2/2.1.3, 3.1 **1.3 Torque slip characteristics of 3 phase Induction Motor** 1.3.1 Explain relationship between torque and slip of induction motor 1.3.2 Define synchronous speed, rotor speed and slip	2

1.3.3 Explain relationship of torque-slip characteristics and rotor resistance of an induction motor 1.3.4 Draw the graphical representation of torque-slip characteristics (for changing resistance values in rotor circuit)	
Specific Learning Objectives: IMO 7.02,2014: F2/2.1.3,3.3; IMO 7.02,2014: F2/2.1.3, 3.1 **1.4 No load & block rotor tests of 3 phase Induction Motor** 1.4.1 Determine equivalent circuit parameters of an induction motor 1.4.2 Calculate no load power and current 1.4.3 Calculate blocked rotor power and current 1.4.4 Draw circle diagram and understand the significance of circle diagram 1.4.5 Calculate all parameters from circle diagram like- losses, efficiency, torque, input power, output power etc.	2
Specific Learning Objectives: IMO 7.02,2014: F2/2.1.3,3.3; IMO 7.02,2014: F2/2.1.3, 3.1 **1.5 Squirrel cage induction motor maintenance, overhauling, salvaging, IR test, winding resistance, continuity measurement. Alternate method of checking Insulation if Insulation tester is faulty, bearing number explanation.** 1.5.1 Describe the complete motor overhauling procedure 1.5.2 Isolate the motor from source 1.5.3 Isolate the motor from load at drive end 1.5.4 Disconnect the end cap, bearing and rotor 1.5.5 Carry out complete overhauling of motor 1.5.6 Decide on the parts for salvaging 1.5.7 Carry out the motor maintenance, and various tests 1.5.8 Inspect the motor visually for any damage or loose part 1.5.9 Carry out the Ohmic value test for motor winding 1.5.10 Analyse the winding status by comparing ohmic values 1.5.11 Carry out IR test for motor winding 1.5.12 Carry out the complete IR test procedure 1.5.13 Prove Megger/IR tester for correct working of megger 1.5.14 Prove Earthing points for good earthing 1.5.15 Carry out and log Phase to ground IR test for 3 & 6 terminal motors 1.5.16 Carry out and log Phase to Phase IR test for 6 terminal motors 1.5.17 Analyse the winding status from IR values 1.5.18 Explain the Alternative method of IR test 1.5.19 Explain the bearing number 1.5.20 Explain the suffix and prefix of the number 1.5.21 Decide on the type of bearing from the middle number	2
Specific Learning Objectives: IMO 7.02,2014: F2/2.1.3, 3.7), (IMO 7.04,2014: F2/1.3(1); IMO 7.02,2014: F2/2.1.3, 3.2 **1.6 OC& SC tests of 3 phase Alternator** 1.6.1 Describe the significance of OC and AC test of alternator 1.6.2 Calculate regulation of alternator for 0.8 leading PF and 0.8 lagging PF 1.6.3 Draw OC and SC curve on a graph paper	2
Specific Learning Objectives: IMO 7.02,2014: F2/2.1.3, 3.7), (IMO 7.04,2014: F2/1.3(1); IMO 7.02,2014: F2/2.1.3, 3.2 **1.7 Load test of 3 phase Alternator** 1.7.1 Write the connections of alternator with prime mover 1.7.2 Perform load test by applying variable load and calculate regulation of alternator 1.7.3 Draw the phasor diagram	2
Specific Learning Objectives: IMO 7.02,2014: F2/2.1.3, 3.7), (IMO 7.04,2014: F2/1.3(1); IMO 7.02,2014: F2/2.1.3 **1.8 Synchronising of 3 phase Alternators** 1.8.1 Understand and apply conditions for synchronization of two alternators 1.8.2 Explain three dark lamp methods of synchronization 1.8.3 Explain two bright one dark lamp method of synchronization	2

1.8.4 Perform load sharing between two alternators	
Specific Learning Objectives: **IMO 7.02,2014: F2/2.1.3, 3.7), (IMO 7.04,2014: F2/1.3(1); IMO 7.02,2014: F2/2.1.3** **1.9 'V' & 'Inverted V' curves of 3 Phase synchronous motor** 1.9.1 Explain the effect of variation in field current on the armature current of synchronous motor (V-curve) 1.9.2 Explain the effect of variation of field current on power factor of synchronous motor (inverted V curve)	2
Specific Learning Objectives: **(IMO 7.02,2014: F2/2.1.3, 3.8), (IMO 7.04,2014: F2/1.3(3)** **1.10To connect single phase transformers (3 pcs) in the following ways a) Y-Y b) Y-D c) D-Y d) D-D and advantages of D-D transformers** 1.10.1 Name the reasons for single earth fault 1.10.2 Develop a simple circuit with a single earth fault 1.10.3 Reasons for double earth fault 1.10.4 Draw & understand the circuit with double earth fault 1.10.5 Explain the grounded supply systems as on shore 1.10.6 Explain tripping arrangement of faulty circuits with grounded supply systems 1.10.7 Make a drawing of an insulated supply system 1.10.8 Describe the continuity of machinery with insulated supply system with single earth fault 1.10.9 Develop the circuit for 3 lamp E/F detection circuit 1.10.10 Describe the circuit when the test switch is made on without Earth fault 1.10.11 Operate and observe the intensity of 3 lamps with E/F 1.10.12 Analyse the severalty of E/F from the intensity of lamps 1.10.13 Locate the single earth fault by switching off breakers 1.10.14 Locate the single earth fault by switching on breakers 1.10.15 Consequences of not Locating the single earth fault 1.10.16 Consequences of not grounding the body of electrical equipment 1.10.17 Differentiate the fault Locating procedures in grounded and insulated supply systems	2

SEMESTER 5

Subject Name/Code: Introduction to CFD/501

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisites: Class 10, + 1 and +2 scheme (MPC Group) / Thermodynamics concepts, Fluid Mechanics, Mathematics – I and II.

Recommended Text:

1. Computational Fluid Dynamics: An Introduction. (2010). Germany: Springer.
2. P.S. Ghoshdastidar (2017) Computational Fluid Dynamics and Heat Transfer ISBN: 9788131533079 Cengage India.
3. Chung, T. J. (2014). Computational Fluid Dynamics. United Kingdom: Cambridge University Press.

Reference:

1. Open-Source Software for Computational Fluid Dynamics - https://openfoam.org/
2. https://cfd.direct/openfoam/user-guide/
3. Open-Source Software for Computational Fluid Dynamics - https://pypi.org/project/mayavi/

Table of Topics

Section	Topics	Hours (L)
A	Introduction to CFD	1
B	Numerical Methods	5
C	Governing Equations of Fluid Dynamics	4
D	Mathematical Behaviour of Partial Differential Equations	3
E	Basic Aspects of Discretization	5
F	Grids With Appropriate Transformation	4
G	Parabolic Partial Differential Equations	3
H	Stability Analysis	4
I	Elliptic Equations	4
J	Hyperbolic Equations	3
K	Scalar Representation of Navier-Stokes Equations	4
L	Grid Generation	5
	Total	**45**

Learning Objectives	L
General Learning Objectives Understand what is CFD and its applications as a research analytical tool. **A Introduction to CFD** **Specific Learning Objective:** Explain the following: 1.1 History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering (e.g., hull & propeller optimisation; flow in heat exchangers etc.)	1
General Learning Objectives Demonstrate an ability to recognize and to use the appropriate model equations to investigate the flow. **B Numerical Methods:** **Specific Learning Objective:** Explain the following: 1.1 Numerical Differentiation and Integration: Newton-cotes integration formulas, integration of equations, numerical differentiation 1.2 Ordinary differential equations: Runge-Kutta Methods, Stiffness and Multistep Methods, Boundary-Value and Eigenvalue problems	5
General Learning Objectives Recognize the type of fluid flow that is occurring in a particular physical system and to use the appropriate model equations to investigate the flow. **C Governing Equations of Fluid Dynamics:** **Specific Learning Objective:** Explain the following: 1.1 Models of the flow 1.2 The substantial derivative 1.3 Physical meaning of the divergence of velocity 1.4 The continuity equation 1.5 The momentum equation 1.6 The energy equation 1.7 Navier-Stokes equations for viscous flow 1.8 Euler equations for inviscid flow	4

1.9 Physical boundary conditions 1.10 Forms of the governing equations suited for CFD 1.11 Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching	
General Learning Objectives Understand related Partial Differential Equations, Implement Scheme to obtain solutions to Partial Differential Equations. **D Mathematical Behaviour of Partial Differential Equations:** **Specific Learning Objective:** Explain the following: 1.1 Classification of quasi-linear partial differential equations 1.2 Methods of determining the classification 1.3 General behaviour of Hyperbolic, Parabolic and Elliptic equations	3
General Learning Objectives Understand the meshing method and how solution for each section is obtained by discretization. **E Basic Aspects of Discretization** **Specific Learning Objective:** Explain the following: 1.1 Introduction to finite differences 1.2 Finite difference equations using Taylor series expansion and polynomials 1.3 Explicit and implicit approaches 1.4 Uniform and unequally spaced grid points	5
General Learning Objectives Understand the matrix and transformation of equations etc. **F Grids with Appropriate Transformation:** **Specific Learning Objective:** Explain the following: 1.1 General transformation of the equations 1.2 Metrics and Jacobians 1.3 The transformed governing equations of the CFD 1.4 Boundary fitted coordinate systems 1.5 Algebraic and elliptic grid generation techniques 1.6 Adaptive grids	4
General Learning Objectives Understand application of PDE Methods particularly for CFD applications. **G Parabolic Partial Differential Equations:** **Specific Learning Objective:** Explain the following: 1.1 Finite difference formulations 1.2 Explicit methods –FTCS, 1.3 Richardson and DuFort-Frankel methods 1.4 Implicit methods –Laasonen 1.5 Crank-Nicolson and Beta formulation methods 1.6 Approximate factorization 1.7 Fractional step methods 1.8 Consistency analysis, Linearization	3
General Learning Objectives Understand how stability improves with decay of errors etc. **H Stability Analysis** **Specific Learning Objective:** Explain the following: 1.1 Discrete Perturbation Stability analysis 1.2 von Neumann Stability analysis 1.3 Error analysis, Modified equations	4

1.4 Artificial dissipation and dispersion	
General Learning Objectives Know about elliptic type of PDEs, formulations and iterations etc. **I Elliptic Equations** **Specific Learning Objective:** Explain the following: 1.1 Finite difference formulation 1.2 solution algorithms: Jacobi-iteration method 1.3 Gauss-Seidel iteration method 1.4 point-and line-successive over-relaxation methods 1.5 alternative direction implicit methods	4
General Learning Objectives Understand hyperbolic type of PDEs and its applications etc. **J Hyperbolic Equations** **Specific Learning Objective:** Explain the following: 1.1 Explicit and implicit finite difference formulations 1.2 splitting methods 1.3 multi-step methods 1.4 applications to linear and nonlinear problems 1.5 linear damping 1.6 flux corrected transport 1.7 monotone and total variation diminishing schemes 1.8 tvd formulations 1.9 entropy condition 1.10 first-order and second-order tvd schemes	3
General Learning Objectives Understand Navier-Stokes equation and its applications. **K Scalar Representation of Navier-Stokes Equations:** **Specific Learning Objective:** Explain the following: 1.1 Equations of fluid motion 1.2 Numerical algorithms: ftcs explicit 1.3 Ftbcs explicit 1.4 Dufort-Frankel explicit 1.5 McCormack explicit and implicit 1.6 Btcs and btbcs implicit algorithms 1.7 Applications	4
General Learning Objectives Understand grid generation using the various types of PDEs etc. **L Grid Generation:** **Specific Learning Objective:** Explain the following: 1.1 Algebraic Grid Generation 1.2 Elliptic Grid Generation 1.3 Hyperbolic Grid Generation 1.4 Parabolic Grid Generation	5

Subject Name/Code: Marine Internal Combustion Engines and Technology 2/502

Instructional hours:

Lecture	: 60 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, practical in workshops and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Marine Diesel Engine, D. K. Sanyal, Bhandarkar Publication.
2. Griffiths, Denis (2004): Marine Low Speed Diesel Engines, IMarEST Publication.
3. Griffiths, Denis (2004): Marine Medium Speed Diesel Engines, MEP Series, Vol. 1, Part 3, IMarEST Publication.

Reference:

1. Cowley J.K. (1992), The Running and Maintenance of Marine Machinery, Institute of Marine Engineers.
2. Pounder C.C. (2000): Marine Diesel Engines, Newnes-Butterworths, London.
3. S. H. Henshall, Medium and High Speed Diesel Engines for Marine Use, 1st Edition, Institute of Marine Engineers, Mumbai, 1996.

Table of Topics

Section	Topics	Hours (L)
A	Forces and Stresses	4
B	Manoeuvring Systems	4
C	Indicator diagrams and power calculations	8
D	Fuel pumps and Metering devices	8
E	Modern Trends in Engine development	8
F	Medium speed engines	8
G	Automation in modern diesel engine plants	6
H	Lubrication systems	4
I	Maintenance of Diesel engines	6
J	Trouble shooting in Diesel engines	4
Total		**60**

Learning Objectives	L
General Learning Objective Understand the stresses in diesel engine components and effects on the performance. **Specific Learning Objectives: (IMO 7.02,2014: F1/1.1.1)** Explain the following: **A Forces and stresses:** 1.1 Balancing 1.2 Overloading 1.3 Types of moments 1.4 Types of couples 1.5 vibrations 1.6 Torsional vibrations 1.7 Axial vibrations 1.8 Radial vibrations 1.9 Vibration effects 1.10 Methods of damping **(This Section may be discussed after Section I).**	4
General Learning Objective Understand the operational aspects of starting, running and stopping the engine. **B Manoeuvring Systems** **Specific Learning Objectives:** **Main machinery and associated systems** 1.1 Describe precautions to be observed when starting up and shutting down 1.2 Explain the need for authorized and documented procedures/checklist for 1.3 Describe limitations/conditions for starting up and shutting down main 1.4 Describe the functions of interlocking and how they work while main machinery is being started up 1.5 Explain procedures for starting up and shutting down main machinery in terms of design features of main machinery including associated systems 1.6 Describe parameters and factors necessary to develop procedures for starting up and shutting down main machinery including associated systems	4

1.7 Explain that principles of starting up and shutting down procedures of main machinery are the same for any type of main diesel engine, steam turbine and gas turbine 1.8 Describe precautions for conducting trial run of main machinery	
General Learning Objective Understand power calculations and analysis, which help in maintenance and operation. **C Indicator diagrams and power calculations** **Specific Learning Objectives** **Diesel engines** 1.1 Explain the use of indicator diagrams and draw diagram to explain 1.2 Explain Component pressure, maximum pressure and faults 1.3 Compute Area of indicator diagram 1.4 Calculate of indicated and effective engine power 1.5 Explain Calculation of turbocharger power 1.6 Estimate effective engine power without indicator diagrams 1.7 Explain Fuel index 1.8 Explain Turbocharger speed relationship to power 1.9 Detect faults from sample indicator diagrams 1.10 Discuss engine condition monitoring and evaluation systems with regard to 1.11 Explain Online system with automatic sampling of engine parameters 1.12 Supplemented by cylinder pressure measurement 1.13 Explain Engine diagnosis system and computer-controlled surveillance	8
General Learning Objective Understand the fuel system components on the engine. **D Fuel pumps and Metering devices** **Specific Learning Objectives** Explain the following**:** **Fuel injection** 1.1 State typical injection pressures and viscosities for different grades of fuel 1.2 Explain how and why fuel pumps, camshafts and injectors are altered for varying fuel types 1.2.1 Describe with aid of simple sketch the difference between and variable injection timing of fuel, showing materials, principal parts, methods of operation and adjustments of common types of fuel pump 1.2.1.1 Compare the injection requirement for slow, medium and high-speed diesel engines, including pilot injection and pre-combustion chambers 1.2.2 Identify the common service faults, symptoms and causes of combustion problems, specifying appropriate adjustments, including methods of fuel pump timing 1.2.3 Uni-fuel and dual -fuel systems (for high/ medium viscosity fuels) 1.2.4 Electronic injection system 1.2.5 Incorporation of FQSL along with Variable injection timing	8
General Learning Objective Understand the changes and developments in marine diesel engines and associated systems. **E Modern Trends in Engine development** **Specific Learning Objectives** Explain the following**:** 1.1 Sulzer RTA marine diesel engine. 1.2 Man& B&W 1.3 Wartsila, Mitsubishi 1.4 LMC& SMC 1.5 SEMT Pielstick 1.6 Intelligent engine (cam-less engine) 1.7 Dual Fuel engines	8

1.8 Methods to increase the overhaul of diesel engine 1.9 Control of marine diesel engines 1.10 Latest trends in modern propulsive machinery systems	
Modern Trends in Engine development **Additional Objectives:** Historical development of marine propulsion engines; Development of Intelligent engine (Electronic Engine); Methods to increase time between overhauls of diesel engine; Modern Control of marine diesel engines; Latest trends in modern propulsive machinery systems WinGD – RT Flex and X-DF Diesel engines, their systems and operations; MAN Energy Systems – ME series of engines; Difference between the otto cycles and diesel cycle based gas engines, additional emission control equipment	
General Learning Objective Understand the types of marine medium speed diesel engines and their features. **F Medium speed engines** **(This Section may be discussed first, followed by Section C)** **Specific Learning Objectives** Explain the following**:** 1.1 Different types of medium speed marine diesel engines 1.2 Direct coupled reversible Slow and medium speed diesel engines 1.3 clutch and geared reversible unidirectional medium speed engines 1.4 with fixed pitch propeller 1.5 clutch and geared reversible unidirectional medium speed engines 1.6 with controllable pitch propeller 1.7 Sketch a diagrammatic arrangement of a propeller drive from two medium speed diesel engine 1.8 Sketch a typical timing diagram for medium speed diesel engine 1.9 Describe a simple governor to maintain a normal speed under conditions of variable load 1.10 Describe with the aid of diagrams a lubrication and piston cooling system for a medium-speed diesel engine 1.11 Development in exhaust valve design 1.12 Describe in simple terms the principal features of a typical 'V'-type medium speed diesel engine. 1.13 Discuss the use of poor-quality residual fuels and their consequences 1.14 Discuss the improvements in designs for higher output	8
General Learning Objective Understand the developments in automation systems of diesel engines. **G Automation in modern diesel engine plants** **Specific Learning Objectives** 1.1 Explain Remote operation of diesel engine plant 1.2 Explain the various alarm and fail systems available on board? 1.3 Explain about the ship security alert system (SSAS) to raise the alarm. 1.4 Explain about machinery alarms and protection device 1.5 List the parts of the generator fitted with temperature alarm 1.6 Explain the operation and uses of governors 1.7 Explain Need for governors 1.8 Explain Governor terms, concepts and operation 1.9 Explain Hydraulic governors 1.10 Explain Digital governors, power sharing 1.11 Explain Governing systems 1.12 Explain Computerized monitoring of marine diesel engines 1.13 Explain about various diagnostic applications in propulsion engines 1.14 Discuss briefly about the concept of intelligent engines	6

General Learning Objective Understand the lubrication systems of large and medium sized diesel engines. **H Lubrication systems** **Specific Learning Objectives** Explain the following: 1.1 Outline principles of diesel engine lubrication 1.2 Describe with figures the distribution of lubricating oil to diesel engines. 1.3 Types of cylinder lubrication and mechanism 1.4 Selection of lubricating oil 1.5 Explain about lubrication system required for turbochargers 1.6 Lubrication of main bearing, bottom end bearing and cross head bearing 1.7 Explain lubrication arrangement in coolers 1.8 Explain about liner wear and its preventive measures	4
General Learning Objective Understand the maintenance routines of diesel engines and apply the knowledge while working on them. **I Maintenance of Diesel engines** **Specific Learning Objectives** Explain the following: 1.1 Dismantle and inspection of all parts for wear and deterioration 1.2 Pistons, rings, liners, bearings, valves 1.3 Crankshaft alignment 1.4 Cooling passages 1.5 Lubrication system 1.6 Driving chain and gears 1.7 Dismantle and inspection of all parts for wear and deterioration of turbo charger 1.8 Erosion on air side 1.9 Impeller 1.10 Nozzles, blades 1.11 Condition of labyrinths 1.12 Reassembles and check clearance 1.13 Engine holding arrangements 1.14 Tightening of bolts	6
General Learning Objective Understand routine and non-routine troubles which may occur in diesel engines. **K Trouble shooting in Diesel engines** **Specific Learning Objectives** Explain the following: 1.1 Hot & cold corrosion 1.2 Overloading 1.3 High exhaust gas temperature 1.4 Misfiring 1.5 Crankshaft web slip 1.6 X-head bearing problems 1.7 Explain the meaning of starting failure in diesel engines 1.8 Explain the procedure for testing the microbiological contamination of fuel oil and lube oil 1.9 Examine the causes, symptoms, effects and methods of treatment of oils that have been infected with microbiological organisms	4

Subject Name/Code: Marine Auxiliary Systems and Deck Machinery/503

Instructional hours:

Lecture	: 60 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, practical in workshops and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Marine Auxiliary machinery - H.D. McGeorge.
2. The Running & Maintenance of Marine Machinery – J. Cowley.

Reference:

1. Basic Marine Engineering- J.K. Dhar.
2. Marine Engineering Practice - IMEI Publication.
3. General Engineering Knowledge for Marine Engineers - Reeds Volume:8.
4. Marine Machineries- Operation & Maintenance – T.B. Srinivasan, IMEI Publication.
5. Introduction to Marine Engineering – D.A. Taylor.

Table of Topics

Section	Topics	Hours (L)
A 1.1- A 1.10	Pumps	12
B 1.1-B 1.6	Heat Exchangers	8
C 1.1-C 1.9	Evaporators and distillers	10
D 1.1 - D 1.7	Air Compressors	10
E 1.1 - E 1.8	Purifiers	10
F 1.1 - F 1.8	Deck Machineries	10
	Total	**60**

Learning Objectives	L
General Learning Objective Understand the design features and the operative mechanism of the various Auxiliary Machineries so that the related machinery is maintained and operated in a safe, economical and efficient manner on board	
A Specific Learning Objectives: Pump Principles (IMO 704,2014: F1/1416) 1.1 Explain the function of a pump as a machinery to transfer fluid between two given points List the losses of head in a pumping system	1
1.2 State the reason for the viscosity of the fluid to be pumped to be within the range specified in the pump design State the permissions that should be obtained before any fluids are moved with reference to their effect on stability of the ship and pollution overboard	1
1.3 Name the types of pumps generally used on ships and the purposes for which they are normally used Explain the basic action of a displacement pump Explain the necessity for a relief valve to be fitted in the discharge of any displacement pump State the reason for the discharge from the relief valve to be contained within the pumping system when a pump is handling oil or other hazardous material	2
1.4 Describe with the aid of diagrams, the functioning of a reciprocating displacement pump works Explain the purpose of an air vessel fitted to the discharge Describe the characteristics of a reciprocating pump, referring to: - Suction lift - Priming - Discharge pressure - Vapour or gas, in the fluid being pumped	1
1.5 Explain the principle of rotary displacement pumps Sketch a single line diagram to show the principal parts of: - A gear pump - A rotary vane pump - A screw-displacement pump	1
1.6 Describe the principles of operation of an axial-flow pump Describe the type of duty best suited to an axial-flow pump	1
1.7 Explain the principles of a centrifugal pump, referring of the purpose of: - The impeller - The diffuser or volute Draw a single line sketch of a vertical single-entry centrifugal pump Distinguish between a ‘single-entry’ and a ‘double entry’ impeller	1
1.8 Describe the arrangement of a vertical multi-stage single-entry centrifugal pump Describe the characteristics of a centrifugal pump, referring to: - Suction lift - Priming	1

- Discharge pressure - Vapour or gas in the fluid being pumped	
1.9 Explain the need for priming and/or air extraction is necessary in pumping operation Make single line Sketch of: - A reciprocating air pump - A water-ring air pump	1
1.10 Make a single line sketch of a central priming system and explain its advantage Explain the principle of an ejector	2
B Specific Learning Objectives: Heat Exchangers –(IMO 704,2014: F1/1416/4)	
1.1 Explain the surface heat-transfer type of marine heat exchangers State the most common cooling medium used Describe surface heat transfer, referring to the relative direction of flow of fluid Define 'contact heat transfer' as the heat flow between fluids initially at different temperatures when they are mixed together	1
1.2 Sketch the principle of construction of the shell and tube surface heat exchanger Explain the meaning of single-pass, two-pass, etc.	2
1.3 State the materials used for the shell, tubes and tube plates of heat Exchangers Explain how: - Differential expansion is allowed for - an effective seal is maintained between the fluids - leakage is detected	1
1.4 Explain how temperature control is achieved in coolers Describe the effect of partially closing the cooling-water inlet valve Explain the effect of entrained air in cooling water and how it is removed	1
1.5 Sketch the principle of construction of the flat plate type surface heat exchangers	1
1.6 List the types of heat exchanger used for the following: - lubricating-oil coolers - fuel-oil heaters - fresh-water coolers - compressed-air coolers - fresh-water heaters - steam condensers - seawater evaporating and distilling plant - seawater heaters - evaporators and condensers in refrigerators	2
C Specific Learning Objectives: Evaporators and distillers – (IMO 704,2014: F1/1416/5, 1434/3/4)	
1.1 List the purposes for which Fresh water is used on board 1.2 Explain the reason for producing fresh water from seawater 1.3 State the two main methods of obtaining vapour from seawater: • By direct boiling, using boiling water evaporators • By the evolution of vapour when the seawater is 'supersaturated', using flash evaporators 1.4 Explain the effect of distillation on the dissolved solids in seawater 1.5 State the importance of recognizing evaporators and distillers as pressure vessels and the necessity to conform to approved standards for materials, fittings and construction	1
1.6 Describe in simple terms, using line Sketch, the construction of a shell and coil evaporator, naming the materials of the principal parts 1.7 List the mountings fitted to a simple shell and coil evaporator 1.8 Explain the reason for fitting a reducing orifice in the steam supply line of such an Evaporator	2
1.9 Explain the principle of flash evaporation 1.10 Describe with the aid of a simple sketch, a two-stage flash evaporator explaining the principle of operation of the evaporator	1
1.11 Sketch and explain a multistage flash evaporator using a number of stages, with seawater feed passing through each stage in succession	1
1.12 State the source of heat transfers to the Seawater a supply of steam or other hot fluid passing through coils OR tubes which are immersed in the seawater or an electrical element immersed in the seawater 1.13 Explain why low-pressure evaporators are used	1

1.14 Explain single-effect, double-effect and multiple effect evaporation 1.15 Explain how the shell and coil evaporators can be connected in series, with the vapour produced in the first unit being used as the heating fluid in the next unit, the seawater passing through-each unit in turn 1.16 Explain the concept of production of vapour in the second and successive units partly by boiling and partly by flash evaporation 1.17 Explain how multiple-effect evaporation produces an increased quantity of fresh water compared to a single evaporator using a similar input of heat	1
1.18 Describe the need for starting freshwater generator and the limitation of keeping it running 1.19 Explain the starting procedures for a typical type of freshwater generator	1
1.20 Explain the formation of scale on the heating surfaces of coils, tubes and other heat-transfer elements and the need to control it 1.21 State the limiting pressure and temperature in the shell to control the formation of scale 1.22 Explain the term 'brine' 1.23 Explain why the density of the brine must be carefully controlled during the operation of an evaporator 1.24 Explain the procedure to maintain brine at optimum density when an evaporator is operating normally 1.25 What is the effect of excessive density of the brine with reference to carry over of the metallic salts contained in seawater with the vapour? 1.26 Describe the type of scale deposited on the heating surfaces 1.27 Explain the methods of removal of the scale	1
1.28 Describe the necessary quality of water being produced by a distiller is to be used for human consumption as per WHO standards 1.29 Explain the need for chemical agents to be added to the water to destroy any harmful bacteria which may be present due to the evaporation process, a temperature below 75°C 1.30 Explain the process to Make water fit for human consumption 1.31 Explain the regulations for producing water when sailing in areas where pollution may be present, i.e., in rivers and estuaries, particularly in the vicinity of land drains or of discharges of sewage or industrial effluents	1
D Specific Learning Objectives: Air Compressor – (IMO 704,2014: F1/1416/6, 1434/2/4) (IMO 702,2014:13110)	
1.1 Describe an air compressor as a pump which takes air from the atmosphere and, with an input of energy, compresses it in one or more stages to a smaller volume with higher pressure and temperature 1.2 Explain the reason for cooling the air, during and after the compression 1.3 State that the compressed air is stored in steel reservoirs until required for some purpose, such as stating a diesel engine	1
1.4 State that, during the compression process, the relationship: Pe^{nn} = α constant will apply 1.5 State that air can be treated as an ideal gas and that the relationship: PV/T = α constant will also apply 1.6 State that for the air storage tank the relationship PV = mRT: will apply, where: m = mass of air stored in the tank (kg) R = specific gas constant for air (=8314 J/kg/K) T = temperature of air, in kelvin units P = air pressure, in Newton per square meter V = volume of reservoir tank, in cubic meters 1.7 Solve simple numerical problems related to the above objectives	2
1.8 List shipboard uses of compressed air 1.9 State the common pressure limit of single-stage compressors 1.10 State that, in order to restrict the rise of air temperature during compression, the air is cooled by circulating water around the cylinder	1
1.11 State that air compressor can be single-stage or multi-stage reciprocating or rotary Machines 1.12 Describe the compression processes in a two-stage reciprocating compressor	1
1.13 Draw a line diagram of a two-stage air compressor indicating stage air pressures and Temperatures 1.14 Explain why intercoolers and after-coolers are used	2
1.15 State the reason why cylinder lubrication must be kept to a minimum consistent with correct and safe operation	1

1.16 State the reason for using cylinder lubricating oil not having a flashpoint below 210°C and the use of synthetic lubricating oil to reduce a hazard 1.17 Describe the attention required to keep the intake air filter working effectively 1.18 Explain the reason for fitting drain valves after air coolers 1.19 Describe the starting-up and stopping procedures 1.20 Explain the principles upon which air compressors are run automatically 1.21 Describe the particular quality required for compressed air that is to be used in control systems 1.22 Explain how the required quality in the above objective is achieved	
1.23 State the functions and operation of all components including fittings and safety devices of air compressors and compressed air systems 1.24 Evaluate the effects of common operational faults of single and multistage air compressors, including leaking valves, leaking piston rings, blocked filters, blocked coolers 1.25 Explain the reasons and the effects of high levels of oil or water in compressed air 1.26 Describe a procedure for inspecting and maintaining air receivers and their fittings	2
E Specific Learning Objectives: Purifier and fuel oil treatment – (IMO 704,2014: F1/1416/7, 1434/1) (IMO 702,2014:1353)	
1.1 State the principles of purifying to eliminate water or dirt particles from oil 1.1.1. Explain why fuel oil treatment is necessary 1.1.2. Explain in simple terms, the purification by using gravity force and filters, and centrifugal separation 1.1.3. Describe the following types of filters, which are used in fuel oil lines • mesh/gauze elements • magnetic elements • fibre assemblies	1
1.2 Explain how the force of gravity is used to separate out liquids and solids of different densities 1.2.1 Describe the operation principles of an oil purifier 1.2.2 Explain why the use of centrifugal separation is much faster and more effective than gravity in the separation process	
1.3 Describe, with the aid of simple sketch, a bowl separator and a tube separator, showing the main components and the principal differences between the two 1.3.1 State the rotation speeds used in the equipment described above	2
1.4 Describe the following with the aid of Sketch: • bowl assembly • Operating water • Seal water • Gravity disk • Valve cylinder • Separation disk/plate	2
1.5 State sequence of discharging sludge 1.5.1 State why oil purifier needs following data concerning oil: - Temperature - Quantity of flow - Density/specific gravity 1.5.2 Explain the function of gravity disk 1.5.3 Explain the function of low- and high-pressure water	1
1.6 Explain the difference between purifying and clarifying 1.6.1 Describe the purification process of fuel oil, stating the approximate temperatures of the oil necessary both in the supply tank and immediately prior to centrifuging 1.6.2 Explain precautions for starting purifier and checking points to ensure a good working Order	1
1.7 Describe the correct procedures for the disposal of waste oil, sludge residue, etc., 1.7.1 Explain precautions/procedures for the operation of purifiers in case of blackout	1
1.8 Explain the automation, monitoring and alarms of oil purifiers with respect to • Temperature control • Automatic start • Automatic desludging • Partial desludging • Total desludging • Monitoring and alarms	2

• Low/high temperature • Water content • Leakage monitoring • Treated oil flowing into heavy liquid side • Non-closure of bowl • Discharge detector for monitoring sludge discharge	
F Specific Learning Objectives: Deck Machinery – (IMO 704,2014: F1/14110) (IMO 702,2014:1357)	
1.1 Describe all the components that constitute a typical electric/hydraulic windlass/mooring winch system	1
1.2 Explain the construction of windlass/mooring winch with visual aids/illustrations of typical ones	1
1.3 Explain the operation mechanism of windlass/mooring winch with visual aids/illustrations of typical ones 131 Explain in simple words, speed control mechanism used in windlass/mooring winch with visual aids/illustrations of typical ones	1
1.4 Describe all the components that constitute a typical electric/hydraulic winch system	1
1.5 Explain the construction of a winch with visual aids/illustrations of typical ones	1
1.6 Explain the operation mechanism of a winch with visual aids/illustrations of typical ones 161 Explain in simple words, speed control mechanism used in winch with visual aids/illustrations of typical ones	1
1.7 Explain the construction of a boat winch with visual aids/illustrations of typical ones 171 Explain the operation mechanism of a boat winch with visual aids/illustrations of typical ones	1
1.8 Explain the automation, monitoring and alarms of self-tensioning mooring winches	3

Subject Name/Code: Marine Steam Plant/504

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Marine Engineering – by group of authorities, Editor: Roy L Harrington, ISBN: 0-939773-10-4, SNAME (USA).

Reference:

1. John B Woodward (1980) Analysis of steam propulsion plants - https://deepblue.lib.umich.edu/handle/2027.42/91754.
2. https://www.spiraxsarco.com/learn-about-steam.
3. Steam: Its Generation and Use. (2005). United States: Babcock & Wilcox.
4. Hunt, E. C. (1999). Modern Marine Engineer's Manual. United State: Cornell Maritime Press.
5. SNAME (1996) T&R Bulletin 3-11: Marine Steam power plant heat balance practices, United State.
6. Resources from Spirax Sarco on the relevant concepts - https://www.spiraxsarco.com/learn-about-steam.
7. Taplin, P.E., H. (2015). Boiler Plant and Distribution System Optimization Manual, Third Edition. (n.p.): Lulu.com.

Table of Topics

Section	Topics	Hours (L)
A	Marine Steam systems and steam utilization	2
B	Steam system piping components ratings and specifications	8
C	Thermal oil systems	2
D	Condensate and Feed water systems	3
E	Steam traps and steam trapping	2
F	Tracing steam lines and insulation	1
G	Waste Heat Recovery Systems (WHRS)	3
H	De-superheating	1
I	Steam Propulsion Plants	8
J	Boiler water treatment	4
K	Control of Boiler	8
L	Boiler and steam plant survey	3
	Total	**45**

Learning Objectives	**L**
General Learning Objective: Understand different types of steam applications and its system, steam distribution systems, calculation to assess steam demands by a consumer, piping layouts, thermal oil systems, condensate and feed systems, steam traps and energy losses, boiler controls, requirements of boiler water treatment, requirements of boiler surveys	
Sub-sub topics **A Marine Steam systems and steam utilization:** **(IMO Model course 7.04 – 1.2, 1.4.2)** **(IMO Model Course – 7.02 – 1.3.14)** **Specific Learning Objective:** 1.1 Discuss various steam systems on board ships 1.2 Explain Heating systems 1.3 Explain Motive power – pumps and turbo-electric generators 1.4 Explain Propulsion plant 1.5 Explain Process consumption – tank cleaning 1.6 Explain Waste heat Recovery Systems	2
B Steam system piping components ratings and specifications **Specific Learning Objective: (IMO Model course 7.04 – 1.4.4, 1.4.1.9)** 2.1 Explain with Examples of rating and sizing calculations for – 2.1.1 A steam heater 2.1.2 Steam demand for tank cleaning 2.1.3 Steam demand for Turbine 2.1.4 Steam flow for Waste Heat Extraction 2.2 Explain Pipes and pipe sizing – standard sizes, pipeline standards for pressure service, pipeline sizing, allowances for fittings, allowances for thermal losses, pressure losses, steam velocity 2.3 Explain Steam mains and drainage for - 2.3.1 Piping layout 2.3.2 Drain points 2.3.3 Water hammer and its effects 2.3.4 Branch lines and connections	8

2.3.5 Steam separators, strainers 2.4 Explain Stalling in heat exchangers and its effects 2.5 Explain Methods of preventing stall 2.6 Explain heat load, heat exchanger and steam load relationship	
C Thermal oil systems **Specific Learning Objective: (IMO Model course 7.04 – 1.4.8) (IMO Model Course – 7.02 – 1.3.25)** 3.1 Introduction to thermal oil systems 3.2 Explain Thermal oil properties, requirements, selection 3.3 Explain Controls and pipeline components of thermal oil systems 3.4 Explain Operation of thermal oil heater, automation and controls 3.5 Explain Safety and environmental aspects of thermal oil use	2
D Condensate and Feed Systems: **Specific Learning Objective: (IMO Model course 7.04 – 1.4.4) (IMO Model Course – 7.02 –1.1.4.1)** 4.1 Describe Condensate and Drains System 4.2 Describe Layout of condensate return lines 4.3 Explain Drain lines to steam traps 4.4 Explain Common return lines – issues with temperature-controlled plant with steam traps draining into flooded lines 4.5 Explain Sizing condensate return lines 4.6 Describe Distilled Water Transfer and feed water systems	3
E Steam traps and steam trapping: **Specific Learning Objective: (IMO Model course 7.04 – 1.4.4)** **(IMO Model Course – 7.02 – 1.2.4, 1.3.3)** 5.1 Explain Use of steam traps 5.2 Explain Types of steam traps – thermostatic steam traps, mechanical steam traps, thermodynamic steam traps 5.3 Explain Considerations for selecting steam traps 5.4 Explain Air venting theory and applications 5.5 Explain Testing and maintenance of steam traps 5.6 Explain Energy losses in steam traps	2
F Tracing steam lines and Insulation: **Specific Learning Objective: (IMO Model Course – 7.02 – 1.2.4, 1.3.3)** Explain the following: 6.1 Insulation of steam lines – materials, installation 6.2 Maintenance of insulation and minimizing losses 6.3 Tracing steam lines – layout 6.4 Tracing steam condensate return	1
G Waste Heat Recovery Systems: **Specific Learning Objective: (IMO Model Course – 7.02 – 1.2.4, 1.3.3)** Explain the following: 2.1 Description of WHRS 2.2 Power concept and arrangement 7.1.1 Steam Turbine Generator – WHRS 7.1.2 Other configurations 7.1.3 Installation 2.3 Single / Dual pressure steam systems 2.4 Thermodynamic concepts and steam generation from Main Engine Waste Heat – calculation 2.5 Acid formation – a limiting factor in WHRS? 2.6 Conventional economizers 2.7 Superheaters	3
H De-superheating:	

Specific Learning Objective: (IMO Model Course – 7.04 – 1.2.3, 1.2.4) Explain the following: 8.1 Basic de-superheating theory 8.2 Basic desuperheater types 8.3 Other types of desuperheater 8.4 Typical desuperheater installations	1
I Steam Propulsion Plants: (IMO Model Course – 7.04 – 1.4.1.2) **(IMO Model Course – 7.02 – 1.2.3, 1.2.4, 1.3.4)** **Specific Learning Objective:** Explain the following: 9.1 Fundamentals of the steam propulsion plant (steam turbine), overview 9.2 The typical plant layout 9.3 Sample heat balance diagrams 9.4 Sample arrangement plans 9.5 Boiler performance curves	8
J Boiler Water Treatment: **Specific Learning Objective: (IMO Model course 7.04 – Appendix 5)** Explain the following: 10.1 Impurities in boiler feed water 10.2 Condensate systems corrosion 10.3 Priming of the boiler 10.4 Water carryover in steam 10.5 Removal of Oxygen from the boiler feed water 10.6 Water treatment – 10.6.1 Chemicals used 10.6.2 Dosage calculations 10.6.3 Location of dosage 10.6.4 Testing and assessment of effectiveness of the treatment	4
K Control of Boiler: **Specific Learning Objective: (IMO Model course 7.04 – 1.4.3, 2.1.2.3)** **(IMO Model Course – 7.02 – 1.3.5, 1.1.4.1,1.3.1.2, 1.3.2,1.3.16,1.3.5.2)** Explain the following: 11.1 Steam pressure control 11.2 Safety controls 11.3 Combustion controls 11.4 Turn down ratio 11.5 Feed water control 11.6 Blow down control 11.7 Furnace Pressure Control 11.8 Steam Temperature Control 11.9 Soot blower control 11.10 Flame safety controls 11.11 Safety interlocks 11.12 Firing rate control 11.13 Boiler Tuning	8
L Boiler Survey: (IMO Model Course – 7.02 – 1.3.23) **Specific Learning Objective:** Explain the following: 12.1 Continuous machinery survey of boiler 12.2 Requirements under ASME BPV Code 12.3 Items for survey 12.4 Checks and inspection 12.5 Tests and certification	3

Subject Name/Code: Naval Architecture 1/505

Instructional hours:

Lecture	: 60 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisite: Class 10, + 1 and +2 scheme (MPC Group); related topics covered in previous Semesters.
2. Additional Objectives are provided for guidance during dissemination and self-learning.
3. The Objectives also help in connecting with the next level of studies under the same Subject.
4. The Objectives may be effectively used for framing assessment questions.

Recommended Text:

1. Naval Architecture (Reed's Vol-4), E. A. Stokoe, Bloomsbury.
2. Gillmer, T. C., Johnson, B. (1982). Introduction to Naval Architecture. Netherlands: 3Island Press.
3. Barrass, B., Derrett, C. D. R. (2011). Ship Stability for Masters and Mates. United Kingdom: Elsevier Science.

Reference:

1. Safety practices related to small fishing vessel stability - http://www.fao.org/3/i0625e/i0625e.pdf.
2. Stability guide for smaller vessels – www.dma.dk.
3. Hull form and Geometry notes - https://www.usna.edu.
4. Dictionary of Ship Hydrodynamics - https://ittc.info/media/1531/alphabetdictionary.pdf.
5. Lewis, E. V. (1988). Principles of Naval Architecture: Stability and strength. United State: Society of Naval Architects and Marine Engineers.
6. Biran, A., Pulido, R. L. (2013). Ship Hydrostatics and Stability. Netherlands: Elsevier Science.
7. International Code on Intact Stability, 2008. (2009). United Kingdom: International Maritime Organization.

Table of Topics

Section	Topics	Hours (L)
A1-A1	**Geometry of Ship and Definitions** **Subtopics**: Ship geometry, Definition of hull surface – coordinate systems, graphic description – Lines plan of ships, coefficients of form, Offset and Offset table, Bonjean Curves.	6
B1-B1	**Basic Ship Hydrostatics** **Subtopics:** Density, relative density. Archimedes principle, Displacements, deadweight, meaning of buoyancy, reserve buoyancy. tonne per centimetre immersion (TPCI). Effect of change in density of water. FWA, DWA and Load line.	6
C1-C1	**Numerical Integration in Naval Architecture** **Subtopics:** Simpson's 1st and 2nd Rules for areas and volumes, 1st moments and centroids, 2nd moments of area (Area moment of Inertia), 5-8-1 & 3-10-1 rule for area, Use of half-spaced ordinates, Tchebycheff's Rules.	8
D1-D3	**Transverse Stability of the Ship** **Subtopics:** Centre of Gravity & angle of List, Stability at small angles of heel, Stability at large angles of Heel, the inclining experiment, Free Surface Affect.	18
E1- E1	**Longitudinal Stability and Trim** **Subtopics:** Centre of Flotation, Longitudinal metacentre. moment to change Trim (MCTC), change in draughts due to small added masses. Change in draughts and trim due to change in density of water.	4
F1- F2	**Flooding and Damage Stability, Stability during Dry-docking and during grounding** **Subtopics:** Assessment of ship conditions after flooding – Permeability, Lost Buoyancy or Added mass, change in mean draught due to bilging of amidships, side and end compartments.	5
G1 –G1	**Stability requirements for vessels** **Subtopic:** IMO code of intact stability, MARPOL & SOLAS guidelines for damage stability, Probabilistic damage stability.	3
H1 –H2	**Strength of Ships** **Subtopic:** Pressure exerted by a liquid on bulkhead, centre of pressure, Longitudinal strength. Curves of buoyancy and weight, Curves of load, shearing force and bending moment, Alternative methods. Standard conditions, still water and wave bending movements and shear forces, Approximation for maximum shearing force and bending moment, Moment of Inertia of section, Section modulus calculation. Stresses in deck and keel.	10
	Total	**60**

Learning Objectives **IMO Model Course 2014 References: 7.02 – 4.1.1.7, 4.1.2, 4.1.3; 7.04 – 4.2.1.1 to 4.1.1.11**	**L**
A Geometry of Ship and Definitions	
A1 General Learning Objective 1.1 Understand application of concepts related to geometry of ship, coefficient of forms and lines plan drawing. **A1 Sub-topic: Lines plan drawing, Coefficient of Forms, Offset and offset table** **Sub-subtopics & SLOs** 1.1.1 Define and explain Lines plan drawing	6

1.1.2 Define and explain Buttocks, waterlines, transverse section, Body plan, half breadth plan, profile view of ship

1.1.3 Define and explain Offset and offset table

1.1.4 Define, explain and utilize following form coefficients of ship in obtaining various principal parameters of ship

1.1.5 Block Coefficient, Prismatic coefficients, Midship coefficient, Water plane area coefficient

Additional Objectives:

Specific Learning Objectives: (IMO Model Course 7.02, 4.1.1.6, 4.1.1.7)

1. Ships' lines, delineation of the lines drawing
2. Arrangement of the lines drawing
3. Perpendiculars – Length between perpendiculars, midship section
4. Parallel middle body
5. Manner of measuring lengths, station ordinates and transverse sections, molded base line, deck lines, molded dimensions
6. Characteristics of the sections, molded drafts and keel drafts, water-planes and waterlines, buttock lines, types of intersecting lines, diagonals, bilge diagonals, frame lines and cant frames
7. Fair form and fairness of lines, designing the form of a proposed vessel, fairing a set of lines
8. Table of offsets, mathematical formulas for ships' hull forms
9. Displacement and Weight Relationship – Archimedes law, buoyancy of submerged bodies, volumes of displacement, effect of density of water
10. Displacement vs weight estimates
11. Integrating Rules and Methods: General, formulas for areas, moments and moments of inertia, Trapezoidal rule, Simpson's First Rule, Simpson's Second Rule, Five – Eight rule for area, Use of half-spaced ordinates, Tchebycheff's Rules
12. Integration for moments and other, Three – Ten Rule for moment, Polar integration
13. The Displacement Sheet – Displacement of Molded form and of Appendages, Centre of Buoyancy, Displacement and other curves, Areas of water plane, Tons per centimetre, Centre of Floatation, Metacentric radius BMT and BML, Longitudinal Centre of Buoyancy (LCB) calculation, curves of sectional areas
14. Approximate formulas for vertical centre of buoyancy – Morrish's formula, MCT1
15. Bonjean Curves – construction and uses
16. Wetted Surface Area (WSA) – definition, calculation, approximate method for WSA
17. Coefficients of Form – Block Coefficient, Midship Section Coefficient, Prismatic or Longitudinal coefficient, water-plane coefficient, displacement length ratio, vertical prismatic coefficient, ratios of dimensions
18. Capacity – general, capacity plan, soundings and sounding tables, increment curve, effect of heel and trim, capacity curve and centre of gravity, Ullage, cargo capacities

B Basic Ship Hydrostatics

B1 General Learning Objective:

2.1. Understand application of various hydrostatic parameters in different density of water

B1 Sub-topic: water Density, relative density. Archimedes principle, Displacements, deadweight, meaning of buoyancy, reserve buoyancy. tonne per centimetre immersion (TPCI). Effect of change in density of water. FWA, DWA and Load line

6

Sub-sub topics & SLOs

2.1.1 Define, explain and utilize Archimedes principle, Load Displacement, Lightship, deadweight, buoyancy, reserve buoyancy

2.1.2 Explain effect of change of mass on draught - Tonnes per centimetre immersion

2.1.3 Explain FWA and DWA and Load line markings

2.1.4 Explain effect of change of density on draught

Additional Objectives:

Specific Learning Objectives:

(IMO Model Course 7.04 – 4.2.1, 3.1.7) (IMO Model Course 7.02 – 4.1.1.7)

1. Hydrostatics, Explain what is stability
2. Six motions of a vessel
3. Centres of gravity and buoyancy
4. The couple
5. Initial stability

6. Statical Stability 7. Transverse metacentre 8. Stable, neutral and unstable equilibrium 9. Metacentric height, metacentric radius 10. Fresh Water Allowance 11. Ship's Hydrostatic Particulars	
C Numerical Integration in Naval Architecture	8
C1 General Learning Objective: 3.1 Understand application of concepts related to Simpson's 1st and 2nd Rules for calculating various areas and underwater volume of ship **C1 Sub topic:** Simpson's 1st and 2nd Rules for areas and volumes. Application of Simpson's rules to calculate areas and volumes. Common areas such as water planes, sections and bulkheads, wetted surface area. Immersed volume of hull by sections and water planes. Bonjean curves and their use **Sub-sub topics & SLOs** 3.1.1 Define, explain and utilize Simpson's 1st and 2nd Rules to calculate areas such as water planes, sections and bulkheads, wetted surface area 3.1.2 Define, explain and utilize Simpson's 1st and 2nd Rules to calculate immersed volume of hull by sections and water planes 3.1.3 Define, explain and utilize Bonjean curves to calculate geometric parameters of ship. 3.1.4 Utilize Simpson's 1st and 2nd Rules to calculate centroids of areas such as water planes, sections and bulkheads 3.1.5 Utilize Simpson's 1st and 2nd Rules to calculate centroids of underwater volume such LCB and VCB 3.1.6 Utilize Simpson's 1st and 2nd Rules to calculate 2nd moments of water plane area-Transverse moment of inertia, IT; Longitudinal moment of inertia, IL	
D Transverse Stability of the Ship	4
D1 General Learning Objective: Understand application of concepts related to CG of a vessel etc. 4.1 **Centre of Gravity & angle of List** **D1 Sub Topic:** Longitudinal centre of gravity, Vertical centre of gravity, shift in centre of gravity due to the addition, removal or transfer of masses. Effect of suspended mass. Angle of List **Sub-sub topics & SLOs** 4.1.1 Define and explain LCG, VCG and TCG, angle of list 4.1.2 Determine the location of LCG, VCG, TCG and angle of list due to addition, removal and transfer of masses 4.1.3 Explain the effect on these due to suspended masses	
D2 General Learning Objective: Understand application of concepts related to metacentric height etc. 4.2 Understand, utilize and determine concepts related GM, BM, FSE and inclining experiment **D2 Sub Topic:** Conditions of equilibrium of floating bodies. Definition of stability, initial stability, meta-centric height, Righting arm at small angles of heel, calculation of BM, GM, Metacentric diagram, free surface effect. Inclining experiment **Sub-sub topics & SLOs** 4.2.1 Define and explain the concepts of metacentre, metacentric height, metacentric radius and righting arm at small angles of heel 4.2.2 Define and explain stable, unstable and neutral equilibrium condition for both floating and submerged bodies 4.2.3 Deduce and utilize the expression for metacentric height, metacentric radius for the small angles of heel 4.2.4 Explain Stiff ships and tender ships 4.2.5 Define and explain the metacentric diagram 4.2.6 Define and explain the free surface effect 4.2.7 Explain in detail and utilize the inclining experiment to find KG and GM of the lightship	8
D3 General Learning Objective: 4.3 Understand application of concepts related to stability at large angles of heel, angle of loll, KN curves and dynamical stability	6

D3 Sub Topic: Definition of large angles of heel, Curve of Statical stability, Angle of loll, Cross curves of stability, KN Tables, Dynamical stability **Sub-sub topics & SLOs** 1.3.1 Derive and explain the wall sided formula 1.3.2 Define and explain angle of loll and possible corrective actions 1.3.3 Explain complete stability using Attwood's formula 1.3.4 Explain the curve of statical stability (GZ curve) 1.3.5 Explain Cross curves of stability, KN curves, 1.3.6 Explain the effect of vertical shift of CG on GZ Curve 1.3.7 Explain the effect of transverse shift of CG on GZ Curve 1.3.8 Explain concept of dynamical stability	
Additional Objectives: **Specific Learning Objectives: (IMO Model Course 7.04 – 4.2.1) (IMO Model Course 7.02 – 4.1.1.7)** Explain the following: 1. Centre of gravity 2. The light ships KG 3. Using moments to find KG 4. Calculating GG' (shift of G) 5. Calculating GG' with suspended weight 6. Finding KG when loading or discharging, required accuracy of KG	
Additional Objectives: **Specific Learning Objectives: (IMO Model Course 7.04 – 4.2.1) (IMO Model Course 7.02 – 4.1.1.7)** Explain the following: 1. Explain what is KM 2. Calculating KB 3. Calculating BM 4. Approximating BM for curved water planes 5. Analysis of vertical movement of KM 6. Effect of vertical movement of M, on beam to draft ratio 7. Summation of KM vertical movement 8. Movement of M with transverse inclination	
Additional Objectives: **Specific Learning Objectives: (IMO Model Course 7.04 – 4.2.1) (IMO Model Course 7.02 – 4.1.1.7)** Explain the following: 1. Necessity of inclining experiment 2. Explain what is required gear and data 3. Performing the experiment 4. Derivation of inclining experiment formula 5. Precautions to take during experiment 6. Example of the experiment 7. Legal requirements and practical applications	
Additional Objectives: **Specific Learning Objectives: (IMO Model Course 7.04 – 4.2.1) (IMO Model Course 7.02 – 4.1.1.7)** Explain the following: 1. Effect of GM 2. Stability of curves 3. Constructing cross curves of stability 4. Drawing the statical stability curve 5. Using GM to obtain an accurate start 6. Correcting for a vertical shift of G 7. Correcting for a change in displacement 8. Correcting for a transverse shift of G 9. Analysing a statical stability curve 10. List in relation to statical stability curves 11. Angle of Loll	
Additional Objectives: **Specific Learning Objective: (IMO Model Course 7.04 – 4.2.1) (IMO Model Course 7.02 – 4.1.1.7)** Explain the following: 1. Effect of surface dimensions	

2. Effect of specific gravity 3. Effect of amount of liquid in tank 4. Effect of weight and vertical position of liquids 5. Free surface corrections 6. Free surface constants 7. Cross – connection valve for deep tanks 8. Effect on overall stability 9. List and its correction	
E Longitudinal Stability and Trim	4
E1 General Learning Objective: 5.1 Understand application of concepts related to related to longitudinal stability and trim. **E1 Sub Topic:** Centre of Flotation, Longitudinal metacentre. moment to change Trim (MCTC), change in draughts due to small added masses Change in draught due to addition of small masses and large masses. Change in draughts and trim due to change in density of water. **Sub-sub topics & SLOs** 5.1.1 Define, explain and utilize centre of flotation, moment to change trim, MCTC and longitudinal metacentre for the calculation of trim, drafts at AP and FP due to addition, removal and shifting of weights 5.1.2 Effect of change in density on trim 5.1.3 True mean draught	
Additional Objectives: **Specific Learning Objectives:** **(IMO Model Course 7.04 – 4.2.1) (IMO Model Course 7.02 – 4.1.2.2) (IMO Model Course 7.02 – 4.1.1.7)** Explain the following: 1. Definition, trimming moments and MCT1, 2. Calculating exact distribution of trim change 3. Calculating MCT1 4. Change of draft at one end only 5. Effect of trim on draft readings 6. Trim and its effect on displacement 7. Effects of trim on transverse stability 8. Trim effects passing from salt to fresh water 9. Change of trim due to large weights 10. LCG method of trim calculation 11. Illustrative problems. 12. Trim and draft calculations	
F Flooding and Damage Stability, Stability during Dry-docking and during grounding	3
F1 General Learning objective: Understand application of concepts related to bilging etc. 6.1 Understand application of concepts related to bilging of compartments **F1 Sub Topic:** Assessment of ship conditions after flooding – Permeability, Lost Buoyancy or Added mass, change in mean draught due to bilging of amidships, side and end compartments **Sub-Sub Topic & SLOs** 6.1.1 Define, explain and utilize permeability, lost buoyancy method and added weight method for calculating drafts at AP and FP due to bilging of compartments located amidships and at the end for the rectangular barge	
F2 General Learning Objective: 6.2 Understand application of concepts related to stability during docking and grounding **F2 Sub Topic:** Stability during Dry-docking and stability during grounding: Stability when docking, Stability on grounding **Sub-Sub Topic & SLOs** 6.2.1 Demonstrate understanding and application of concepts related to stability during docking and grounding	2

Additional Objectives: **Specific Learning Objectives: (IMO Model Course 7.02 – 4.1.2, 4.1.2.1, 4.4.2.1)** Explain the following: 1. Fundamental effects of Damage – extent of damage and location and number of bulkheads 2. Effects of flooding – Change of draft 3. Change of trim, heel 4. Change of stability 5. Freeboard and GM in damaged condition 6. Loss of ship 7. DEFINITIONS – Subdivision load line, subdivision length, breadth of vessel, Bulkhead deck, Margin line, Draft, Permeability, Volume, Intact buoyancy, floodable length, factor of subdivision, permissible length, criterion of service 8. The damaged condition, damaged condition due to collision 9. Effect of flooding on transverse stability 10. Remedial measures to improve transverse stability 11. Dangerous effect of flooded wing compartments 12. Added weight method using the statical stability curve 13. Damage on transverse stability 14. Effect of grounding on stability 15. Effect of flooding on reserve buoyancy 16. How the ship's officer uses floodable length curves 17. Effect of permeability on floodable length 18. Longitudinal hull strength and the damaged condition 19. How fast will a ship sink? 20. Action to be taken in the event of partial loss of intact buoyancy 21. Floodable length requirements, factor of subdivision, special provisions, permeability, rules with regard to minimum spacing of bulkheads, steps, recesses and local subdivision	
G Stability requirements for vessels	3
G1 General Learning Objective: Understand application of concepts related to MARPOL & SOLAS. 7.1 Explain concepts related to IMO code of intact stability, MARPOL & SOLAS guidelines for probabilistic damage stability **G1. Sub Topic:** IMO code of intact stability, Definitions as per SOLAS – water tight bulkhead, bulkhead deck, Probabilistic damage stability (MARPOL & SOLAS guidelines for damage stability) **Sub-Sub Topic & SLOs** 7.1.1 Explain concepts related to IMO code of intact stability- requirements for righting lever curve, wind heeling criteria, criteria for passenger ships, ship carrying cargo in bulk 7.1.2 Explain Bulkhead deck, Margin line, Permeability, floodable length, factor of subdivision, permissible length, criterion of service 7.1.3 Explain concepts related to MARPOL & SOLAS guidelines for probabilistic damage stability	
Additional Objectives: **Specific Learning Objectives: (IMO Model Course 7.04 – 4.6.1, 4.2.1)** **(IMO Model Course 7.02 – 4.1.3.1)** Explain the following: 1. Regulations on requirements of stability for various ships 2. Calculations of volumetric heeling moments 3. Allowance for a vertical shift of grain 4. Stability requirements for loading cargoes 5. Determining maximum allowable heeling moment, comparison of regulations 6. Document of authorization 7. Exemptions for certain voyages 8. Stability calculation form 9. Preloading planning calculations 10. Stability requirements 11. Bulk carriers and Panama Canal draft calculations 12. SOLAS – Subdivision and Stability 13. SOLAS – Carriage of Grain	
Additional Objectives: **Specific Learning Objectives: (IMO Model Course 7.04 – 4.6.1, 4.2.1)**	

(IMO Model Course 7.02 – 4.1.1.7) Explain the following: 1. Evolution of the loading computer 2. Need for new loading computers 3. Approved trim and stability booklet 4. Stress tables and stress calculating equipment 5. Methods of improving stability 6. Drafts and list 7. Stability during dry-docking 8. Defined Stability References and stability during grounding 9. Ships stability booklet and its contents	
Additional Objectives: **Practical Stability & Trim Considerations** **Specific Learning Objectives: (IMO Model Course 7.04 – 4.6.1, 4.2.1)** **(IMO Model Course 7.02 – 4.1.1.7)** Explain the following: 1. Factors affecting the rolling of ships 2. Anti-rolling devices and their effect 3. Explain what is a good GM 4. Purpose of ballasting, safety with a small GM 5. How to load a ship to obtain GM and trim	
Additional Objectives: **Specific Learning Objectives: (IMO Model Course 7.02 – 4.4.2.1)** **Case studies on** 1. Fire and capsizing 2. The grounding and capsizing 3. Cargo shift and sinking 4. Moderate collision 5. Loss of ship due to insufficient reserve buoyancy 6. Loss of the ship	
H Strength of Ships	
H1 General Learning Objective: 8.1 Understand application of concepts related to force acting on the bulkhead and its centre of pressure **H1 Sub Topics: Pressure exerted by a liquid on bulkhead, centre of pressure** **Sub-Sub Topics & SLOs** 8.1.1 Define, explain and utilize concepts related to force acting on the bulkhead and its centre of pressure for regular and irregular shapes	3
H2 General Learning Objective: 8.2 Demonstrate understanding and application of concepts related to longitudinal strength of ship and calculation of stresses acting in the deck and keel for the midship section **H3 Sub Topics:** Longitudinal strength. Curves of buoyancy and weight, Curves of load, shearing force and bending moment, Alternative methods. Standard conditions, still water and wave bending movements and shear forces, Approximation for maximum shearing force and bending moment, Moment of Inertia of section, Section modulus calculation. Stresses in deck and keel **Sub-Sub Topics & SLOs** 8.2.1 Explain concept of longitudinal strength 8.2.2 Explain and utilize different methods used for the calculation of bending moments acting on rectangular barges, for both in still water and on waves 8.2.3 Define and explain Sagging and Hogging condition of ship 8.2.4 Determine values of loads, shear force and bending moment acting at various longitudinal locations of box barge and draw SFD and BMD for the same 8.2.5 Define, explain and utilize concept of section modulus of ship's midship section and calculate stress in deck and keel plate based on the maximum bending moment acting on it	7

Subject Name/Code: Ship Structure and Marine Shafting/506

Instructional hours:

Lecture	: 30 hours
Total contact hours	: 30 hours
Credits	: 2

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisites: 10, + 1 and +2 scheme (MPC Group); related topics covered in previous Semesters.

Recommended Text:

1. Young, P., Kemp, J. F. (2013). Ship Construction Sketch and Notes. (n.p.): Taylor & Francis.
2. Eyres, D. J., Bruce, G. J. (2012). Ship Construction. Germany: Elsevier Science.
3. Ship Construction - Reeds Volume:5.
4. Merchant Ship Construction - H.J. Pursey.
5. Merchant Ship Construction - D.A. Taylor.

Reference:

1. Surveyor's Glossary Hull Terms & Hull Survey Terms Recommendation 82 July 2003 / Rev.1 Oct 2018 - https://www.iacs.org.uk/download/1868.
2. J.Moe (1971) Loading of the Hull Girder – Translated by F C Michelsen, Report No.118 The Dept. of NAME, The University of Michigan College of Engineering. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/91751/Publication_No_118.pdf?sequence=1&isAllowed=y.
3. Marine Engineering – by group of authorities, Editor: Roy L Harrington, ISBN: 0-939773-10-4, SNAME (USA).
4. Hughes, O. F. (1983). Ship Structural Design: A Rationally-based, Computer-aided, Optimization Approach. United Kingdom: Wiley.
5. Hunt, E. C. (1999). Modern Marine Engineer's Manual. United State: Cornell Maritime Press.
6. Lewis, E. V. (1988). Principles of Naval Architecture: Stability and strength. United State: Society of Naval Architects and Marine Engineers.
7. Soares, C. G. (2009). Risk-Based Ship Design: Methods, Tools and Applications. Germany: Springer Berlin Heidelberg.

Table of Topics

Section	Topics	Hours (L)
A1-A3	**Types of Ships** **Subtopics**: Classification of ships based on purpose, General Arrangement of Main Cargo ships	2
B1	**Structural terms used in ships** **Subtopics:** Ship structural components	1
C1	**Ship Structural Materials** **Subtopics:** Ship structural materials	2
D1-D2	**Loads and stresses acting on the ship** **Subtopics:** Loads and stresses acting on the ship structure and resisting structural components, Ship-board loads and stresses management	3
E1	**Stiffening of plates – Framing systems** **Subtopics:** Framing systems	1
F1- F2	**Bottom and side structures** **Subtopics:** Bottom structure, Side structure	2
G1 –G3	**Shell and deck Structures** **Subtopics:** Hatches and closing, Deck structure, Shell and associated structure	3
H1	**Midship section** **Subtopic:** Midship section of important cargo ships	1
I1-I4	**Bulkheads & Deep Tanks:** **Subtopic:** Types of bulkheads, Arrangement of plating and stiffeners on WT bulkheads. Openings in watertight bulkheads, Deep tanks	2
J1-	**Fore-End Arrangements** **Sub Topic:** Fore end arrangements	3
K1	**Aft End Arrangement** **Sub Topic:** Aft end arrangements	3
L1	**Load Line and Tonnage** **Sub Topic:** Load line markings and tonnage	2
M1	**Ship surveys** **Sub Topic:** Annual Surveys and harmonised system	2
N1-N2	**Propeller shafting and components** **Sub Topic:** Shafting installation – description, Shafting ancillaries – design features	3
	Total	**30**

Learning Objectives **IMO Model Course Competence References** 7.02 – 4.1.1, 4.1.2, 4.1.3, 1.1.5 7.04 – 4.2.2.2, 4.2.2.3, 4.2.2.4, 4.2.2.7, 1.4.1.5	**L**
A Types of Ships	
General Learning Objective Understand differences between ships and classify the ships based on their purpose **A1 Sub-topic: Classification of ships based on purpose** **Sub-subtopics & SLOs** 1.1 Classification of ships based on purpose 1.1.1 Distinguish between ships based on the purpose for which they are built 1.1.2 Divides the ships into main categories of merchant, military, auxiliary and research 1.1.3 Construct a table showing the subcategories of the types at 1.1.2 1.1.4 Construct a table showing detailed divisions of merchant and auxiliary ships	1
A2 Sub-topic: General Arrangement of main cargo ships **Sub-subtopics & SLOs**	1

1.2 General Arrangement of main cargo ships Discuss and distinguish the designed features of the following ship types: 1.2.1 General cargo ships 1.2.2 Oil Tankers 1.2.3 Bulk carriers 1.2.4 Container carriers 1.2.5 RO-RO ships 1.2.6 Passenger ships 1.2.7 Liquefied gas carriers 1.2.8 Chemical Tankers	
B. Structural terms used in ships **Subtopics: Ship structural components**	
General Learning Objective: Understand appropriate terms to identify and illustrate ship's structural features and components.	
B1 Sub-topic: Ship structural components **Sub-sub topics & SLOs** 2.1 Identify and illustrate the ship's structural parts with the help of ship's plan and drawings 2.1.1 shell plating, decks, tank top Keel, bottom side girders, bottom longitudinals, stringers, deck girders 2.1.2 Keel, bottom side girders, bottom longitudinals, stringers, deck girders 2.1.3 Frame spacing and Frame stations 2.1.4 Solid floors, bracket or open floors, web frames, hold frames, deck beams, beam knees, brackets, tank-side brackets 2.1.5 bulkheads and stiffeners, pillars 2.1.6 hatch side girders, hatch end beams, half beams, coamings, stays, bulwarks 2.1.7 bow and stern framing, can't beams, breast-hooks 2.1.8 Bulbous bow, Stern frame, transom floor	1
C Ship Structural Materials	
General Learning Objective: Understand mild steel, aluminium and FRP as the materials that are used in the construction of ships, their advantages and disadvantages	
C3 Sub topic: Ship structural materials **Sub-sub topics & SLOs** 3.1 Describe the desirable properties for material used in ship building as follows: 3.1.1 List Steel, Aluminium and FRP as the main materials used in ship building 3.1.2 Describe advantages / disadvantages of mild steel as material for ship construction 3.1.3 Describe advantages / disadvantages of aluminium as material for ship construction 3.1.4 Describe advantages / disadvantages of FRP as material for ship construction 3.1.5 State that the ship building steel is required to be standardised 3.1.6 Describe the alloying materials of the ship building steel and their importance 3.1.7 Describe the IACS grades of steel for ship construction and their use 3.1.8 Define the term 'scantlings' 3.1.9 Describe the various sections used and their general purpose. Flat Plate, Offset bulb plate, Equal angle, Unequal angle, Channel, Tee, Round, Half Round 3.1.10 Describe the use of Steel Castings and Forgings in ship building	2
D Loads and stresses acting on the ship	
General Learning Objective: Understand the stresses due to various loads acting on the ship structure and state the structural components resisting them	

D1 Loads and stresses acting on the ship structure and the resisting structural components **Specific Learning Objectives:** 4.1 Describe the loading conditions and stresses caused on ship's structure and the structural components resisting the loads 4.1.1 Distinguish between global and local loads and List them 4.1.2 Describe Longitudinal bending and shear in still water and in seaway • Describe in qualitative terms shear force and bending moments • Explain what is meant by 'hogging' and by 'sagging' and Distinguish between them • Describe the loading conditions which give rise to hogging and sagging stresses • Describe how hogging and sagging stresses are caused by the sea state • Explain how hogging and sagging stresses result in tensile or compressive forces in the deck and bottom structure 4.1.3 Describe water pressure loads on the ship's hull 4.1.4 Describe racking stress and its causes 4.1.5 Describe torsional stress and its causes 4.1.6 Describe stresses due docking loads 4.1.7 Explain what is meant by 'panting' and state which part of the ship is affected 4.1.8 Explain what is meant by 'pounding' or 'slamming' and state which part of the ship is affected 4.1.9 Describe stress Concentrations around openings 4.1.10 Describe liquid pressure loading on the tank structures 4.1.11 Describe qualitatively the stresses set up by liquid sloshing in a partly filled tank	2
D2 Ship-board loads and stresses management **Specific Learning Objectives:** 4.2.1 State that each ship above a specified length is required to carry a loading manual, in which are set out acceptable loading patterns to keep shear forces and bending moments within acceptable limits 4.2.2 State that the classification society may also require a ship to carry an approved means of calculating shear forces and bending moment at stipulated stations 4.2.3 Demonstrate the basic knowledge and use of a stress table 4.2.4 Demonstrate the basic knowledge and use of a stress calculating equipment (loadicator) 4.2.5 State the information available from loadicator 4.2.6 State that the loading manual and instrument, where provided, should be used to ensure that shear forces and bending moments do not exceed the permissible limits in still water during cargo and ballast handling 4.2.7 Describe the likelihood of overstressing the hull structure when loading certain bulk cargoes	1
Loads and stresses acting on the ship **Additional Objectives for Assessments (Guidance for understanding Naval Architecture):** 1. Demonstrate understanding and application of concepts related to force acting on the bulkhead and its centre of pressure 2. Define and explain concepts related to force acting on the bulkhead and its centre of pressure for regular and irregular shapes 3. Explain concept of longitudinal strength 4. Longitudinal strength: Curves of buoyancy and weight, Curves of load, shearing force and bending moment, Alternative methods. Standard conditions, still water and wave bending movements and shear forces, Approximation for maximum shearing force and bending moment, Moment of Inertia of section, Section modulus calculation. Stresses in deck and keel 5. Explain different methods used for the calculation of bending moments acting on rectangular barges, for both in still water and on waves 6. Define and explain Sagging and Hogging condition of ship 7. Determine values of loads, shear force and bending moment acting at various longitudinal locations of box barge and draw SFD and BMD for the same 8. Define, explain and utilize concept of section modulus of ship's midship section and calculate stress in deck and keel plate based on the maximum bending moment acting on it	

E Stiffening of plates – Framing systems	
General Learning Objective: Understand the requirement for stiffening of the hull plating and illustrates how it is accomplished by use of frames in transverse and longitudinal direction	
E1 Framing systems **Specific Learning Objectives:** 5.1 Stiffening of plates – Framing Systems 5.1.1 Demonstrate understanding of the function of primary and secondary stiffeners 5.1.2 Describe with aid of Sketch the longitudinal, transverse and combination framing systems 5.1.3 Illustrates Systems of framing on transverse sections of the ship 5.2.4 List advantages / disadvantages of each system	1
F Bottom and side structures	
General Learning objective: Understand construction of bottom structure, side structure and the brackets connecting them	
F1 Sub Topic: Bottom structure **Specific Learning Objectives:** 6.1.1 List the advantages of double bottom over single bottom ships 6.1.2 Describe double bottom structure for longitudinal and transverse framing and illustrates with the aid of neat Sketch on the transverse section.: Water tight floors, solid and bracket floors, CVK, Intercostal Side girders, bottom longitudinal 6.1.3 Describe types of keels used in single and double bottom arrangements with the help of neat Sketch 6.1.4 Describe duct keel structure, its purpose and safety features with the aid of Sketch	1
F2 Sub Topic: Bottom structure **Specific Learning Objectives:** 6.2.1 Describe the types of side framing with the help of neat sketch 6.2.2 Describe tank-side brackets and its function with the help of a sketch in the following cases • Flat margin plate • Sloped margin plate for general cargo and reefer ships 6.2.3 Describe beam knee and its function with the help of a sketch in the following cases • Radiused sheer strake • Plain sheer strake	1
G Shell and Deck structure	

G. General Learning Objective: Understand constructional features such as: Deck plating & deck girders. Discontinuities, such as hatches and other openings. Supporting & closing arrangements, Plating systems for shell plating including keel, bilge strake, sheer strake, Bulwark, bilge keel **G1. Sub Topic: Hatches and closing** **Sub-Sub Topic & SLOs** 7.1.1 Describe the stress concentration in the deck round hatch openings 7.1.2 Explain compensation for loss of strength at hatch openings 7.1.3 Sketch a transverse section through a hatch coaming, showing the arrangement of coamings and deep webs 7.1.4 Sketch a hatch corner in plan view, showing the structural arrangements 7.1.5 Describe arrangement of modern weather-deck mechanical steel hatches with the aid of Sketch 7.1.6 Describe how water tightness is achieved at the coamings and cross joints 7.1.7 Describe the cleating arrangements for the hatch covers 7.1.8 Describe the arrangement of portable beams, wooden hatch covers and tarpaulins 7.1.9 Sketch an oil tight hatch cover	1
G2. Sub Topic: Deck Structure **Sub-Sub Topic & SLOs** 7.2.1 Describe the longitudinal and transverse deck framing systems with emphasis on Deck-side girders, Hatch end beams and half beams and tripping brackets 7.2.2 Describe the contribution of deck plating to deck strength and how the plating thickness varies	1
G3. Sub Topic: Deck Structure **Sub-Sub Topic & SLOs** 7.3.1 Demonstrate understanding of shell expansion plan and illustrate the following: • Seams and butts • Keel strake, Garboard strake, bilge strake sheer strake, stringer plate • Variation in plate thickness and use of different grades of steel • Stealer plates 7.3.2 Describe the arrangement of bilge keel 7.3.3 Describe the arrangement of bulwark and guard rail stanchions	1
H Midship section	
General Learning Objective: Understand the construction of midship sections of General Cargo, Tanker, bulk carrier and container ships with the help of neat labelled Sketch **H 1 Sub Topic: Midship section of important cargo ships** **Sub-Sub Topics & SLOs** 8.1.1 Draw neat Sketch of typical midships sections of following ships showing both primary and secondary frames and labels parts • General Cargo • Double hull Tanker • Bulk carrier • Container carrier	1
I Bulkheads & Deep Tanks	
General Learning Objective: Understand Principle Dimensions of the ship & various terms related to ship construction so that different dimension will be used for the various calculation.	

I 1 Sub Topic: Types of Bulkheads **Sub-Sub Topics & SLOS:** 9.1.1 Classifies bulkheads as • watertight and non-watertight • transverse and longitudinal bulkheads • Plain stiffened and corrugated 9.1.2 State the functions of watertight bulkheads and their positioning 9.1.3 Describe the structure of a plain stiffened watertight bulkhead with the help of Sketch 9.1.4 Describe the structure of a corrugated bulkhead with the help of Sketch 9.1.5 Describe the requirements of fore peak bulkhead	1
I 2 Sub Topic: Openings in watertight bulkheads **Sub-Sub Topics & SLOS:** 9.2.1 Describe the requirements of a sliding watertight door with regard to construction and operation 9.2.2 Describe the requirements of a hinged watertight door with regard to construction and operation 9.2.3 State that openings may be required in watertight bulkheads for cables and pipes 9.2.4 Describe with the help of neat Sketch, how these openings are made watertight	0.5
I 3 Sub Topic: Deep tanks **Sub-Sub Topics & SLOS:** 9.3.1 Describe with the help of Sketch the structure and access opening for Deep tanks for water ballast or dry cargo 9.3.2 Describe with the help of Sketch the structure and access opening for Deep tanks for oil fuel, oil cargo or fresh water	0.5
J Fore-end Arrangements	
General Learning Objective: Understand Stem construction and arrangements to resist panting. Forepeak – Collision bulk head, Bulbous bows; Anchor and cable arrangements, Chain locker	
J1 Sub Topic: Fore-end Arrangements **Sub-Sub Topics & SLOS:** 10.1.1 Describe stem construction with neat Sketch 10.1.2 Describe breast hook and soft nose 10.1.3 Draw a neat sketch of centreline profile through fore end showing structural arrangements including collision or fore peak bulkhead, chain locker, anchor chain arrangement 10.1.4 Describe structural arrangement for panting and pounding with relevant Sketch 10.1.5 State the purpose of bulbous bow and describe its structure 10.1.6 List the parts of the anchor and chain cable arrangement briefly stating their purpose 10.1.7 Describe the features of chain cable locker and the bitter end arrangement	3
K Aft-end Arrangements	
General Learning Objective: Describe with the help of neat Sketch Types of sterns, Stern frame and rudder. Types of rudders. Rudder support. Rudder carrier bearing, shaft tunnel, shaft bearings. Aft peak tank.	
K1 Sub Topic: Aft-end Arrangements **Sub-Sub Topics & SLOS:** 11.1.1 Describe cruiser and transom stern arrangements and state their advantages / disadvantages 11.1.2 Describe the functions of the stern frame and its connection with the main hull structure 11.1.3 Classify rudders into balanced, semi-balanced and unbalanced rudders based on the position of stock 11.1.4 Describe following rudder and stern frame combinations in use showing how the rudder is supported and state the importance of jumping clearance • Fabricated stern frame with unbalanced rudder • Cast steel stern frame with balanced rudder	3

• Open water stern with spade rudder with horn 11.1.5 Describe rudder carrier bearing with a sketch showing the bearing and watertight gland 11.1.6 Describe shaft tunnel arrangement with a neat sketch	
L Load Line and Tonnage	
General Learning Objective: Understand definition of freeboard, conditions for assignment, Load line Surveys. Details of markings permanently carved. Definition of GT and NT as per Tonnage regulations.	
L1 Sub Topic: Load Line and Tonnage **Sub-Sub Topics & SLOS:** 12.1.1 Define deck line and freeboard 12.1.2 State the conditions of assignment of freeboard 12.1.3 Sketch with details of the permanent load line markings 12.1.4 Demonstrate understanding of the importance of periodical load line surveys 12.1.5 Define GT and NT with relevant definitions from tonnage regulations the bitter end arrangement	2
M Ship Surveys	
General Learning Objective: Understand Load line and general Surveys.	
M1 Sub Topic: Ship Surveys **Sub-Sub Topics & SLOS:** 13.1.1 Describe the functions of classification societies 13.1.2 Describe the role of a class surveyor in ship construction process 13.1.3 Describe the periodical surveys carried out by the classification society arrangement 13.1.4 Harmonised systems of survey	2
N Propeller shafting installations	
General Learning Objective: Understand shafting construction and their design features and associated ancillaries	
N1 Sub Topic: Shafting installation - description **Sub-Sub Topics & SLOS:** 14.1.1 Describe the following installations/equipment constructing shafting: • Rope guard • Stern tube • Stern tube bearing • Shaft seal • Propeller shaft • Intermediate shaft • Aft bearing • Plumber block • Thrust bearing 14.1.2 Describe the details of oil shaft seal and stern tube bearing including their components 14.1.2 Describe the details of thrust bearing	1
N2 Sub Topic: Shaft and ancillaries - design features **Sub-Sub Topics & SLOS:** Describe the design features and operative mechanism of propeller shaft and associated ancillaries: 14.2.1 Shaft alignment • establishing the shaft Centre line • deviation while building • alignment deviation in service • fair curve alignment • shaft checks 14.2.2 Shaft bearings • plain bearings • tilting pad bearings	2

• roller bearings 14.2.3 Coupling bolts 14.2.4 Stern tubes 14.2.5 Stern tube sealing arrangements 14.2.6 Methods of mounting fixed pitch propellers • keyed propellers • keyless propellers	

Subject Name/Code: Marine Design: Pressure Vessels, Machinery Components and Vibrations /507

Instructional hours:

Lecture	: 30 hours
Tutorial	: 15 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Machine Design -Pandya & Shah.
2. Mechanical Vibrations, G.K. Grover.
3. Mechanical Vibration, V P Singh.

Reference:

1. Classification Society Publications.
2. Design of Machine Elements – V.B. Bhandari, TMH.

Table of Topics

Section	Topics	Hours (L:T)
A	Procedure in Mechanical Design	2:1
B	Design considerations	4:2
C	Design of Marine Machine Components	12:6
D	Design of Pressure Vessels	4:2
E	Marine Machinery Vibrations	8:4
	Total	**30:15**

Learning Objectives	(L:T)
A. Procedure in Mechanical Design	
1.0 General Learning Objective Understand the procedure for design of mechanical systems	
Sub-sub topics & SLOs 1.1 Concepts of design, procedure & processes 1.2 Design synthesis and Feasibility 1.3 Preliminary Design Alternative and Final Design alternative, Preliminary & Final Plans Drawings 1.4 Use of Standards in design 1.5 Selection of preferred sizes	2:1
Additional Objectives (Marine Design): Explain the following: The design spiral in ship design; Evaluation of main and auxiliary machinery, space, weight, rating and legal compliance; Requirements of performance under ship motions; Other requirements such as energy efficiency, materials, automation, maintenance etc.; Utility factor and Load factors Concepts of design, procedure & processes; Design synthesis and Feasibility; Preliminary Design Alternative and Final Design alternative; Preliminary & Final Plans Drawings Use of Standards in design; Selection of preferred sizes	
B. Design considerations	
2.0 General Learning Objective Understand the considerations for design of mechanical systems	
Sub-sub topics & SLOs 2.1. **Strength Considerations** 2.1.1 Strength of materials, Strength under combined stresses, Static loads, Impact loads, repeated loads, completely reversed loads, Static plus Alternating loads, Cyclic & combined loads, Fatigue strength 2.1.2 Explain Reliability 2.1.4 Explain Stress concentration, Dynamic Stresses 2.1.5 Explain Selection of materials 2.1.6 Explain Specifications: - Fit, tolerance, finish 2.2 Other considerations: - 2.2.1 Explain Manufacturing methods- casting, forging, fabrication and Plastic mouldings 2.2.2 Explain Initial and servicing cost 2.2.3 Explain Ergonomics and aesthetic appeal	4:2
C. Marine Machinery Component Design	
3.0 General Learning Objective: Understand design of some key components of marine systems	
Sub-sub topics & SLOs Explain the following: 3.1 **Design of Shafts, Keys, Couplings**	12:6

3.1.1. Design of shafts subjected to twisting moment, bending moment, axial load and combined twisting and bending moments incorporating ASME Code 3.1.2 Design of keys 3.1.3 Design of flexible and flange couplings **3.2 Design of Rolling Contact Bearings** 3.2.1 Designation, Types and design of rolling contact bearings 3.2.2 Determination of static and dynamic load capacity, dynamic load rating 3.2.3 Selection of ball and roller bearings from manufacturer's catalogue **3.3 Design of Belt, Rope, Chain drives** 3.3.1 Types and Selection of belts 3.3.2 Designation and selection of ropes 3.3.3 Selection of chains based on power transmission requirements **3.4 Design of Welded, Rivetted, Knuckle Joints** 3.4.1 Design of welded joints for different types of loadings based on strength requirements; Stress analysis 3.4.2 Design of rivetted joints for different types of loadings based on strength requirements; Stress analysis 3.4.3 Design of knuckle joints for different types of loadings based on strength requirements; Stress analysis	
Additional Objectives (Marine Machinery): Explain the following: Auxiliary machinery specifications for Compressors; pumps; heat exchangers; fans; blowers; purifiers; electrical motors; generator; scrubbers; Inert gas generators; sewage treatment plant; fresh water generation; hydraulic power packs; OEM guidance for care, maintenance, inspection and repair; Design considerations of the equipment – rating, performance, ambient corrections and test reports; Reliability and availability of equipment; Classification rules covering the equipment	
D Design of Pressure Vessels	
4.0 General Learning Objective: Understand and appreciate design of Pressure Vessels taking care of latest developments and IMO requirements.	
Specific Learning Objectives: Explain the following: 4.1.1 Determination of Stresses in Thin cylindrical and spherical shells subjected to internal pressure 4.1.2 Determination of Stresses in Thick cylindrical and spherical shells subjected to internal pressure 4.1.3 Design considerations of pressure vessels subjected to internal pressure	4:2
Additional Objectives (Design Considerations): Explain the following: Various pressure class equipment used in ships – Air bottles, boilers, tanks, void spaces, pipelines, fuel systems, gas bottles, hydraulic and pneumatic components; International design codes – ASME, API, NFPA, CGI, AGA, ISO and Classification role in the safety of pressure vessels. Responsibility of shipboard staff in maintaining and operating the equipment. Certificate of approvals; Applicable standards for installing CNG and Type C LNG tanks, LPG, Ammonia storage and other chemicals; Requirements for Venting, Inerting and relief; Use of double walled pipelines for hydraulic oil; Failure of pressure vessels – cracks, explosion, implosion, BLEVE Standard procedures for pressure tests and NDT inspections; Hazop, Hazan and Hazid with pressure vessels and systems; On-board record keeping, surveys and certification	
E. Marine Machinery Vibrations	
5.0 General Learning Objective- Study and Analysis of Marine Machinery Vibrations	
Specific Learning Objectives: Explain the following: **5.1 Longitudinal vibrations:** 5.1.1. Introduction 5.1.2Determination of natural frequency and mode shapes for SDOF and MDOF systems 5.1.3Vibration reducer, excitation orders (Harmonic Components) 5.1.4Vibratory thrust calculations 5.1.5Acceptable limits for longitudinal vibrations **5.2 Torsional Vibrations:** 5.2.1 Modes of torsional vibrations	8:4

5.2.2 Models for torsional vibration analysis- Geared turbine, diesel drives; 5.2.3 Determination of natural frequencies and mode shapes, nodes, antinodes – Geared turbine drive, Diesel Drive 5.2.4 Excitation orders, Damping; Vibratory torque calculations- Geared turbine drive, Diesel drive 5.2.5 Acceptable limits by classification societies. **5.3 Transverse Vibrations:** 5.3.1 Introduction **5.**3.2 Determination of natural frequencies of transverse vibrations of multi rotor systems **5.4 Whirling Vibrations:** 5.4.1Introduction 5.4.2Determination of whirling natural frequency 5.4.3 Acceptable limits for whirling vibration	
Additional Objectives (Vibrations): Explain the following: Undamped Free vibrations for Single degree of freedom systems; Damped Free vibrations for Single degree of freedom systems; Harmonically forced vibrations for Single degree of freedom systems; General forcing condition and response; Two degree of freedom systems; Multi-degree of freedom systems; Vibration of continuous systems; Machinery foundation vibrations and basics of hull vibration; Undamped Free vibrations for Single degree of freedom systems; Undamped Free vibrations for Single degree of freedom systems; Undamped Free vibrations for Single degree of freedom systems; Whirling of the shafts; Vibration monitoring on ships, resilient mountings, bracing, vibration damper, barred speed and conditions; Balancing of rotors – turbomachinery, impellers, fans shafts	

Subject Name/Code: Marine Electrical Motors: Starters and Drive Controls /508

Instructional Hours :	
Lecture	: 15 hours
Tutorial	: 15 hours
Total contact hours	: 30 hours
Credits	: 2

Teaching Methods

The course shall be conducted with classroom lectures and tutorials.

Assessment Methods **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Marine Electrical Technology 11th Edition; By Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN: 9789352139514.
2. Maritime Electrical Installations and Diesel Electric Propulsion by Alf Kåre Ådnanes, ABB AS.

Reference:

1. Handbook to IEEE Standard 45TM A Guide to Electrical Installations on Shipboard by Mohammed M. Islam. IEEE – Published by the standards information Network, IEEE.
2. The Motor Guide- basic technical information about low voltage standard motors – ABB, ISBN 952-91-0728-5 Second edition 2005.
3. Motor Handbook – ISEA power electronics and electrical drives – Institute for Power Electronics and Electrical Drives, RWTH Aachen University, version 2.1.

Table of Topics

Section	Topics	Hours (L : T)
A1	**Electrical Motors** **Sub-Topics:** Constructional and Operating Features of Induction Motors On-board Ships	3: 3
B1	**Electrical Motor Starting Methodologies** **Sub-Topics:** Constructional and Operating Features of DC Motors On-board Ships	3 : 3
C1	**Electrical Servo Motors** **Sub-Topics:** Starters and Speed Controllers for AC and DC Motors	1 : 1
D1	**Operational Control Equipment for Electrical Motors** **Sub-Topics:** Salient Feature of DC and AC Servo Motors	5 : 5
E1	**Maintenance and Repair of Electrical Motors** **Sub-Topics:** Salient Features of AC and DC Motors and Their Control Systems	2 : 2
F1	**Maintenance and Repair of Starters for Electrical Motors** **Sub-Topics:** Detection of Electric Malfunction and Measures to Prevent Damage, Basic Maintenance and Repair Guidelines	1 : 1
	Total	**15 : 15**

Learning Objectives	L : T
A Electrical Motors **General Learning Objectives** • Understand the fundamentals and features of electrical motors in general • Know the differences in construction and usage of AC and DC motors • Know how to operate the motors **Topic: AC Electrical Motors** **Sub-Topics:** 1.1 Constructional and Operating Features of Induction Motors On-board Ships	
Specific Learning Objectives: (IMO 7.04,2014: 2.1.1.5) **1.1 Constructional and Operating Features of Induction Motors On-board Ships** 1.1.1 State normal supply for 3-Phase induction motors 1.1.2 Name the types of motors commonly used on-board ships giving their applications 1.1.3 Give the actual components from a three-phase induction motor identifies - rotor - bearings - fan - stator - field windings - rotor cage - method of lubrication - terminals 1.1.4 Explain the differences between the following motor enclosure, describing how cooling is achieved in each case: - drip-proof - totally enclosed - deck watertight - flameproof	1 : 1
1.1.5 Sketch a graph showing the relationship between speed and load and between current and load, from no load to full load 1.1.6 Give a motor name plate, Explain the meaning of all of the information displayed 1.1.7 Explain in simple terms how the driving torque is produced in an induction motor 1.1.8 Explain why slip is essential	1 : 1
DC Electrical Motors **General Learning Objectives** • Understand the fundamentals and features of electrical motors in general • Know the differences in construction and usage of AC and DC motors • Know how to operate the motors **Topic: DC Electrical Motors** **Sub-Topics:** 1.1 Constructional and Operating Features of DC Motors On-board Ships	

Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 – 1.5) **1.1 Constructional and Operating Features of DC Motors On-board Ships** Explain what is meant by back emf of a motor 1.1.2 Rate the supply voltage to the back emf and to the voltage drop in the armature 1.1.3 Explain why the starting current is high compared to the load current 1.1.4 Explain why a starter is required and the principle involved 1.1.5 State that the rotational speed (N) is approximately proportional to the applied voltage / field flux or N = k x V/φ 1.1.6 From the above objective Explain how the rotational speed is affected by - i. Varying the voltage ii. Varying the strength of the magnetic field 1.1.7 Describe the typical applications of: - Shunt motors - Series Motors 1.1.8 In compound motors, Explain what is meant by: a. long shunt, b. short shunt c. cumulatively connected	1 : 1
B Electrical Motor Starting Methodologies **General Learning Objectives** • Understand the operation of various starters for electrical motors • Trace Electrical Motor Starter Circuits **Topic: Electrical Motor Starting Methodologies** **Sub-Topics:** 1.1 Starters and Speed Controllers for AC and DC Motors	
Specific Learning Objectives: (IMO 7.04,2014: 2.1.1.6) **1.1 Starters and Speed Controllers for AC and DC Motors** 1.1.1 Explain the following starting methods for DC Motors and its characteristics a. starting rheostat b. automatic starters 1.1.2 Explain the following starting methods for AC Motors and its characteristics a. DOL starting b. star – delta starting c. compensator starting 1.1.3 State what should be taken into consideration when selecting starting methods for AC Motors	1 : 1
1.1.4 Explain the basic reason for the provision of motor protection 1.1.5 Explain the principles of the most common overcurrent relays 1.1.6 Explain the difference between the largest possible overload current and a fault current 1.1.7 Describe the function of the overcurrent trip, time delays and fuses with both overload and fault currents 1.1.8 Explain the basis upon which fuses are chosen 1.1.9 Explain the principles of a thermal relay, including the means of its adjustment 1..1.10 Explain what is meant by single phasing and its effect on a motor - a. when running, b. when starting c. if continued attempts to start are made 1.1.11 Describe in principle the protection against running with a phase open circuited 1.1.12 Explain why under voltage trips are necessary	1 : 1

1.1.13 State applications where the following speeds are suitable: a. single fixed speeds b. two or three fixed speeds c. infinitely variable speeds 1.1.14 Describe briefly how steeped speeds can be provided 1.1.15 List the means of producing variable speeds 1.1.16 Describe the principle of Ward – Leonard drive 1.1.17 Explain the principle of a variable – frequency motor	1 : 1
C Electrical Servo Motors **General Learning Objectives** • Understand the fundamentals and features of electrical servo motors in general • Know the differences in construction and usage of AC and DC servo motors • Know how to operate the servo motors **Topic: Electrical Servo Motors** **Sub-Topics:** 1.1 Salient Feature of DC and AC Servo Motors	
Specific Learning Objectives: (IMO 7.04,2014: 2.1.1 – 3.8 – 1.8.2) **1.1 Salient Feature of DC and AC Servo Motors** 1.1.1 Describe a DC Servo motor and explain how it varies from the common motor 1.1.2 Explain the problems of using a three phase AC Machine as a servo motor 1.1.3 Describe the applications of a two-phase AC Servomotor, explaining how its characteristics can be varied.	1 : 1
D Operational Control Equipment for Electrical Motors **General Learning Objectives** • Understand the construction and principle of operation of Electrical Motor • Understand the features of speed controllers using electronic components **Topic: Operational Control Equipment for Electrical Motors** **Sub-Topics:** 1.1 Salient Features of AC and DC Motors and Their Control Systems	
Specific Learning Objectives: (IMO 7.02,2014: 2.1.3 – 3.1) **1.1 Salient Features of AC and DC Motors and Their Control Systems** 1.1.1 Explain the following: - construction, principle of operation of 3-phase induction motors - design features of star and delta motors - starting, speed controlling and braking methods of 3-phase induction motors - load-torque characteristics and protection	1 : 1
1.1.2 Three phase synchronous motors - construction - principle of operation - load characteristics - power factor improvement with synchronous motors	1 : 1
1.1.3 Effect of varying frequency and voltage of A.C. motors - speed - temperature - torque - power output - starting time, current	1 : 1
1.1.4 Motor control and protection - D.C. motors	1 : 1

- A.C. motors	
1.1.5 Insulated Gate Bipolar Transistor (IGBT) motor speed control - gate driving characteristics with high current - high frequency, high current switch - advantages of IGBT in varying motor speed control	1 : 1
1.1.6 Motor speed control by thyristors - application of thyristors in motor speed control	
E Maintenance and Repair of Electrical Motors **General Learning Objectives** • Know the safety precautions to be observed before, during and after maintenance • Know the main steps to carrying out effective maintenance on motors • Understand the various test methodologies **Topic: Maintenance and Repair of Electrical Motors** **Sub-Topics:** 1.1 Detection of Electric Malfunction and Measures To Prevent Damage 1.2 Basic Maintenance and Repair Guidelines	
Specific Learning Objectives: (IMO 7.04,2014: 2.2.3 – 2.2) **1.1 Detection of Electric Malfunction and Measures to Prevent Damage** 1.1.1 Explain the purpose of under voltage protection of generators and of motors	1 : 1
Specific Learning Objectives: (IMO 7.04,2014: 2.2.2 – 2.4) **1.2 Basic Maintenance and Repair Guidelines** 1.2.1 List the principal maintenance equipment for motors 1.2.2 Carry out the maintenance necessary for a cage electric motor, paying particular attention to - - damp, condensation and air flow - dust and oil - external and internal surfaces - frequency of maintenance - deterioration of insulation - cleaning, inspection, renewal and lubrication of bearings 1.2.3 Describe the most common causes of failure of insulations 1.2.4 Check the insulation resistance of a three-phase induction motor	1 : 1
F Maintenance and Repair of Starters for Electrical Motors **General Learning Objectives** • Understand the maintenance procedures and knows the major focus areas for starters • Understand defect rectification in starters **Topic: Maintenance and Repair of Starters for Electrical Motors** **Sub-Topics:** **1.1 Basic Maintenance and Repair Guidelines**	
Specific Learning Objectives: (IMO 7.04,2014: 2.2.2 – 2.5) **1.1 Basic Maintenance and Repair Guidelines** 1.1.1 Carry out the maintenance necessary and completes reports on starters and controllers with specific reference to - - casings corrosion and bonding - contactors, magnet faces, pitting, overheating, spring force, lubrications - connections, cables and leads - correct operation when in use 1.1.2 Detect and Rectify faults in motors, starters and protection equipment	1 : 1

Subject Name/Code: Heat Transfer and Marine Heat Exchangers/509

Instructional hours:

Lecture	: 30 hours
Tutorial	: 15 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisites: 10, + 1 and +2 scheme (MPC Group) ;topics covered in previous Semesters..

Recommended Text:

1. Lienhard, J. H. (2011). A Heat Transfer Textbook. United State: Dover Publications. (Free resources).
2. DeWitt, D. P., Lavine, A. S., Bergman, T. L., Incropera, F. P. (2011). Fundamentals of Heat and Mass Transfer; United Kingdom: Wiley.
3. Arpaci, V. S., Selamet, A., Kao, S. (1999). Introduction to Heat Transfer. United Kingdom: Prentice Hall.

Reference:

1. Standards of the Tubular Exchanger Manufacturers Association. (1999). United State: Tubular Exchanger Manufacturers Association.
2. Liu, H., Pramuanjaroenkij, A., Kakaç, S. (2020). Heat Exchangers: Selection, Rating, and Thermal Design, Fourth Edition. United State: CRC Press.
3. Marine Engineering – by group of authorities, Editor: Roy L Harrington, ISBN: 0-939773-10-4, SNAME (USA).
4. Hunt, E. C. (1999). Modern Marine Engineer's Manual. United State: Cornell Maritime Press.
5. Lienhard, J. H. (2011). A Heat Transfer Textbook. United State: Dover Publications. https://ahtt.mit.edu/.
6. Heat Transfer - https://nptel.ac.in/courses/103/105/103105140/.

Table of Topics

Section	Topics	Hours (L:T)
A	Introduction to heat transfer	1:1
B	Conductive heat transfer – basic equations	1:2
C	One dimensional steady state heat conduction	5:2
D	Convection heat transfer	3:2
E	Free convection	4:2
F	Heat Exchangers – Introduction / Nomenclature	1:2
G	Heat Exchangers – Fabrication and construction details	6:0
H	Heat Exchangers - Thermal relations:	6:2
I	Radiation: Processes and Properties	3:2
	Total	**30:15**

Learning Objectives	**(L:T)**
A. Introduction to heat transfer	
General Learning Objective: Understand the basic concept of heat transfer **Sub topics:** 1. Conduction 2. Convection 3. Radiation 4. Combined Transfer Mechanism 5. Units 6. Dimensions	
Specific Learning Objectives: 1.1 Explain the mechanism of heat transfer	0.5:0
Specific Learning Objectives: 1.2 Explain the different modes of heat transfer	0.5:1
B. Conductive heat transfer – basic equations	
General Learning Objective: Understanding basic heat conduction equations. **Sub topics:** 1. Basic Equations – One dimensional heat conduction equation 2. Three-dimensional heat conduction equation 3. Boundary conditions 4. Summary of basic equations 5. Demonstration of how to determine the Thermal Conductivity of metal rod	
Specific Learning Objectives: 1.1 Derive heat conduction equation in Cartesian coordinates and 1-D system	0.5:0

Specific Learning Objectives: 1.2 Explain concept and determine the thermal conductivity of different materials	0.5:2
C. One dimensional steady state heat conduction	
General Learning Objective: Understand the basic concepts of One-dimensional steady state heat conduction and its applications. **Sub topics:** Explain the following: 1. The slab 2. The cylinder 3. The sphere 4. Composite medium 5. Thermal contact resistance 6. Critical thickness of insulation 7. Finned surfaces 8. Temperature dependent k(T) 9. Demonstration of how to determine the Thermal Conductivity of Insulating materials	
Specific Learning Objectives: 1.1 Understand basic concept of heat conduction	1:0
Specific Learning Objectives: 1.2 Understand One-D steady state conduction through different surfaces 1.2.1 Define through slab 1.2.2 Define through cylinder 1.2.3 Define through sphere	2:2
Specific Learning Objectives: 1.3 Understand concept of critical thickness of insulation	2:0
D Convection heat transfer	
General Learning Objective: Understand basic concepts of Convective heat transfer and its applications. **Sub topics:** Explain the following: 1. Concepts and basic relations 2. Flow over a body 3. Flow inside a duct 4. Concepts on turbulence 5. Equations of motion 6. Equation of energy 7. Dimensionless parameters 8. Boundary-layer equations. **9.** Demonstration of how to determine convective heat transfer coefficient through Forced Convection	
Specific Learning Objectives: 1.1 Explain basic relations in convective heat transfer	0.5:0
Specific Learning Objectives: 1.2 Explain convective heat transfer over a body and through a duct	1:2
Specific Learning Objectives: 1.3 Explain the different equations in convective heat transfer	0.5:0
Specific Learning Objectives: 1.4 Explain the concept of boundary layer	1:0

E. Free convection	
General Learning Objective: Understand the basic concepts of free convection and its applications. **Sub Topic:** Explain the following: 1. Dimensionless parameters of free convection 2. An approximate analysis of laminar free convection on a vertical plate 3. Correlations of free convection on a vertical plate 4. Free convection on a horizontal plate 5. Free convection on a horizontal plate 6. Free convection on an inclined plate 7. Free convection on a long cylinder 8. Free convection on a sphere 9. Simplified equations for air 10. Mechanism of free convection in enclosed spaces 11. Correlations of free convection in enclosed spaces 12. Combined free and forced convection 13. Correlations 14. Demonstration of how to determine Heat Transfer through Natural Convection	
Specific Learning Objectives: 1.1 Explain the basic concepts of free convection	1:0
Specific Learning Objectives: 1.2 Explain dimensionless numbers	1:0
Specific Learning Objectives: 1.3 Explain analysis of free convection over flat plate and pipe/through pipe	1:2
Specific Learning Objectives: 1.4 Explain the combined effect of free and forced convection	1:0
F. Heat Exchangers – Introduction / Nomenclature	
General Learning objective: Understand the basic concept of a heat exchanger **Sub Topic:** 1. Size Numbering and Type Designation-Recommended Practice 2. Nomenclature of Heat Exchanger Components 3. Study of parallel and counter flow heat exchangers	
Specific Learning Objectives: 1.1. Describe types of heat exchangers	0.25:2
Specific Learning Objectives: 1.2. Describe application of H.E. in marine application	0.5:0
Specific Learning Objectives: 1.3. Understand cooler evaporators and heaters	0.25:0
G. Heat Exchangers – Fabrication and construction details	
General Learning objective: Understand the basic concept of fabrication and constructional details of **heat exchanger** **Sub Topic:** Explain the following: 1. Shop operation 2. Inspection nameplates drawings and guarantees 3. General construction features of TEMA standard heat exchangers 4. Standard TEMA class – scope 5. Tubes shells and shell covers baffles and support plates 6. Floating end construction 7. Gaskets	

8. Tube sheet 9. Flexible shell elements 10. Channels 11. Covers and bonnets 12. Nozzles 13. End flanges and bolting 14. Size Numbering and Type Designation-Recommended Practice 15. Nomenclature of Heat Exchanger Components	
Specific Learning Objectives: 1.1. Describe constructional details of heat exchangers	3:0
Specific Learning Objectives: 1.2. Explain TEMA (Tubular exchanger manufactures association) construction standards for heat exchanger and also the class -scope of TEMA	3:0
H. Heat Exchangers - Thermal relations:	
General Learning Objective: Understand the basic thermal relations and laws of a heat exchanger **Sub Topic:** Explain the following: 1. Basic relations 2. Temperature distribution in heat exchangers 3. Overall heat transfer coefficients 4. Fouling 5. Fluid temperature relations 6. Mean metal temperatures of shell and tubes 7. The LMTD method for heat exchanger analysis 8. Corrections for LMTD for use with cross flow and multi-pass exchangers 9. e-NTU method for heat exchanger analysis 10. Compact heat exchangers and optimization 11. Study of different components and performance of the shell and tube heat exchangers	
Specific Learning Objectives: 1.1 Explain the basic relations for H.E design, sizing etc.	1:2
Specific Learning Objectives: 1.2 Explain temperature distribution in parallel and counter flow H.E	1:0
Specific Learning Objectives: 1.3 Explain the concept of overall heat transfer coefficient for H.E	1:0
Specific Learning Objectives: 1.4 Explain H.E. analysis methods (LMTD and E-NTU)	2:0
Specific Learning Objectives: 1.5 Explain selection criteria and optimisation of H.E	1:0
I. Radiation: Processes and Properties	
General Learning Objective: Understand the basic processes and properties of radiation. **Sub Topics:** Explain the following: 1. Fundamental concepts 2. Radiation heat fluxes 3. Mathematical definitions 4. Radiation Intensity and Its Relation to Emission 5. Relation to Irradiation 6. Relation to Radiosity for an Opaque Surface 7. Relation to the Net Radiative Flux for an Opaque Surface 8. Blackbody Radiation 9. The Planck Distribution 10. Wien's Displacement Law 11. The Stefan–Boltzmann Law 12. Band Emission 13. Emission from Real Surfaces	

14. Absorption Reflection and Transmission by Real Surfaces – Absorptivity Reflectivity Transmissivity 15. Kirchhoff's Law 16. Demonstration of how to determine the emissivity of the black body	
Specific Learning Objectives: 1.1 Explain the basic concepts of radiation	0.5:0
Specific Learning Objectives: 1.2. Explain surface emission properties	1:0
Specific Learning Objectives: 1.3 Explain different laws related to radiation	0.5:0
Specific Learning Objectives: 1.4 Explain the concept of black body radiation	1:2

Subject Name/ Code: Marine Steam Plant (P)/510

Instructional hours:

Practical	: 15 hours
Total contact hours	: 15 hours
Credits	: 0.5

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. Practical Handouts.
2. Marine Engineering – by group of authorities, Editor: Roy L Harrington, ISBN: 0-939773-10-4, SNAME (USA).

Reference:

1. John B Woodward (1980) Analysis of steam propulsion plants - https://deepblue.lib.umich.edu/handle/2027.42/91754.
2. https://www.spiraxsarco.com/learn-about-steam.
3. Steam: Its Generation and Use. (2005). United States: Babcock & Wilcox.
4. Hunt, E. C. (1999). Modern Marine Engineer's Manual. United State: Cornell Maritime Press.
5. SNAME (1996) T&R Bulletin 3-11: Marine Steam power plant heat balance practices, United State.
6. John B Woodward (1980) Analysis of steam propulsion plants, The Dept. of NAME University of Michigan – Report No.108.
7. Resources from Spirax Sarco on the relevant concepts - https://www.spiraxsarco.com/learn-about-steam.

Practical Laboratory Exercises

List of Experiments

Section	Study of Steam Systems	Hours (P)
1	Tracing pipelines of ships steam plant – Main and Auxiliary	1
2	Tracing pipelines of boiler feed water system	1
3	Tracing pipelines of boiler condensate and drain system	1
4	Tracing pipelines of boiler fuel oil supply and change over	1
5	Industrial standards / pipe line and component specifications	1
6	Types of boiler burners – maintenance routines	1
7	Inspection of combustion spaces	1
8	Isolation of subsystems and safe maintenance practices	1
9	Energy loss in steam systems – maintenance of steam traps, insulation.	1
10	Condenser cleaning, repairs and maintenance	1
11	Condensate line steam traps and filters maintenance	1
12	Boiler automation – measurement and operation	1
13	Boiler automation – safety and shutdown systems	1
14	Operation of boiler plant / WHRS	2
	Total	**15**

Subject Name/ Code: Marine Simulators: Plant and Machinery Systems (P)/511

Instructional hours:

Practical	: 60 hours
Total contact hours	: 60 hours
Credits	: 2

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Internal continual Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
External Practical Exam	: 50%

Recommended Text:

1. Practical Handouts.
2. Ship's equipment Manuals.

Reference:

1. Vendor's Manuals.

Table of Topics

Section	Topics	Hours (P)
A1-3	**Marine steam Plant** **Sub-Topics:** Layout of the steam plant, Marine Turbine operation, Marine steam turbine Emergency operations	10
B1 -2	**Marine IC engine 2** **Sub-Topics:** Layout of Diesel Engine plant, Operation & watch keeping, Maintenance & Troubleshooting	10
C1- 3	**Marine Auxiliary Machinery** **Sub-Topics:** Fresh water generator & hydrophore system, Steering gear system, Fresh water-cooling system, Sea water cooling system, Bilge system, Ballast water system, Fuel oil system, Lubricating the oil system, Compressed air & control air system	15
D1-3	**Marine Deck Machinery** **Sub-Topics:** Windlass & Mooring winches, Hatch cover system, Remote cargo valve operating system, Lifeboat.	5
E1 - 3	**Marine Electrical Motor Starter & control Drive** **Sub topics:** Low tension switchgear and protective devices, DOL starter of 3 phase induction motor, Star- delta starter of 3 phase induction motor, Auto transformer starter of 3 phase induction motor circuit, Soft starter of 3 phase induction motor circuit, Air circuit breaker operation, construction and maintenance, Main air compressor 2 Nos. (Lead/lag) operation auto / manual circuit with all safeties, Main sea water pump 2 Nos. with auto stand-by starting circuit, Engine room crane (Hoist/lower, port/stbd, fwd/aft) circuit with electromagnetic brake operation circuit, Emergency Generator automatic starting & operation circuit	20
	Total	**60**

Learning Objectives	P
A. Marine steam Plant **General Learning Objective** Understand Watch keeping during operation of Marine steam Plant with its safety features & emergency operating conditions.	**10**
Specific Learning Objectives (IMO 7.04- 1.4.1/1.2 1), 2) **A.1: - Layout of the steam plant** 1.1 Describe main components of a ship's steam plant 1.2 Describe Main steam supply system 1.3 Describe Turbine plant drain system 1.4 Describe Turbine plant gland steam system 1.5 Describe Turbine Plant Lubrication system 1.6 Describe Steam Plant Feed water system 1.7 Describe Automation & control system	2.5
A.2: - Marine Turbine operation (simulator) Explain the following: 2.1 Starting Steam Turbine Plant from Cold 2.2 Warming through procedure 2.3Manoeuvring with steam turbine 2.4 Running full speed and Watchkeeping on the steam turbine plant	2.5

A.3: Marine steam turbine Emergency operations (simulator) Describe follow-up action on the following: 3.1 Main propulsion turbine Breakdown 3.2 The H.P. Turbine becomes inoperative 3.3 L.P Turbine not in operation	1
A4: Simulator Steam plant (IMO 7.04,2014: 1.4 1)– p50) 4.1 Describe system preparation and putting in operation 4.2 Describe control of auxiliary boiler furnace, heat recovery boiler 4.3 Describe control condenser control 4.4 Describe control the auxiliary boiler	2
A5: Boiler fuel system (IMO 7.04,2014: 1.4 1)– p50) 5.1 Explain the purpose of boiler fuel system 5.2 Describe the components modelled in the boiler fuel oil system 5.3 Describe system preparation and putting in operation 5.4 Describe corrective action of control failure, filter choke and oil leakage 5.5 Describe switch over to heavy fuel oil to diesel oil	2
B Marine IC engine 2 **General Learning Objective** Understand Watch keeping during operation of a Marine Diesel engine plant with its safety features & emergency operating conditions	**10**
Specific Learning Objectives: (IMO 7.04 - 1.4.1/1.1 6) p34 +1.4.2/2.1 p55+1.4.3/3.1 p57)	
B.1: Layout of Diesel Engine plant Explain the following: 1.1 Lubrication system 1.2 Jacket cooling F.W water system 1.3 Central cooling S.W system 1.4 Fuel Oil system 1.5 Starting & Manoeuvring system	3.5
B.2: Operation & watch keeping Explain the following: 2.1 Preparation of propulsion engine for the voyage 2.2 Manoeuvring with diesel engine plant 2.3 Running Full speed & keeping watch of parameters 2.4 Operational problems with diesel engine plants	2.5
B .3: Maintenance & Troubleshooting Explain the following: 3.1 Measuring engine performance 3.2 Measuring performance of Turbocharger 3.3 Troubleshooting with engine running parameters 3.4 Taking liner calibration. 3.5 Measuring Valve timing 3.6 Taking Tappet clearances 3.7 Measuring various Bearing clearances	4
C: Marine Auxiliary Machinery **General Learning Objective** Understand operation of various Marine Auxiliary systems, machinery and components of the Systems	**15**
Specific Learning Objectives: (IMO 7.04 - 1.4.1/1.6 1)+4)+5)+6) p45+3.2.3/.2+.3+.4+.5+.6+.7)	
C1: Fresh water Generator & Hydrophore system 1.1 Identify the Components of a marine Fresh water evaporator 1.2 Explain the operation with troubleshooting of problems of fresh water generators 1.3 Describe to control the hydrophore system 1.4 Describe the control of sea water hydrophore system (for toilets) 1.5 Describe functions of vacuum toilet system (FW or SW usage)	2.5
C 2: Steering Gear System	2.5

2.1 Identify the components of a ships steering gear system 2.2 Explain the operations and checks carried out on the steering gear system 2.3 Explain the operation of the emergency steering gear system	
C3: Marine Auxiliaries systems 3.1 Identify the components of the shipboard system 3.2 Identify the system and controls for level, temperature & pressure of the system 3.3 Identify the components of various type's heaters & coolers used in the system. Along with the cleaning procedures 3.4 Identify the use of various filters, strainers, valves & pumps used in the system 3.5 Identify the operation of compressor along with its safeties 3.6 Identify the operation of centrifugal purifier	4
C4: Bilge & Ballast water system (IMO 7.04,2014: 1.5.2(2.2)-p63) 4.1 Explain the purpose of the bilge& Ballast water system 4.2 Explain how to maintain system readiness for bilge transfer operations 4.3 Explain system preparation and put in operation 4.4 Explain control of bilge pump, separator control and drain control	2
C5: Fire main and foam system (IMO 7.04,2014: 1.5.2(2.2)-p63) 5.1 Explain the purpose of the fire main and foam system 5.2 Describe the components modelled in the fire main and foam system 5.3 Describe system preparation and putting in operation	2
C6: Provision cooling system (IMO 7.04,2014: 1.4.1 (1.6) -2f – p48) 6.1 Describe the system configuration of the provision cooling system 6.2 Explain the purpose, alarms and safety system of the Provision cooling system 6.3 Perform the starting of the planting the manual and defrosting it 6.4 Describe replenishment of liquid refrigerant	2
D: Marine Deck Machinery **General Learning Objective** Understand & identify the components of ships windlass, Mooring winch, Hatch cover operating system, Remotely operated cargo valve system	**5**
Specific Learning Objectives:	
D1: Windlass & Mooring winches 1.1 Identify the various parts of a ship windlass & Mooring winch 1.2 Describe the operation of the windlass & Mooring winch	1
D2: Hatch cover system 2.1 Identify the various parts of a ship Hatch cover system 2.2 Describe the operation of opening, Closing & locking the cargo hatch	1
D3: Remotely operated cargo valve system. 3.1 Identify the various parts of a remotely operated cargo valve system 3.2 Describe the operation of opening, Closing & controlling flow through the valves	1
D4: Lifeboat (IMO 7.04,2014: 4.4.2 – p197) 4.1 Explain the purpose of lifeboats 4.2 Explain a lifeboat in operation 4.3 Explain lowering and hoisting operations of lifeboats 4.4 Explain control over system operation	2
E: Marine Electrical Motor Starter & control Drive	
General Learning Objective Understand the working of low-tension switchgear, Protective devices and starters, emergency generator and according controls, electrical motor starter and control/switchgear, Emergency Generator automatic starting & operation circuit **E1. Sub-topic: Marine Electrical Motor Starting methodology (IMO 7.04 - 2.1.1.4.1 &2.1. 1.6), (IMO 7.04-2.1.1.6, 2.1.1.5.1 &2.2.2.4), (IMO 7.04- 2.1.1.6 & 2.1.1.5.1,2.2.2.4 and 2.2.2)** **Sub-sub topics & SLO** 1.1 Low tension switchgear and protective devices 1.2 DOL starter of 3 phase induction motor	**20**

1.3 Star- delta starter of 3 phase induction motor 1.4 Auto transformer starter of 3 phase induction motor circuit 1.5 Soft starter of 3 phase induction motor circuit	
1.1 To Study Low tension switchgear and protective devices Explain the following: 1.1.1 Operation of contactors 1.1.2 Operation and setting of timers 1.1.3 Working of OLR 1.1.4 Push buttons	3
1.2 DOL starter of 3 phase induction motor Explain the following: 1.2.1 Working of a DOL starter 1.2.2 Maintenance of DOL starters 1.2.3 Operate the DOL starter 1.2.4 Diagnose and rectify created fault	3
1.3. Star- delta starter of 3 phase induction motor Explain the following: 1.3.1 Working of a star delta starter 1.3.2 Maintenance of star delta starter 1.3.3 Operate the star delta starter 1.3.4 Diagnose and rectify created fault	3
1.4 Auto transformer starter of 3 phase induction motor circuit Explain the following: 1.4.1 Working of Auto transformer starter 1.4.2 Maintenance of auto transformer starter 1.4.3 Operate the auto transformer starter 1.4.4 Diagnose and rectify created fault	3
1.5 Soft starter of 3 phase induction motor circuit Describe the following: 1.5.1 Working of a soft starter 1.5.2 Maintenance of soft starter 1.5.3 Operate the soft starter 1.5.4 Diagnose and rectify created fault	3
E2. Sub-topic: Marine Electrical Motor Starter & control /switch gear **(IMO 7.04- 2.2.1.4.1), (IMO 7.04-2.2.1.5.1 and 2.2.2.4),** **Sub-sub topics & SLO** 2.1 Air circuit breaker operation, construction and maintenance 2.2 Main air compressor 2 Nos. (Lead/lag) operation auto / manual circuit with all safeties. 2.3 Main sea water pump 2 Nos. with auto stand-by starting circuit 2.4 Engine room crane (Hoist/lower, port/stbd, fwd/aft) circuit with electromagnetic brake operation circuit	
2.1 Air circuit breaker operation, construction and maintenance 2.1.1 Explain the working of the Air circuit breaker 2.1.2 Explain maintenance of the Air circuit breaker 2.1.3 Diagnose fault	1
2.2 Main air compressor 2 Nos. (Lead/lag) operation auto / manual circuit with all safeties. 2.2.1 Explain the working of Air compressor circuit 2.2.2 Operate the Air compressor 2.2.3 Diagnose and rectify the created fault	1
2.3 Main sea water pump 2 Nos. with auto stand-by starting circuit 2.3.1 Describe the working of the Main sea water pump 2.3.2 Operate the Main sea water pump 2.3.3 Diagnose and rectify the created fault	1
2.4 Engine room crane (Hoist/lower, port/stbd, fwd/aft) circuit with electromagnetic brake operation circuit. 2.4.1 State the working of the engine room crane circuit	1

2.4.2 Operate the engine room crane 2.4.3 Diagnose and rectify the created fault	
E3. Sub-topic: Generator control (IMO 7.04-2.1.1.3 & 2.2.2.2) **Sub-sub topics & SLO** **3.1 Emergency Generator automatic starting & operation circuit**	
3.1 Emergency Generator automatic starting & operation circuit 3.1.1 Explain the working of the Emergency Generator circuit 3.1.2 Operate the Emergency Generator 3.1.3 Diagnose and rectify the created fault	1

SEMESTER 6

Subject Name/Code: Artificial Intelligence and Machine Learning/601

Instructional hours:

Lecture	: 30 hours
Total contact hours	: 30 hours
Credits	: 2

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisites: Class 12 Physics, Chemistry, Maths.
2. The scope of this subject is limited to a basic introduction to Ai/ML; and learning different AI algorithms and computer programming is out of scope of this subject.
3. An extended learning may be provided by adopting suitable external Course on the Subject (e.g., NPTEL/SWAYAM etc.)

Recommended Text:

1. Artificial Intelligence – A modern approach by Stuart Russell and Peter Norvig (Prentice - Hall).
2. A first course in artificial intelligence by Deepak Khemani (McGraw Hill Education India).

Reference:

1. https://scikit-learn.org/stAble/tutorial/index.html.
2. https://scikit-learn.org/stAble/auto_examples/index.html.
3. Ertel, W. (2018). Introduction to Artificial Intelligence. Germany: Springer International Publishing.
4. Müller, A. C., Guido, S. (2016). Introduction to Machine Learning with Python: A Guide for Data Scientists. United States: O'Reilly Media.

Table of Topics

Section	Topics	Hours (L)
A	Introduction to AI	3
B	Search and Games	4
C	Uncertainty and AI	4
D	Machine Learning	7
E	Neural Networks	4
F	AI Ethics	3
G	AI in Marine Industry	5
	Total	**30**

Learning Objectives	L
General Learning Objective: Demonstrate knowledge and understanding of different elements of artificial intelligence and machine learning.	
A Introduction to AI **General Learning Objective** Understand the history and philosophy of AI, definition of AI and identify AI systems	
Specific Learning Objectives: Explain the following: 1.1. Explain what is AI 1.2. History and Philosophy of AI 1.3. Definition of AI 1.4. Examples of AI 1.5. Identify AI systems 1.5.1. Strong and Weak AI 1.5.2. Narrow and General AI 1.6. Field of AI 1.6.1 Machine learning 1.6.2. Deep Learning 1.6.3. Data Science 1.6.4. Robotics **Note:** Only basic overview of fields with examples is required	3
B. Search and Game Tree **General Learning Objective** Understand different approaches to AI problem solving like search and game tree	

Learning Objectives	L
Specific Learning Objectives: 1.1. Search and Problem Solving 1.1.1. Identify and Search Problems 1.1.2. State space, transitions and cost **Note:** Only basic search approach without any specific search algorithm 1.1.3. Solve simple problems involving game tree (e.g., Chess problem, checkers etc.) (Assignment based on problem solving with search) **Note:** A very simple assignment without using any search algorithm or computer programming. For example, finding an optimal route of a ship visiting different ports with minimum fuel consumption. 1.2. Problem Solving with Game Tree 1.2.1. Game tree 1.2.2. Minimax principle to find optimal move 1.2.3. Assignment based on Game Tree **Note:** A very simple assignment without computer programming	4
C Uncertainty and AI **General Learning Objective** Understand how AI deals with uncertainty using odds and probability and its application to Bayes rule	
Specific Learning Objectives: Explain the following: 1.1. Probability 2.2. Odds 1.3. Converting odds to probability 1.4. Bayes rule 1.4.1. prior odds 1.4.2. likelihood ratio 1.4.3. posterior odds 1.4.4. Simple assignment on Bayes rule to calculate likelihood ratio and posterior odds 1.5. Naive Bayes Classification	4
D. Machine Learning **General Leaning Objective** Understand machine learning techniques like nearest neighbour classifier, linear regression and logistic regression	

Learning Objectives	L
Specific Learning Objectives Explain the following: 1.1. Types of Machine Learning 1.1.1. Supervised learning 1.1.2. Unsupervised learning 1.1.3. Reinforcement learning 1.2. Nearest neighbour Classifier 1.2.1. Simple classification assignment using nearest neighbour classifier 1.3. Linear Regression **Note:** simple overview without statistical theory 1.3.1. Simple assignment on obtaining desired parameters from a given linear regression graph. **Note:** Assignment should be **purely on graph reading** without actually developing linear regression graph 1.4. Logistic Regression **Note**: simple overview without statistical theory 1.4.1. Simple assignment on obtaining desired parameters from a given logistic regression graph. **Note:** Assignment should be **purely on graph reading** without actually developing logistic regression graph	7
E. Neural Networks **General Learning Objective** Understand neural networks and their applications	
Specific Learning Objectives Explain the following: 1.1. Introduction to neural networks 1.1.1. Explain what are neural networks 1.1.2. elements of neural network 1.1.3. processing power of neural network 1.1.3. need for artificial neural network 1.1.4. deep learning 1.2. Development of neural networks 1.2.1. weights and inputs 1.2.2. Activations and outputs 1.2.3. Perceptron 1.2.4. A simple assignment based on a neural network classifier 1.3. Advanced Neural network Simple theoretical introduction to 1.3.1. Convolutional Neural Network (CNN) 1.3.2. Generative Adversarial Network (GAN)	4
F. AI Ethics **General Learning Objective** Understand the impact of artificial intelligence on our society	

Learning Objectives	L
Specific Learning Objectives Explain the following: 1.1. Future of AI – hype v/s reality 1.2. Societal implications of AI 1.2.1. Algorithmic bias 1.2.2. Filter bubbles 1.2.3. Fake v/s Real 1.2.4. Privacy Issues 1.2.5. Employment 1.3. Essay assignment on the topics covered in this objective	3
G. AI in Marine Industry **General Learning Objective** Understand implementation of AI to marine applications such as improving operational efficiency of sea vessels, protecting marine environment, increasing operational safety etc.	
Specific Learning Objectives 1.1. Current state of artificial intelligence research in marine industry domain 1.2. Case Study 1 One case study based on artificial intelligence implementation in marine industry domain Case study should be of based on an actually implemented real world problem for example improving operational safety, protecting marine environment, improving fuel efficiency of sea vessels etc. Case study should cover problem statement, role and method of AI implementation and end results taking into account all (or most) of the objectives covered in this subject 1.3. Case Study 2 One case study based on artificial intelligence implementation in marine industry domain Case study should be of based on an actually implemented real world problem for example Application of Linear Regression for Ships price prediction in the Ships sale and Purchase process, Application of POMDP/Bellman Equation for Collision Avoidance on Autonomous ships. etc. <u>The area of application of case study 2 should be different than that of Case Study 1</u>	5

Subject Name/Code: Marine Machinery Systems and Design/602

Instructional Hours:

Lecture	: 60 hours
Tutorial	: 15 hours
Total contact hours	: 75 hours
Credits	: 5

Teaching Methods:
The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations**.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1.Machine Design -Pandya & Shah.
2. Design of Machine Elements — V.B. Bhandari, TMH.
3. CAD/CAM/CIM Radha Krishnan & Subramanian / New age.
4. CAD/CAM Principles and Applications / P.N.RAO/TMH.

Reference:

1. Classification society Publications, (e.g., LR Rulebook).
2. Marine Medium Speed Diesel Engines; Dr. Denis Griffiths, Institute of Marine Engineers; ISBN: 1 902536185.
3. Marine Low Speed Diesel Engines; Dr. Denis Griffiths, Institute of Marine Engineers; ISBN: 090097679.
4. POUNDERS Marine diesel engines and gas turbines. Dough Woodyard, BUTTERWORTH-HEINEMANN; ISBN: 978-0-7506-5846-1.
5. Diesel motor ships engines and machinery; Christen Knak; G. E. C. Gad; ISBN: 978-8712467779.
6. Materials for marine machinery, S. H. Frederick and H. Capper; Institute of Marine Engineers; ISBN: 0900976-42-x.
7. CAD/CAM Theory and Practice / Ibrahim Zeid /TMH.
8. Computer Numerical Control Concepts and Programming / Warrens & Seames / Thomson.

Table of Topics

Section	Topics	Hours (L:T)
A	**Procedural Steps in Mechanical Design** Sub- topics: Concepts of design, procedure & processes, Design synthesis and Feasibility Preliminary Design Alternative and Final Design alternative, Preliminary & Final Plans & Drawings, Use of Standards in design, Selection of preferred sizes	2:0
B	**Marine Machinery Component Design** Sub- topics: Design of some marine machinery components – e.g., Helical close coiled springs - compression, tension and torsion springs, Flywheel, Journal Bearings, Thrust bearings, Piston, Crank Shaft and Connecting Rod	18:5
C	**Design of Advanced Marine Systems** Sub- topics: Bulk CO2 system (High Pressure and Low-pressure system), Fire Fighting system including emergency fire pump, Power Transmission system including Thrust Blocks, Intermediate shaft and Tail-End Shaft, Electro-hydraulic Steering Gear System including Rudder, Rudder stock, Tiller arm, ram & cylinder, Marine Diesel Engine Air Starting Systems including Air receivers, Compressors and Air starting valves, Marine Diesel Engine Fuel Injection System including Fuel pumps and Fuel-injectors, Lubricating Oil systems including pumps and purifiers	28:7
D	**Computer Aided Design** Sub- topics: Analysis of stress, strain, vibration, thermal stress, deflection through method of Finite Element Analysis by use of various software e.g. AUTO – CAD, Pro-engineer, NX, Solid Edge, ANSYS	12:3
	Total	**60:15**

Learning Objectives	**L : T**
A. Procedural Steps in Mechanical Design **General Learning Objective** Understand the procedure of design and apply in designing calculations	
Specific Learning Objectives Explain and apply the following: 1.1 Concepts of design, procedure & processes 1.2 Design synthesis and Feasibility 1.3 Preliminary Design Alternative and Final Design alternative, Preliminary & Final Plans & Drawings 1.4 Use of Standards in design, 1.5 Selection of preferred sizes	2:0
B. Marine Machinery Component Design **General Learning Objective** Understand design of some key components of marine systems	
Specific Learning Objectives Explain the following with considerations and limitations: 1.1 Design of some marine machinery components - Compression and tension springs 1.2 Design of marine machinery components - Torsion springs 1.3 Design of marine machinery components - Flywheel 1.4 Design of marine machinery components - journal Bearing	18:5

1.5 Design of some marine machinery components - Thrust Bearings 1.6 Design of marine machinery components - Piston 1.7 Design of marine machinery components - Crank Shaft 1.8 Design of marine machinery components - Connecting Rod	
C. **Design of Advanced Marine Systems** **General Learning Objective** Understand and appreciate the design of marine systems taking care of latest developments and IMO requirements	
Specific Learning Objectives: **(IMO MC 7.02, 2014: F1/1.1/Page 38-43)** Explain the requirements for the following with reasons: 1 1. System design of Bulk CO2 system (High Pressure and Low-pressure system) 1.2. System design of Fire Fighting system including emergency fire pump 1.3. System design of Power Transmission system including Thrust Blocks, Intermediate shaft and Tail-End Shaft 1.4. System design of Electro-Hydraulic Steering Gear System including Rudder, Rudder stock, Tiller arm, ram & cylinder 1.5. System design of Marine Diesel Engine Air Starting Systems including Air receivers, Compressors and Air starting valves 1.6. System design of Marine Diesel Engine Fuel Injection System including Fuel pumps and Fuel-injectors 1.7. System design of Lubricating Oil systems including pumps and purifiers	28:7
D. **Computer Aided Design** **General Learning Objective** Demonstrate design process using various software tools	
Specific Learning Objectives Applying available tools, demonstrate the following: 1.1 Analysis of stress, strain, vibration, thermal stress, deflection through method of Finite Element 1.2 Analysis by use of various software e.g., AUTO-CAD, Pro-engineer, NX, Solid Edge, ANSYS	12:3

Subject Name/Code: Marine Propulsion Plant: Configuration and Characteristics/603

Instructional hours:

Lecture	: 30 hours
Total contact hours	: 30 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisites: Class 10, + 1 and +2 scheme (MPC Group); topics covered in previous Semesters.

Recommended Text:

1. John B Woodward III (1976) Matching engine and propeller, 'The Diesel Engine: To Drive a Ship' Department of Naval Architecture and Marine Engineering Report No. 105, January 1971, College of Engineering the University of Michigan Ann Arbor, Michigan 48104
2. Engine Selection Guides / Installation Guides – Various Engine Manufacturers – MAN, WinGD, Wartsila, MaK, Rolls Royce, ABB, Nishishiba
3. Basic Principles of Ship Propulsion – Technical Article by MAN Diesel & Turbo - https://www.man-es.com/marine/products/planning-tools-and-downloads/technical-papers
4. Harvald, S. A. (1983). Resistance and Propulsion of Ships. United Kingdom: Wiley.
5. Hewitt, Wesley Charles (1972) Ship power plant selection, MIT https://archive.org/details/shippowerplantse00hewi/page/n35/mode/2up
6. Marine Engineering – by group of authorities, Editor: Roy L Harrington, ISBN: 0-939773-10-4, SNAME (USA).
7. Principles of Naval Engineering, prepared by Bureau of Naval Personnel – NAVPERS 10788-B (Free version) - https://archive.org/details/principlesofnava00unit
8. Hunt, E. C. (1999). Modern Marine Engineer's Manual. United State: Cornell Maritime Press.
9. John B Woodward (1980) Analysis of steam propulsion plants, The Dept. of NAME University of Michigan – Report No.108.

Reference:

1. Marine Diesel Standard Practices – Diesel Engine Manufacturer's Association (DEMA).

Table of Topics

Section	Topics	Hours (L)
A	Propeller and Load diagrams	4
B	Propulsion Systems and configuration	3
C	Reduction Gearing Arrangements	6
D	Propulsion Characteristics of Diesel	4
E	Propulsion Characteristics of Steam Plant	3
F	Propulsion characteristics gas turbines	3
G	Propeller Curve Operation and CPP operation:	4
H	Ship Propeller and Machinery Interaction	3
	Total	**30**

Learning Objectives	L
A Propeller and Load diagrams **General Learning Objective** Understand the use of Engine Layout and Load diagrams and the various parameters. **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.3)** Explain the following: 1.1 Propeller curve 1.2 Propeller design point 1.3 Fouled hull, sea margin and heavy propeller 1.4 Constant ship speed lines 1.5 Sea Trial related to engine speed and power measurement	4
B Propulsion systems and configuration **General Learning Objective** Understand the connections of various prime movers to the propelling drives and other line shafting arrangements. **Specific Learning Objective: IMO Model Course 7.02 – 2.1.2)** Explain the following: 1.1 Brief description of various types of propulsion arrangements – covering: 1.1.1 Slow Speed Diesel Engine direct drive to propeller 1.1.2 Medium and high speed with reduction gearing 1.1.3 Electric Propulsion arrangement using diesel-electric, turbo-electric plants 1.1.4 Gas Turbine with reduction gearing 1.1.5 Steam Turbine with reduction gearing 1.1.6 Hybrid Propulsion system arrangement	3
C Reduction Gearing Arrangements **General Learning Objective** Understand line shafting reduction gear arrangements. **Specific Learning Objective: (IMO Model Course – 7.04 – 1.4.1, 1.4.2, 3.2.5.1)** **(IMO Model Course 7.02 - 1.3.10, 1.1.5)** Explain the following: 1.1 Introduction 1.2 Articulation and gear arrangement 1.3 Methods of manufacture	6

1.4 Tooth design factors – tooth contact pressure 1.5 Tooth bending strength 1.6 Tooth scoring, subsurface shear stress 1.7 Gear design – determination of approximate size of gears 1.8 Torsional pinion deflection 1.9 Bending pinion deflection 1.10 Other deflections 1.11 Gear alignment and installation 1.12 Critical speeds 1.13 Gear case; pinions and gear case 1.14 Journal and thrust bearings 1.15 Couplings 1.16 Clutches 1.17 Lubrication 1.18 Accessories 1.19 Weight estimates 1.20 Application – Locked train gears, gears for diesel – engine drives, 1.21 Gears for contra-rotating propellers, CODOG gears, Epicyclic gears 1.22 Gear box selection for the propulsion plant	
D Propulsion Characteristics of Diesel **General Learning Objective** Understand Engine Load diagrams and factors limiting engine power and measures for effective operations. **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.3.2)** Explain the following: 1.1. Diesel Engine Operating Region and Load Diagram 1.2 Continuous Service Rating 1.3 Engine Margin 1.4 Limits of Continuous Operation 1.5 Limits for overload operation 1.6 Turbocharger – Diesel Engine Matching, Compressor Maps 1.7 Specific Fuel Oil Consumption (SFOC) 1.8 SFOC based on reference ambient conditions stated in ISO 3046/1-1986 1.9 Adjustments to SFOC for lower calorific value of fuels and ambient conditions different from ISO reference conditions	4
E Propulsion Characteristics of Steam Turbine Plant: **General Learning Objective** Understand the limiting parameters for a steam propulsion system and measures for effective operations. **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.3.3)** Explain the following: 1.1 Continuous service rating 1.2 Engine margin 1.3 Constant ship speed lines 1.4 Limits for continuous operation 1.5 Specific fuel oil consumption (SFOC) 1.6 SFOC based on reference ambient conditions stated in ISO 3046/1-1986 1.7 Adjustment of SFOC for lower calorific value of fuels and ambient conditions 1.8 Different from ISO reference conditions 1.9 Performance data of individual turbines and cycle components during sea trial 1.10 Periodic acquisition of above-mentioned data and comparison for location of deterioration 1.11 Enthalpy drop test in superheated section of steam turbine 1.12 Quantification of stage efficiency losses 1.13 Leakage	3

1.14 Friction 1.15 Aerodynamic 1.16 Changes in flow passage areas	
F Propulsion characteristics gas turbines **General Learning Objective** Understand the limiting parameters for a gas turbine propulsion system and measures for effective operations. **Specific Learning Objective: (IMO Model Course 7.02 – 1.2.3.4)** Explain the following: 1.1 Continuous service rating 1.2 Engine margin 1.3 Limits for continuous operation 1.4 Limits for overload operation 1.5 Specific fuel oil consumption (SFOC) 1.6 SFOC based on reference ambient conditions stated in ISO 3046/1-1986 1.7 Adjustment of SFOC for lower calorific value of fuels and ambient conditions different from ISO reference conditions	3
G Propulsion characteristics of Electric Motor **General Learning Objective** Understand the features of an electric propulsion system and its limiting factors. **Specific Learning Objective: (IMO Model Course 7.02 – 2.1.4.1)** Explain the following: 1.1 The layout of electric propulsion, characteristics and efficiencies 1.2 Different electric motors for propulsion, their characteristics 1.3 Matching electric motor with propeller 1.4 Ratings for the continuous service, limits for overload 1.5 Constant ship speed lines	4
H Ship's Propeller and Machinery Interaction **General Learning Objective** Understand the features of a conventional propeller and prime mover related factors. **Specific Learning Objectives: IMO Model Course 7.02 – 1.2.3)** **(IMO Model Course 7.04 – 1.4.1.5, 3.2.5.1, 4.2.2.6)** Explain the following: 1.1 Ship propeller interaction 1.2 Influence of condition of the ship 1.3 Number of propeller blades 1.4 Propeller area ratio 1.5 Pitch ratio, service condition 1.6 Wake and thrust deduction 1.7 Interaction at extreme loading 1.8 Specification of speed power and rate of revolution 1.9 Choice of design point 1.10 Engine propeller matching 1.11 Choice of propeller	3

Subject Name/Code: Marine Propulsion Plant and Auxiliary Machinery: Performance Assessment/604

Instructional hours:

Lecture	: 30 hours
Tutorial	: 30 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, practical in workshops and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Pounder C.C. (2009): Marine Diesel Engines, Newnes-Butterworths, London.
2. Reeds Vol 8-General Engineering Knowledge for Marine Engineers.
3. Reeds Vol 12-Motor Engineering Knowledge for Marine Engineers.

Reference:

1. The Running and Maintenance of Marine Machinery- Cowley.
2. IMO Model Course **7.04**: 1.4.1/1.1 3) +4) +5) p34+3.2.3/3.8+3.9 p145, 1.4.1/1.6 1) +4) +5) +6). p45+3.2.3/.2+.3+.4+.5+.6+.7, **7.02**:1.4.1/1.5 1) p441.4.1/1.6 7) +8) +1.4.1/1.7 p52 +3.2.3/.11+.13+.14 p147. +1.4.1/1.10 p55, 1.4.1/1.1 6) p34 +1.4.2/2.1 p55+1.4.3/3.1 p57.

Table of Topics

Section	Topics	Hours (L:T)
A1-A3	**Main Propulsion** **Sub-Topics:** Main engine, Indicator instrument, Draw/power card.	8:8
B1-B3	**Aux Engine** **Sub-Topics:** Electrical power generation, power calculations, paralleling	8:8
C1-C2	**Aux Boiler** **Sub Topic**: Warming up, hammering, draining, water treatment and tests, performance assessment.	4:4
D1-D3	**Compressor** **Sub Topic:** Starting, maintenance, inspection trouble shooting, performance assessment.	4:4
E1-E2	**Purifier** **Sub Topic:** Trouble shooting, performance assessment.	4:4
F1-F2	**Heat exchanger** **Sub Topic:** Heat exchanger, design, operation maintenance, performance assessment.	2:2
	Total	**30:30**

Learning Objectives	L:T
A. Main engine--7.04-p56-1.4.3, 7.02-p38-1.1, p52-1.31 **General Learning Objective:** Understand the performance evaluation of a typical Marine Engine (2S & 4S).	
Specific Learning Objectives: Understand the method of performance evaluation of main engine on-board.	
A1 Main engine power calculation Explain the following: A1.1 Parameters defining the power evaluation of main engine A1.2 Theoretical background of basic PLAN formula A1.3 How to find these values on-board A1.4 Understand the working of indicator instrument A1.5 Power card and draw card A1.6 Understand the different type of analysis for these cards A1.7 Types of power calculation based on Torque meter or based on fuel rack A1.8 Difference and interpretations from different ways of power calculations	3:3
A2 Main engine power calculation by digital methods Explain the following: A2.1 Setup and parameters monitored in digital methods A2.2 Understand the connection and associated instrument working A2.3 Analyse the different cards, inter-relate the results A2.4 Data logger and troubleshooting based on event log A2.5 Crank shaft angle encoder basic working A2.6 Understand how main engine rpm is controlled using governor	3:3
A3 Main engine performance improvement Explain the following: A3.1 Parameters based analysis for performance improvement A3.2 Fuel SFOC meaning and comparisons A3.3 Operation and maintenance parameters for improving SFOC within design limits	2:2

B. Auxiliary Engine-7.04-p58-3.3, 7.02-p52-1.31 **General learning Objective:** Understand the performance evaluation of a typical Marine Auxiliary Engine (4S)	
Specific learning Objective Understand the meaning and method of Aux engine performance evaluation, importance of power generation on-board, methods and controls.	
B1 Aux engine performance evaluation Explain the following: B1.1 Understand the type of power plant generators on board B1.2 Electrical alternator type and parameters B1.3 The displayed parameters and effect on power generation on board B1.4 Frequency, power factor, kVAR, kW, kVA (cosine and sine component) B1.5 Meaning and method of improving active and reactive parts	3:3
B2 Aux engine power management Explain the following: B2.1 Parameters on-board for power management on-board B2.2 Components sharing of power B2.3 Minimum practical requirements of power generation B2.4 Paralleling of generators B2.5 Type of governor droop etc. characteristics B2.6 Parameters based analysis for performance improvement	3:3
B3 Aux engine emergency scenarios Explain the following: B3.1 To handle Blackout scenarios B3.2 Power evaluation and performance in blackout scenarios B3.3 Emergency generators power management B3.4 ESB-Emergency Switch Board power management	2:2
C Aux Boiler performance-7.04-p41, 7.02-p52-1.31, 7.02-p60-63-3.13 **General learning Objective:** Understand the performance evaluation of a typical Marine Boiler	
Specific learning Objective: Explain the Aux Boiler burner, economizer, associated mountings/components, parameters and performance evaluation	
C1.Aux Boiler power production C1.1Explain the Aux Boiler burner C1.2Explain the associated parameters and power production C1.3Methods to evaluate the performance of Aux boiler C1.4Production of heart smoke steam water consumption C1.5Compare sea trial data (of boiler running) steam production, temperature, pressure, etc.	2:2
C2. Aux Boiler Emergency/manual operations C2.1Explain the Aux Boiler emergency operation scenarios C2.2Explain methods to evaluate the performance and basic of emergency operation including safe performance C2.3Explain handling emergency scenarios like leak, smoke, non-firing, etc.	2:2
D Air Compressor performance-7.04-p59-2, 7.02-p58-3.11 **General Learning Objective** Understand the basic working and performance assessment of a typical Air compressor	
Specific Leaning Objective Explain basic operation maintenance and performance assessment of air compressor on-board.	
D1 Air compressor performance assessment Explain the following: D1.1 Parameters to observe on air compressor D1.2 Air temperature, cooling water temp, oil level, stage pressures D1.3 Cylinder lubrication basics	2:2

D1.4 Parameters used to monitor performance assessment of purifier, timing test of filling air bottles, associated data from sea trial and comparisons	
D2 Air compressor parameter affecting the performance Explain the following: D2.1 Air compressor components working and understanding D2.2 Maintenance overhauling understanding basics D2.3 Bumping clearance effect on performance D2.4 Stage pressure and effect on performance D2.5 Various temperature and effects on performance D2.6 Various pressures of lube oil on cylinder/crankcase and effect on performance	1:1
D3 Air compressor troubleshooting Explain the following: D3.1 Alignment and coupling D3.2 Unloading and associated troubles D3.3 HP and LP valve operation, maintenance and troubleshooting D3.4 Oil carry over and troubleshooting D3.5 Leak detection and troubleshooting	1:1
E Purifier performance-7.04-p59-2 **General Learning Objectives** Understand the Performance assessment of a typical purifier used for FO, DO, Lo etc.	
Specific Learning Objective Explain Purifier parameters, running and control methods	
E1 Purifier performance assessment Explain the following: E1.1 Understand the purifier assessment parameters, flow, temperature, density E1.2 Understand the back pressure and adjustments E1.3 Leak and overflow understanding and assessment E1.4 Alarms and data related to performance of all purifiers on-board	2:2
E2 Purifier starting/stopping/troubleshooting Explain the following: E2.1 Understand the reasons of purifier overflow E2.2 Understand the various ways of detecting the leak/overflow and alarm detection E2.3 Explain precautions of parameters maintenance E2.4 Understand the steps involved in starting and stopping sequence E2.5 Auto monitoring system understanding troubleshooting and restarting procedures E2.6 Understand the gravity disc section procedure or adjustments as required for change in oil properties E2.7 Handling the waste sludge	2:2
F Heat Exchanger—7.04-p49- 4 of 1.4 **General Learning Objective** Understand the performance assessment of typical Marine Heat Exchangers	
Specific learning objective Understand the concept of heat transfer and performance assessment	
F1 Heat exchanger performance assessment Explain the following: F1.1 To understand the heat transfer surface F1.2 Find and compare sea trial data F1.3 Understand the concept of parameters differences and inferences to be made according to the quantity of heat transfer as required F1.4 Types of heat exchangers, shell and tube type, plate type F1.5 Understand the application in SW/FW coolers, heaters, etc.	2:2

Subject Name/Code: Naval Architecture 2/605

Instructional hours:

Lecture	: 60 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisites: Class 10, + 1 and +2 scheme (MPC Group); topics covered in previous Semesters.

Recommended Text:

1. Pemberton, R., Stokoe, E. A. (2018). Reeds Vol 4: Naval Architecture for Marine Engineers. United Kingdom: Bloomsbury Publishing.
2. Muckle, W. (2013). Naval Architecture for Marine Engineers. United Kingdom: Elsevier Science.
3. Introduction to Naval Architecture, 4th Edition; E. C. Tupper; Paperback ISBN: 9780750665544. eBook ISBN: 9780080478715; Butterworth-Heinemann; 2004.

Reference:

1. Bhattacharyya, R. (1978). Dynamics of Marine Vehicles. United Kingdom: Wiley.
2. Harvald, S. A. (1983). Resistance and Propulsion of Ships. United Kingdom: Wiley.
3. Lewis, E. V. (1988). Principles of Naval Architecture: Resistance, propulsion and vibration. United State: Society of Naval Architects and Marine Engineers.
4. Ghose, J. P., Gokarn, R. P. (2004). Basic Ship Propulsion. India: Allied Publishers.

Free Resources Online:

1. C Chryssosstomidis and M Triantafyllou (1981) Naval Architecture for Offshore Applications - https://dspace.mit.edu/bitstream/handle/1721.1/74137/2-019-fall-2005/contents/syllabus/offshore_design.pdf.
2. Resistance and Propulsion - https://repository.tudelft.nl/islandora/object/uuid:f6cb04ef-c2d1-4a76-898d-0e9961eac462/datastream/OBJ/download.
3. J.M.J. Journée and W.W. Massie (2001) OFFSHORE HYDROMECHANICS (First Edition) Delft University of Technology - https://ocw.tudelft.nl/wp-content/uploads/OffshoreHydromechanics_Journee_Massie.pdf.

Table of Topics

Section	Topics	Hours (L)
A1-A2	**Rudder Theory** **Subtopics**: Basic requirements of rudder. Rudder nomenclature, area and shape of rudder, physics of control surfaces, properties of hydrofoils – lift and drag, action of the rudder in turning a ship, forces on rudder, torque on stock, angle of heel when turning. Types of rudders, position of rudder, stern rudders & bow rudders. Model experiments and full-scale manoeuvring trials – course keeping, course changing, emergency manoeuvre qualities, turning test, Z-manoeuvre test, modified Z-manoeuvre test, direct spiral test, reversed spiral test, pull-out test, stopping test	14
B1-B3	**Resistance and Fuel Consumption** **Subtopics:** Components of ship resistance; Frictional Resistance, Residuary Resistance, Froude's Law of comparison, Speed to Length Ratio, Froude's Number, Reynold's Number Determination of ship's resistance. Model experiments, Effective power calculations, Ship correlation factor (SCF), Application of ITTC methods in solving problems related to estimation of total resistance. Admiralty coefficient, Fuel coefficient and Fuel consumption	12
C1-C5	**Propellers and Power** **Subtopics:** Propeller geometry and terminologies, Apparent and real slip, Wake and wake distribution, Thrust deduction fraction, Propulsion machinery layout, Power and efficiencies in ship propulsion system, QPC. Axial Momentum theory, Momentum theory including rotation and Blade element theory. Circulation theory, Lifting line theory. Law of similitude, model tests with propellers, Ship model correlation, Open water characteristics, propeller in behind condition (Ship propeller interaction) Cavitation – cavitating flows, types of propeller cavitation, detrimental effects of cavitation, criteria for prevention of cavitation. Special types of propeller arrangements – FPP, CPP, Propellers in Nozzles, Paddle wheel, Vertical axis propellers – Voith Schneider, Jet propellers	24
D1-D3	**Motion of ship on waves** **Subtopics:** Theory of waves. Trochoidal waves. Sinusoidal waves. Irregular wave pattern, Wave spectra, Ship motions – Roll pitch yaw surge, sway and yaw Anti- rolling devices- (i) Bilge keels (ii) Fin Stabilizers (iii) Passive and active anti-roll tanks	10
	Total	**60**

Learning Objectives IMO Model Course 2014 references IMO Model Course 7.04 – 1.4.1.7, 4.2.2.6; IMO Model Course 7.02 – 1.2.2.4, 4.1.1.9	L
A Rudder Theory	
A1 General Learning Objective 1.1 Understand and utilize concepts related to forces on rudder causing ship to turn, torque on rudder stock and angle of heel when turning. **A1 Sub-topic:** Basic requirements of rudder. Rudder nomenclature, area and shape of rudder, physics of control surfaces, properties of hydrofoils – lift and drag, action of the rudder in turning a ship, forces on rudder, torque on stock, angle of heel when turning, Types of rudders, position of rudder- stern rudders & bow rudders. **Sub-subtopics & SLOs** 1.1.1 Explain the purpose of rudder in turning the ship 1.1.2 Define and explain various terminologies related to rudder and turning of ship including pivoting point and drift angle 1.1.3 Explain the physics of lift & drag acting on the hydrofoil surface and its application to the rudder in generating rudder torque about rudder axis, in turn, turning the ship 1.1.4 Explain and utilize empirical formulae to calculate force acting on the rudder for various conditions of movement of the ship and various configurations of rudder 1.1.5 Explain and utilize methodology to calculate the rudder stock diameter based on the force, torque and bending moment acting on the rudder 1.1.6 Explain Turning circle test for the various angles of heel and drift during the entire turn 1.1.7 Explain different types of rudders 1.1.8 Explain efficient position of rudder in turning the ship – Bow and stern rudder	10
A2 General Learning Objective 1.2 Understand different Manoeuvring trials to be conducted as per the requirements of the IMO **A2 Sub-topic:** Model experiments and full-scale manoeuvring trials – course keeping, course changing, emergency manoeuvre qualities, turning test, Z-manoeuvre test, modified Z-manoeuvre test, direct spiral test, reversed spiral test, pull-out test, stopping test. **Sub-subtopics & SLOs** 1.2.1 Explain model and full-scale manoeuvring trials with various terminologies related to particular trial 1.2.2 Explain Turning circle test, Z-manoeuvre test, modified Z-manoeuvre test, direct spiral test, reversed spiral test, pull-out test, stopping test	4
B Resistance and Fuel Consumption	
B1 General Learning Objective: 2.1. Understand and utilize concepts related to different types of resistance experienced by the ship's hull using Froude's Law of comparison **B1 Sub-topic:** Components of ship's resistance; Frictional Resistance, Residuary Resistance, Froude's Law of comparison, Speed to Length Ratio, Froude's Number, Reynold's Number **Sub-sub topics & SLOs** 2.1.1 Define and explain resistance of the ship 2.1.2 Define, explain and compare following components of resistances 2.1.3 Viscous Resistance, Wave-making Resistance, Residuary Resistance, Frictional Resistance, Viscous Pressure Resistance, Eddy making resistance 2.1.4 Define and explain the utilization of Form factor	6

2.1.5 Define and explain the utilization Boundary layer theory 2.1.6 Define and explain the wave-interference 2.1.7 Define and explain the utilization of coefficient of friction by Froude and ITTC 1957 friction Line 2.1.8 Define, explain, prove and solve problems related to Froude’s law of comparison and his experiment 2.1.9 Define and explain concept of Speed to Length Ratio, Froude’s Number and Reynold’s Number	
B2 General Learning Objective: 2.2. Understand and utilize Froude’s methodology and ITTC 1957 method to predict effective power of the ship **B2 Sub-topic:** Determination of ship’s resistance. Model experiments, Effective power calculations, Ship correlation factor (SCF), Application of ITTC methods in solving problems related to estimation of total resistance. **Sub-sub topics & SLOs** 2.2.1 Define and utilize laws of similarity 2.2.2 Carry out dimensional analysis for the total resistance of the ship 2.2.3 Explain Froude’s and Reynold’s similarity of law 2.2.4 Develop equations for the model parameters from the ship parameters 2.2.5 Sketch and describe Model test setup to predict resistance of the ship 2.2.6 Describe and solve problems to estimate total resistance and in turn to predict effective power of the ship using Froude’s methodology and ITTC methods 2.2.7 Define, explain and utilize ship correlation factor (SCF)	4
B3 General Learning Objective: 2.3. Understand and apply concepts of Admiralty coefficient and Fuel coefficient to calculate fuel consumption for various routes and displacement of the ship. **B3 Sub-topic:** Determination of ship’s resistance. Model experiments, Effective power calculations, Ship correlation factor (SCF), Application of ITTC methods in solving problems related to estimation of total resistance. **Sub-sub topics & SLOs** 2.3.1 Define, explain and utilize Admiralty coefficient, Fuel coefficient, specific fuel consumption and propulsive efficiency to calculate fuel consumption for various routes and displacement of the ship	2
C Propellers and Power	
C1 General Learning Objective: 3.1 Understand and utilize concepts related to geometry of the propeller, slip and wake of it on its various efficiencies. **C1 Sub topic:** Propeller geometry and terminologies, Apparent and real slip, Wake and wake distribution, Thrust deduction fraction, Relative rotative efficiency, Propulsion machinery layout, Power and efficiencies in ship propulsion system, QPC. **Sub-sub topics & SLOs** 3.1.1 Define, explain and utilize following parameters of the propeller in calculating various geometric parameters of the propeller blade Diameter, number of blades, RPM, Helix, helical surface, projected, developed & expanded areas & sections of blade, leading & trailing edge, face & back, root & tip, rake & rake angle, skew & skew angle, chord, pitch and pitch angle 3.1.2 Define, explain and utilize following parameters of the propeller in calculating various efficiencies of the propulsion plant layout and calculate different powers at various stages of layout	8

3.1.3 Speed of advance of the propeller, Wake, Froude's & Taylor's wake fraction, Real, apparent and effective slip of the propeller, thrust deduction factor, Hull efficiency, propeller efficiency, relative rotative efficiency, QPC	
C2 General Learning Objective: 3.2 Explain different theories of propeller to calculate its efficiency. **C2 Sub topic:** Axial Momentum theory and Blade element theory, Circulation theory. **Sub-sub topics & SLOs** 3.2.1 Define, explain and utilize axial momentum theory in deriving expressions and calculating values of ideal efficiency and Thrust loading coefficient of the propeller 3.2.2 Explain the concept of tug applying a static pull at Bollard or of a ship at a dock trial 3.2.3 Define Blade element theory 3.2.4 Define Circulation Theory – Lifting line method	4
C3 General Learning Objective: 3.3 Understand and utilize concepts of model testing of propeller both in open water and behind the ship to obtain different parameters out of it. **C3 Sub topic:** Law of similitude, model tests with propellers, Ship model correlation, Open water characteristics, propeller in behind condition (Ship propeller interaction). **Sub-sub topics & SLOs** 3.3.1 Utilize laws of similarity for the propeller model testing 3.3.2 Define, explain and utilize Reynold's number, Advance coefficient, Froude's number, thrust coefficient, torque coefficient, open water efficiency and effective pitch to calculate various operating parameters of the model propeller and its prototype 3.3.3 Explain Open water characteristics of the propeller 3.3.4 Explain the concept of Bollard pull condition, 100% slip condition and feathering condition by drawing velocity diagrams for the same 3.3.5 Explain the Bp-Delta diagram for the propeller 3.3.6 Explain self-propulsion tests on ship 3.3.7 Indicate how Taylor's wake fraction, speed of advance, thrust deduction factor relative rotative efficiency are determined using thrust & torque identity to calculate hull & quasi-propulsive coefficient (QPC)	8
C4 General Learning Objective: 3.4 Understand and explain cavitation of the propeller, it's effect and ways to mitigate it. **C4 Sub topic:** Cavitation – cavitating flows, types of propeller cavitation, detrimental effects of cavitation, criteria for prevention of cavitation. **Sub-sub topics & SLOs** 3.4.1 Define and explain the phenomenon of cavitation, vapour pressure and cavitation number 3.4.2 Explain different types of propeller cavitation 3.4.3 Explain different detrimental effects of cavitation 3.4.4 Explain different methods used to prevent the propeller cavitation 3.4.5 Cavitation criteria and cavitation checks	2
C5 General Learning Objective: 3.5 Explain special types of propeller arrangements. **C5 Sub topic:** Special types of propeller arrangements – FPP, CPP, Propellers in Nozzles, Paddle wheel, Vertical axis propellers – Voith Schneider, Jet propellers. **Sub-sub topics & SLOs** 3.5.1 Explain theory, advantages, disadvantages and applications of special types of propeller arrangements	2

3.5.2 Explain FPP, CPP, Propellers in Nozzles, Paddle wheel, Vertical axis propellers – Voith Schneider, Jet propellers	
D Motion of ship on waves	
D1 General Learning Objective: 4.1 Explain theories for the regular and irregular wave patterns. **D1 Sub Topic:** Theory of waves. Trochoidal waves. Sinusoidal waves. Irregular wave pattern, Wave spectra. **Sub-sub topics & SLOs** 4.1.1 Define and explain Regular and Irregular wave pattern 4.1.2 Define and explain different types of regular waves 4.1.3 Define and explain Trochoidal waves Sinusoidal waves 4.1.4 Define and explain wave period, wave energy, histogram of wave periods, energy spectrum, sea spectra, partially and fully developed sea	4
D2 General Learning Objective: 4.2 Understand and utilize concepts of Added mass, Radius of Gyration to calculate period of motion for Roll, Heave and Pitch. **D2 Sub Topic:** Ship motions – Roll, pitch, yaw, surge, sway and yaw; Forces caused by ship motions. **Sub-sub topics & SLOs** 4.2.1 Define and explain various undamped motions of ship in three dimensions 4.2.2 Utilize Newton's law of motion to derive expressions for period of motions for Rolling, Pitching and heaving 4.2.3 Define and utilize expressions for Added mass, Radius of Gyration and periods for Roll, Pitch and Heave motion	4
D3 General Learning Objective: 4.3 Understand the theory and working principles of different Anti-rolling devices. **D3 Sub Topic:** Anti- rolling devices- (i) Bilge keels (ii) Fin Stabilizers (iii) Passive and active anti-roll tanks. **Sub-sub topics & SLOs** 4.3.1 Explain theory and working principles of following Anti-rolling devices 4.3.2 Explain Bilge keels, Fin Stabilizers, Passive and active anti-roll tanks	2

Subject: Name/Code: Shipboard Safety Management/606

Instructional hours:

Lecture	: 30 hours
Tutorial	: 30 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Taylor D. A., Introduction to Marine Engineering, revised second edition, Butterworth-Heinemann, 1999 ISBN 0 7506 25309.
2. McGeorge H. D., Marine Auxiliary Machinery, seventh edition, Butterworth-Heinemann, 1995 ISBN 0 7506 4398 6.
3. Shipboard Operations, H. I. Lavery.

Reference:

1. STCW code, Chapter VIII, Section A VIII/2, Part 3 Para 8.
2. R2 ILO/IMO/WHO INTERNATIONAL MEDICAL GUIDE FOR SHIPS (3rd Edition) Code I115E ISBN 978-92-415-47208.
3. R3 INTERNATIONAL SHIP AND PORT FACILITY SECURITY CODE (ISPS Code) (2003 Edition) Code I116E ISBN 978-92-801-51497.
4. R4 INTERNATIONAL SAFETY MANAGEMENT CODE (ISM Code) AND GUIDELINES ON IMPLEMENTATION OF THE ISM CODE (2010 Edition) Code IB117E ISBN 978-92- 801-51510.
5. R5 CODE OF THE INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES FOR A SAFETY INVESTIGATION INTO A MARINE CASUALTY OR MARINE INCIDENT.
6. (Casualty Investigation Code) (2008 Edition) Code I128E ISBN 978-92-801-14980.
7. R6 INTERNATIONAL CODE FOR FIRE SAFETY SYSTEMS (FSS Code) (2007 Edition) Code IA155E ISBN 978-92-801-14812.
8. R8 INTERNATIONAL MARITIME DANGEROUS GOODS CODE (IMDG Code)2008Edition.
9. IMO Model Course 2.03 Advanced Firefighting

Recommended Videos:

1. V23 CRISIS MANAGEMENT Code No. 507.
2. V24 FIRE PARTY OPERATIONS Code No.509.
3. V25 THE INTERNATIONAL SAFETY MANAGEMENT CODE No.524.
4. V26 LOAD LINE SURVEYS – PART 1 Code No.544.
5. V27 SAFETY CONSTRUCTION SURVEY–PART 2 Code No.545.
6. V28 SAFETY EQUIPMENT SURVEY–PART 3 Code No.546.
7. V29 PERSONAL SAFETY IN THE ACCOMMODATION Code No.554.
8. V30 PERSONAL SAFETY ON DECK Code No.555.
9. V31 PERSONAL SAFETY IN THE ENGINE ROOM Code No.556.
10. V32 PERSONAL SAFETY ON BULK CARRIERS Code No.558.
11. V33 PERSONAL SAFETY ON GENERAL CARGO SHIPS Code No.559.
12. V34 PERSONAL SAFETY ON CONTAINER SHIPS Code No.560.

Table of Topics

Section	Topics	Hours (L:T)
A	Knowledge of life-saving appliances regulations	4:4
B	Organization of fire drills and abandon ship drills	4:4
C	Maintenance of operational condition of life-saving, Fire-fighting and other safety systems	6:6
D	Actions to be taken to protect and safeguard all persons on board in emergencies	3:3
E	Action to limit damage and salve the ship following a fire, collision, explosion or grounding	5:5
F	Contingency plans for response to emergencies on ships while at sea or at port. Candidates will acquire knowledge to deal with emergencies on board ships.	5:5
G	Ship construction including damage control	3:3
	Total	**30:30**

<table>
<tr><th>Learning Objectives</th><th>L : T</th></tr>
<tr><td>A Knowledge of life-saving appliances regulations (IMO 7.02,2014: F4/4.3.1)

General Learning Objective
Understand regulations and arrangement of life-saving appliances, organisation of fire and abandon ship drills</td><td></td></tr>
<tr><td>Specific Learning Objectives

1.1 Demonstrate a thorough knowledge of the regulations concerning life-saving appliances and arrangements (SOLAS), including the LSA Code
1.2 Conduct of fire and abandon ship drills
1.2.1 Prepare schedules for the conduct of fire and abandon ship drills so that all required drills and equipment are covered within required timeframes
1.2.2 Discuss ways in which crew can be motivated to participate fully in drills
1.3 Prepare plans for effective drills
1.3.1 Organize effective drills including the briefing, conduct and debriefing of the drill
1.3.2. Discuss the process for ensuring that required changes are made to the safety management system and on-board procedures as a result of the lessons learnt from drills
1.4 Discuss the use and upkeep of the SOLAS training manual in terms of the safety equipment provided and the required maintenance of this equipment</td><td>4:4</td></tr>
<tr><td>B. Organization of fire drills and abandon ship drills (IMO 7.02,2014: F4/4.3.2)

General Learning Objectives

Understand procedures for maintaining LSA and FFA equipment on board, preparation of survey of these equipment and preparation of checklists for inspection.</td><td></td></tr>
</table>

Specific Learning Objectives: 1.1 Prepare procedures and schedules for the maintenance of life-saving, firefighting and other safety systems on board 1.2 Prepare schedules for the required survey of life-saving, firefighting and other safety systems on board 1.3 Prepare for and support the survey of life-saving, firefighting and other safety systems on board 1.4 Prepare procedures and checklists for the inspection of watertight doors, side scuttles, cross flooding arrangements, valves and other closing mechanisms 1.5 Prepare procedures and checklists for the inspection of life-saving, firefighting and other safety systems on board 1.6 Ensure that regular inspections of life-saving, firefighting and other safety systems on board are undertaken and that any deficiencies are identified and rectified 1.7 Prepare maintenance plans and procedures for watertight doors, side scuttles, cross flooding arrangements, valves and other closing mechanisms	4:4
C. Maintenance of operational condition of life-saving, Fire-fighting and other safety systems **(IMO 7.02,2014: F4/4.3.3)** **General Learning Objectives** Understand maintenance of operational conditions of life-saving, Fire-fighting and other safety systems	
Specific Learning Objectives 1.1 Discuss the use and upkeep of the SOLAS training manual in terms of the safety equipment provided and the required maintenance of these equipment 1.2 Prepare procedures and checklists for the inspection of life-saving, firefighting and other safety systems on board. 1.3 Ensures that regular inspections of life-saving, firefighting and other safety systems on board are undertaken and that any deficiencies are identified and rectified 1.4 Prepare procedures and schedules for the maintenance of life-saving, firefighting and other safety systems on board 1.5 Prepare schedules for the required survey of life-saving, firefighting and other safety systems on board 1.6 Prepare for and supports the survey of life-saving, firefighting and other safety systems on board 1.7 Prepare procedures and checklists for the inspection of watertight doors, side scuttles, cross flooding arrangements, valves and other closing mechanisms 1.8 Prepare maintenance plans and procedures for watertight doors, side scuttles, cross flooding arrangements, valves and other closing mechanisms	6:6
D. Actions to be taken to protect and safeguard all persons on board in emergencies **(IMO 7.02,2014: F4/4.3.4)** **General Learning Objectives** Understand actions to be taken to protect and safeguard all persons on board in emergencies ensuring that a supply of blankets is taken to the survival craft	

Specific Learning Objectives 1.1 State that some crew members will be assigned specific duties for mustering and control of passengers 1.2 List those duties as: – warning the passengers – ensuring that all passenger spaces are evacuated – guiding passengers to muster stations – maintaining discipline in passageways, stairs and doorways – checking that passengers are suitably clothed and that Life jackets are correctly donned – taking a roll-call of passengers – instructing passengers on procedure for boarding survival craft or jumping into the sea – directing passengers to embarkation stations – instructing passengers during drills	3:3
E Action to limit damage and salve the ship following a fire, collision, explosion or grounding **(IMO 7.02,2014: F4/4.3.5)** **General Learning Objectives** Understand actions to limit damage and salve the ship following a fire, explosion, or grounding	
Specific Learning Objectives 1.1 Explain means of limiting damage and salving the ship following a fire or explosion 1.2 Describe the use and limitations of standard procedures and prepared contingency plans in emergency situations 1.3 Describe methods of fighting fires (Refer: IMO Model Course 2.03, Advanced training in firefighting) 1.4 State that cooling of compartment boundaries where fire has occurred should be continued until ambient temperature is approached 1.5 Explain the dangers of accumulated water from firefighting and describe how to deal with it 1.6 State that watch for re-ignition should be maintained until the area is cold 1.7 Describe the precautions to take before entry to a compartment where a fire has been extinguished 1.8 Describe the inspection for damage 1.9 Describe measures which may be taken to plug holes, shore-up damaged or stressed structure, blank broken piping, Make safe damaged electrical cables and limit ingress of water through a damaged deck or superstructure 1.10 Outline the measures to be taken when the inert-gas main and gas lines to a mast riser are fractured 1.11. State that continuous watch should be kept on the damaged area and temporary repairs 1.12 State that course and speed should be adjusted to minimize stresses and the shipping of water 1.13 Procedure for abandoning ship 1.13.1. State that a ship should only be abandoned when imminent danger of sinking, breaking up, fire or explosion exists or other circumstances Make remaining on board impossible 1.13.2 Describe the launching of boats and life rafts when the ship is listing heavily 1.13.3. Describe the launching of boats and life rafts in heavy weather conditions 1.13.4. Describe the use of oil to calm the sea surface and explain why fuel oil is not suitable	5:5
F Contingency plans for response to emergencies on ships while at sea or at port. Candidates will acquire knowledge to deal with emergencies on board ships. **(IMO 7.02,2014: F4/4.3.5)** **General Learning Objectives** Learn contingency plans for response to emergencies on ships while at sea or at port. Candidates will acquire knowledge to deal with emergencies on board ships	

Specific Learning Objectives 1.1 Draw up a muster list and emergency instructions for a given crew and type of ship 1.2 Assign duties for the operation of remote controls such as: -main engine stop -ventilation stops -lubricating and fuel oil transfer pump stops -dump valves -CO_2discharge -watertight doors -and for the operation of essential services such as: -emergency generator and switchboard -emergency fire and bilge pumps 1.3 Describe options for the division of the crew, e.g., into a command team, an emergency team, a back-up emergency team and an engine-room emergency team 1.4 Explain the composition of the emergency teams in the above objective 1.5 State that crew members not assigned to emergency teams would prepare survival craft, render first aid, assemble passengers and generally assist the emergency parties as directed 1.6 Designate muster positions for the command team, both at sea and in port 1.7 Designate muster positions for the emergency teams 1.8 State that the engine-room emergency team would take control of engine- room emergencies and keep the command team informed 1.9 State that good communications between the command team and the emergency teams are essential 1.10 Prepare contingency plans to deal with: -fire and/or explosion in specific areas, such as galley, accommodation, container stows on or under deck, engine-room or cargo space, including coordination with shore facilities in port, taking account of the ship's fire- control plan -rescue of victims from an enclosed space 1.11 Water ingress into the ship – serious shift of cargo piracy attack – being towed by another ship or tug – heavy-weather damage, with particular reference to hatches, ventilators and the security of deck cargo – rescue of survivors from another ship or from the sea – leakages and spills of dangerous cargo stranding – abandoning ship 1.12 Explain how drills and practices should be organized 1.13 Describe the role of a shipboard safety committee in contingency planning 1.14 Describe actions to take in the event of fire on own ship, with particular reference to cooperation and communication with shore facilities 1.15 Describe action which should be taken when fire occurs on a nearby ship or an adjacent port facility 1.16 Describe the circumstances in which a ship should put to sea for reasons of safety	5:5
G. Ship construction including damage control (IMO 7.02,2014: F4/4.3.5) **General Learning Objectives** Acquire the knowledge of ship construction including damage control and Flooding of compartments	

Specific Learning Objectives 1.1 Define: margin line, permeability of a space 1.2 Explain what is meant by 'floodable length' 1.3 Explain what is meant by 'permissible length of compartments' in passenger ships 1.4 Describe briefly the significance of the factor of subdivision 1.5 State the assumed extent of damage used in assessing the stability of passenger ships in damaged condition 1.6 Summarize, with reference to the factor of subdivision, the extent of damage which a passenger ship should withstand 1.7 Describe the provisions for dealing with asymmetrical flooding 1.8 State the final conditions of the ship after assumed damage and, where applicable, equalization of flooding 1.9 State that the master is supplied with data necessary to maintain sufficient intact stability to withstand the critical damage explain the possible effects of sustaining damage when in a less favourable condition 1.10 Distinguish between ships of Type A and Type B for the purposes of computation of freeboard 1.11 Describe the extent of damage which a Type A ship of over 150 meters length should withstand 1.12 Explain that a Type A ship of over 150 meters' length is described as a 'one-compartment ship' 1.13 Describe the requirements for survivability of Type B ships with reduced freeboard assigned 1.14 Summarize the equilibrium conditions regarded as satisfactory after flooding 1.15 State that damage to compartments may cause a ship to sink as a result of: - insufficient reserve buoyancy, leading to progressive flooding - progressive flooding due to excessive list or trim - capsizing due to loss of stability structural failure	3:3

Subject Name/Code: Marine Simulators: Electrical, Propulsion and Manoeuvring (P)/607

Instructional hours:

Practical	: 60 hours
Total contact hours	: 60 hours
Credits	: 2

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Experiment Exam	: 50%

Recommended Text:

1. Taylor D. A., Introduction to Marine Engineering, revised second edition, Butterworth-Heinemann, 1999 ISBN 0 7506 25309.
2. Doug Woodyard (Editor), Pounder's Marine Diesel Engine, seventh edition, Butterworth-Heinemann, 1998 ISBN 0 7506 2583 X.
3. McGeorge H. D., Marine Auxiliary Machinery, 7th edition, Butterworth-Heinemann, 1995 ISBN 0 7506 4398 6.

Reference:

1. Instruction Manual for the main propulsion plant being simulated.
2. Ships Machinery Manuals.
3. Vendors Manuals.

Table of Topics

Section	Topics	Hours P
A1-A2	**Description of basic engine functions and their simulation** **Sub-Topics/SLOs:** Engine operation, Safety and interlocks, Different modes of operation, Troubleshooting	8
B1-B12	**Diesel engine operation and maintenance** **Sub-Topics:** Demonstration of working of engine, to change load and speed, to change ambient operating conditions, To Simulate engine load and speed, to watch engine operation parameters, Maintenance strategy	13
C1-C9	**Manoeuvring** **Sub-Topics**: Engine sound simulation, Control form bridge, remote and local control of propulsion plant, Manoeuvring system, Bridge control	12
D1-D5	**Diesel Engine Combustion Gas Monitoring System** **Sub-Topics:** Starting the plant and watch keeping, Telegraph, Capturing the engine performance with indicator cards, Effects of VIT	12
E1-E10	**Electrical and Propulsion** **Sub-Topics:** Introduction, Propulsion arrangements, Propulsion simulation	15
	Total	**60**

Learning Objectives	P
A.1-2 Description of basic engine functions and their simulation **General Learning Objective** Understand the basic operations of engine and ship's plant in a simulated environment Understand necessary actions to contain the effects of the malfunction identified; attention to relevant procedures; safe working practices for engine operation.	8
Specific learning objective (IMO 7.04,2014: 1.4.3 (3.1) page 56)	
A.1: Engine operation, Safety and interlocks, Different modes of operation 1.1 Observe and apply safe practices in all exercises: Demonstrate correct assessment of risk of equipment malfunctions or breakdown on available information 1.2 Use checklists in all exercises: Demonstrate the use of a checklist to ensure that actions and activities are carried out in a safe and correct sequence 1.3 Arrangement of alarms: Demonstrate a basic knowledge of the alarm and safety system associated with the main engine 1.4 UMS checklist: Execute all orders and actions for UMS 1.5 Modes of operation of main engine remote and bridge: Demonstrate the controls that are used and where they are located	
A.2: Troubleshooting Explain the following: 2.1 Fuel injection timing 2.2 Worn piston rings in one cylinder 2.3 Fire in scavenge space 2.4 Fouled turbo charger (exhaust side) 2.5 Fouled turbo charger (air side) 2.6 Fouled turbo charger (air cooler) 2.7 Blackout	

2.8 Clogged auxiliary machinery air filter 2.9 Overheated main bearing 2.10 Flooded bilge sump 2.11 Bridge control failure	
B.1-12 Diesel engine operation and maintenance **General Learning Objective** Demonstrate working of an engine, to change load and speed, to change ambient operating conditions, to simulate engine load and speed, to watch engine operation parameters, Maintenance strategy	13
Specific learning objective (IMO 7.04,2014: 1.4.3 (3.1) page 56)	
B. Sub Topics: Explain the following: 1.1 Working of M.E 1.2 To change engine's load and speed 1.3 To change ambient operating conditions 1.4 To simulate engine faults in varying degrees 1.5 To mix different simulations 1.6 To watch engine operation parameters 1.7 To watch functions inside the cylinder 1.8 To simulate the engine sound which varies with speed 1.9 To carry out maintenance and repairs 1.10To try out different maintenance strategies 1.11To print engine data 1.12To use the lesson facility	
C.1-9 Manoeuvring **General Learning Objective** Prepare, start and run the main propulsion unit and associated systems, set the main propulsion unit controls to maximum full ahead sea power as directed from bridge control, or apply manoeuvring procedures and use the controls to obtain required power outputs.	12
Specific learning objective (IMO 7.04,2014: 1.4.3 (3.1) page 56)	
C. Sub Topics: 1.1 Describe the manoeuvring system of main engine 1.2 Describe the ME Selective Catalytic Reduction 1.3 Describe and simulate ME cylinder and piston ring monitor 1.4 Familiarize with two stroke diesel engines 1.5 Start the plant and checking the systems 1.6 Engage the turning and turning the engine on T /G. 1.7 Give command from bridge telegraph and acknowledging the command on E/R Telegraph 1.8 Blow through the engine, significance of blowing through the engine 1.9 Start the M/E and running in compliance with the bridge requirement (communicated by telegraph)	
D.1-5 Diesel Engine Combustion Gas Monitoring System **General Learning Objective** Establish normal running mode and observe operating conditions including variations on fuel quality, load and performance monitoring.	12
Specific learning objective (IMO 7.04,2014: 1.4.3 (3.1) page 56)	
D. Sub Topics: 1.1 Capture the engine performance in the form of power card, draw card, and fuel pump pressure card. Analysing the cards 1.2 Change the fuel quality (like Sulphur etc.) and observing its effects on exhaust emission 1.3 Study the effect of VIT	

1.4 Start and running the engine from ECR, bridge and emergency station 1.5 Find fault with the help of parameters reading and cards	
E.1-10 Electrical and Shafting Propulsion **General Learning Objective** Describe the propulsion arrangements and its simulation and procedures for electrical power plant operation.	15
Specific Learning Objective: (IMO 7.04,2014: 1.4.3 (1.4 & 1.5) page 44) and for electrical (2.1)(2) page 95	
E. Sub Topics: Explain the following: 1.1 Propeller Servo Oil System 1.2 Thrust block and bearing 1.3 Stern Tube System 1.4 Ship Load 1.5 Propeller and Ship Model 1.6 Set the main propulsion unit and associated systems 1.7 Apply manoeuvring procedure and use the controls to obtain required power outputs. 1.8 Electrical Power Plant 1.9 Shaft Generator/Motor 1.10Main Switchboard-Starter section	

Subject Name/Code: Marine Propulsion Plant: Configuration and Characteristics(P)/ 608

Instructional hours:

Practical	: 30 hours
Total contact hours	: 30 hours
Credits	: 1

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Additional Information on Subject:

1. Pre-requisites: Class 10, + 1 and +2 scheme (MPC Group); topics covered in previous Semesters.

Recommended Text:

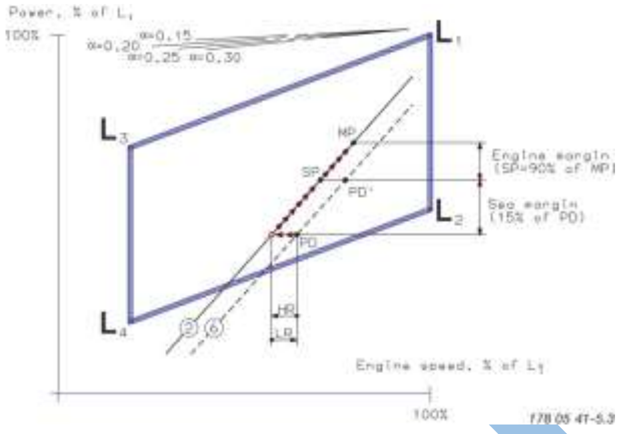
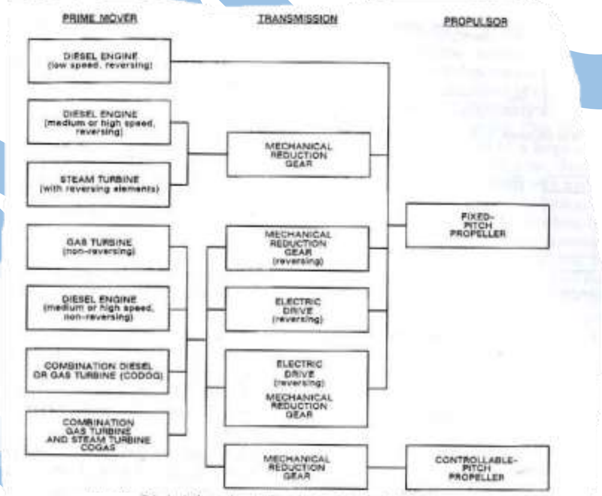
1. Full mission simulator (for various ship types) – training manuals
2. John B Woodward III (1976) Matching engine and propeller, 'The Diesel Engine: To Drive a Ship' Department of Naval Architecture and Marine Engineering Report No. 105, January 1971, College of Engineering the University of Michigan Ann Arbor, Michigan 48104.
3. Engine Selection Guides / Installation Guides – Various Engine Manufacturers – MAN, WinGD, Wartsila, MaK, Rolls Royce, ABB, Nishishiba.
4. Harvald, S. A. (1983). Resistance and Propulsion of Ships. United Kingdom: Wiley.

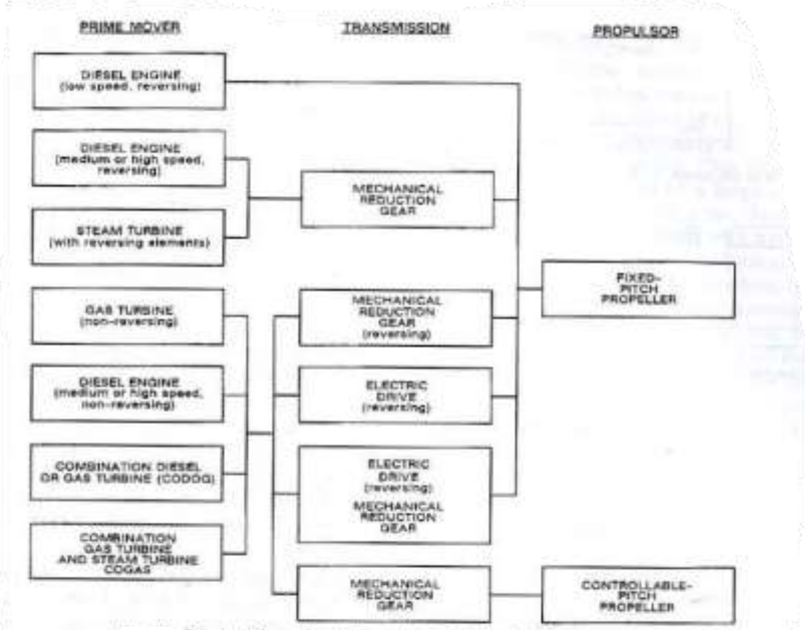
Reference:

1. Woodward, J.B. (1975). Marine Gas Turbines. United Kingdom: Wiley.
2. Harvald, S.A. (1983). Resistance and Propulsion of Ships. United Kingdom: Wiley.
3. Marine Diesel Standard Practices. (1982). (nap.): Diesel Engine Manuf. Assn.
4. McBirnie, S.C., Fox, W.J. (1970). Marine Steam Engines and Turbines. United Kingdom: Newnes-Butterworths.
5. Basic Principles of Ship Propulsion – Technical Article by MAN Diesel & Turbo - https://www.man-es.com/marine/products/planning-tools-and-downloads/technical-papers.
6. Hewitt, Wesley Charles (1972) Ship power plant selection, MIT https://archive.org/details/shippowerplantse00hewi/page/n35/mode/2up.
7. Marine Engineering – by group of authorities, Editor: Roy L Harrington, ISBN: 0-939773-10-4, SNAME (USA).
8. Principles of Naval Engineering, prepared by Bureau of Naval Personnel – NAVPERS 10788-B (Free version) - https://archive.org/details/principlesofnava00unit.
9. Hunt, E. C. (1999). Modern Marine Engineer's Manual. United State: Cornell Maritime Press.
10. John B Woodward (1980) Analysis of steam propulsion plants, The Dept. of NAME University of Michigan –Report No.108.

Table of Topics

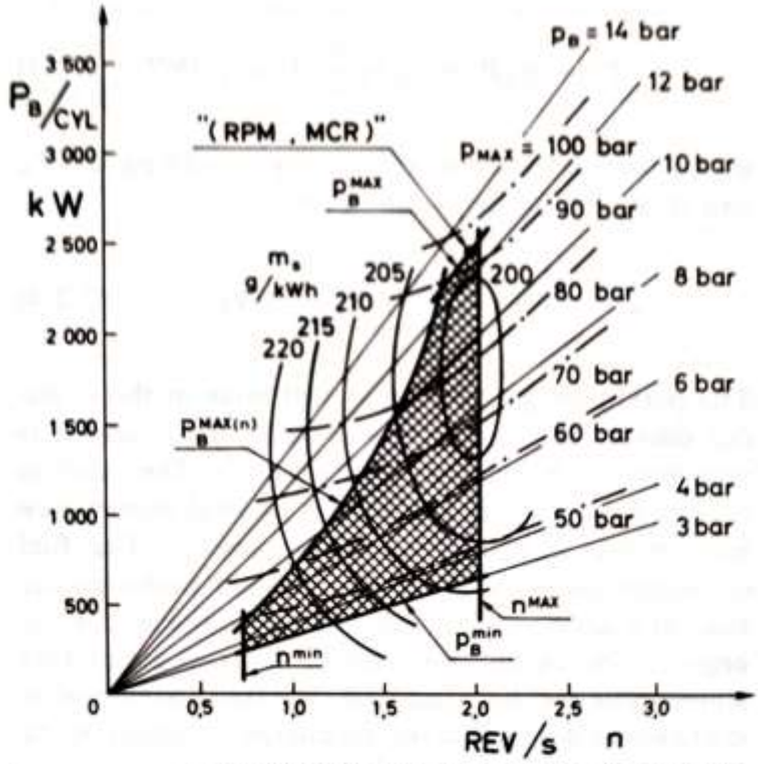
Section	Topics	Hours (P)
A	Propeller and Load diagrams	4
B	Propulsion Systems and configuration	3
C	Reduction Gearing Arrangements	6
D	Propulsion Characteristics of Diesel	4
E	Propulsion Characteristics of Steam Plant	3
F	Propulsion characteristics gas turbines	3
G	Propeller Curve Operation and CPP operation Ship	4
H	Propeller and Machinery Interaction	3
	Total	**30**

Section	Learning Objectives	Hours (P)
A	**Specific Learning Objectives:** 1. Refer to Theory Subject 603.  (Courtesy: A Molland and MAN B&W)	4
B	**Specific Learning Objectives:** 1. Refer to Theory Subject 603. Propulsion Systems and configuration: 1. Explain and analyse one example of each.  Principal alternatives in the selection of a propulsion arrangement	3
C	**Specific Learning Objectives:** 1. Refer to Theory Subject 603. **Reduction Gearing Arrangements:** 1. Explain and discuss the selection of reduction gearing for any one configuration (minimum) as a practical exercise	6

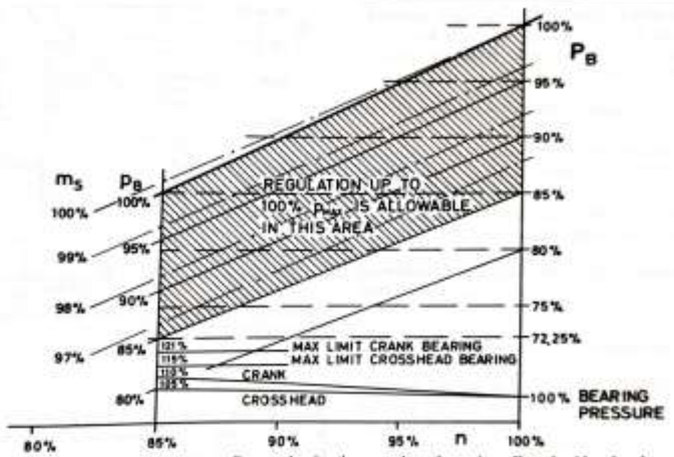
<table>
<tr><td></td><td>

Principal alternatives in the selection of a propulsion arrangement</td><td></td></tr>
<tr><td>D</td><td>Specific Learning Objectives:
1. Refer to Theory Subject 603.

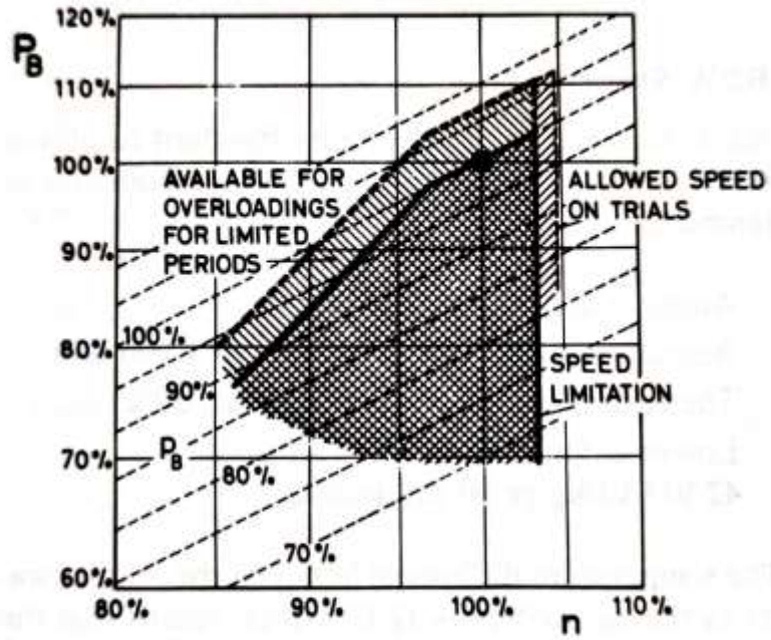
Propulsion Characteristics of Diesel
Explain the following and work on examples with data for selection of engine with parameters for a particular vessel:
• Engine Description
• Primary engine data
• Fuel operating modes and maps
• Operating conditions
  ○ Reference conditions
  ○ Design conditions
• Engine rating field and power range
  ○ Engine rating field
  ○ Power range limits
    ▪ 100% Torque Limit
    ▪ Overload Limit
    ▪ Speed Limit
    ▪ Over speed Limit
    ▪ Engine Operation Power Limit
    ▪ Transient Operation Power Limit
    ▪ Nominal Engine Characteristic
    ▪ Light Running Propeller Curve
    ▪ CMCR Power
    ▪ 110 % CMCR Power
    ▪ Engine Operation Power Range
    ▪ Overload Power Range
    ▪ Prohibited operation area</td><td>4</td></tr>
</table>



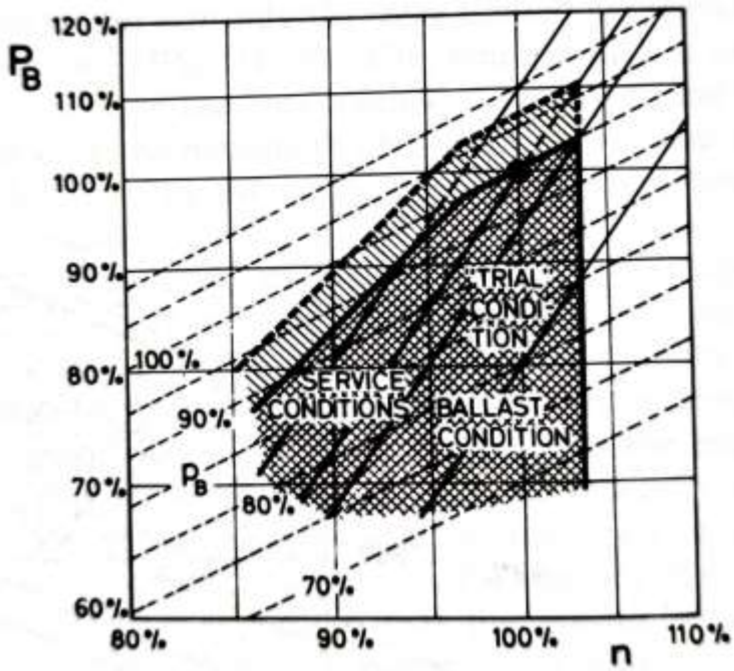
Rate of revolution versus power diagram for a two-stroke diesel engine.



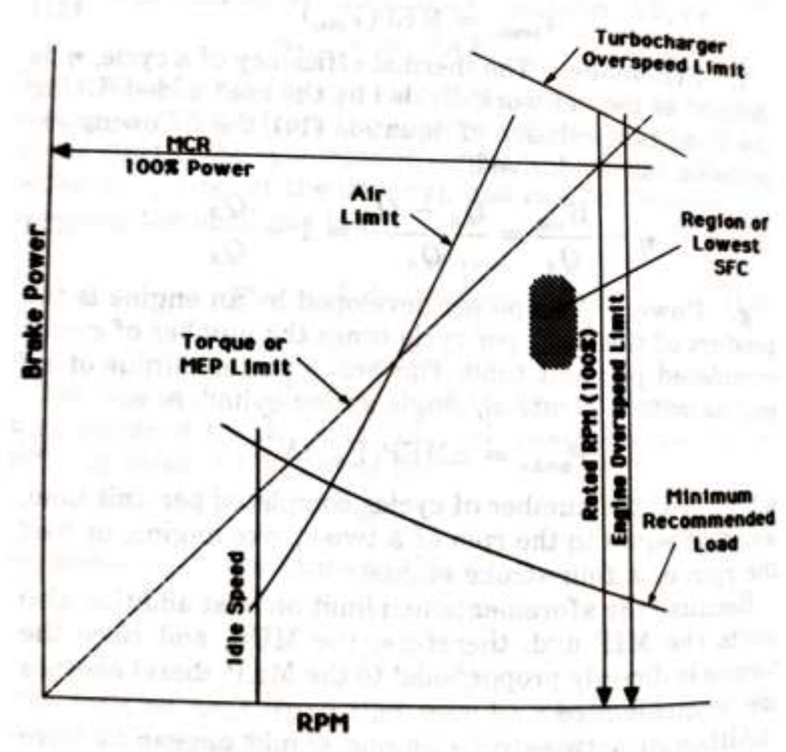
Rate of revolution versus power diagram showing the area where the engine will work with reduced mean effective pressure and reduced rate of revolution. The shaded area shows where the maximum pressure can be regulated up to the maximum value allowable, thus giving reduced specific fuel consumption (m_s).



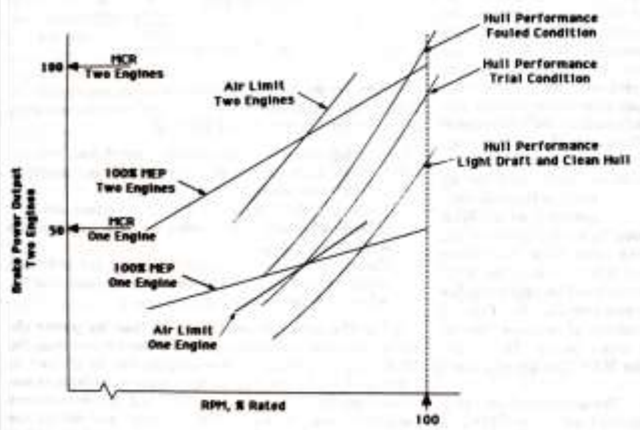
Logarithmic rate of revolution versus power diagram with area of overload shown.



Logarithmic rate of revolution versus power diagram for different ship conditions.



Engine performance limits



Speed-power curves for two engines geared to a single fixed-pitch propeller

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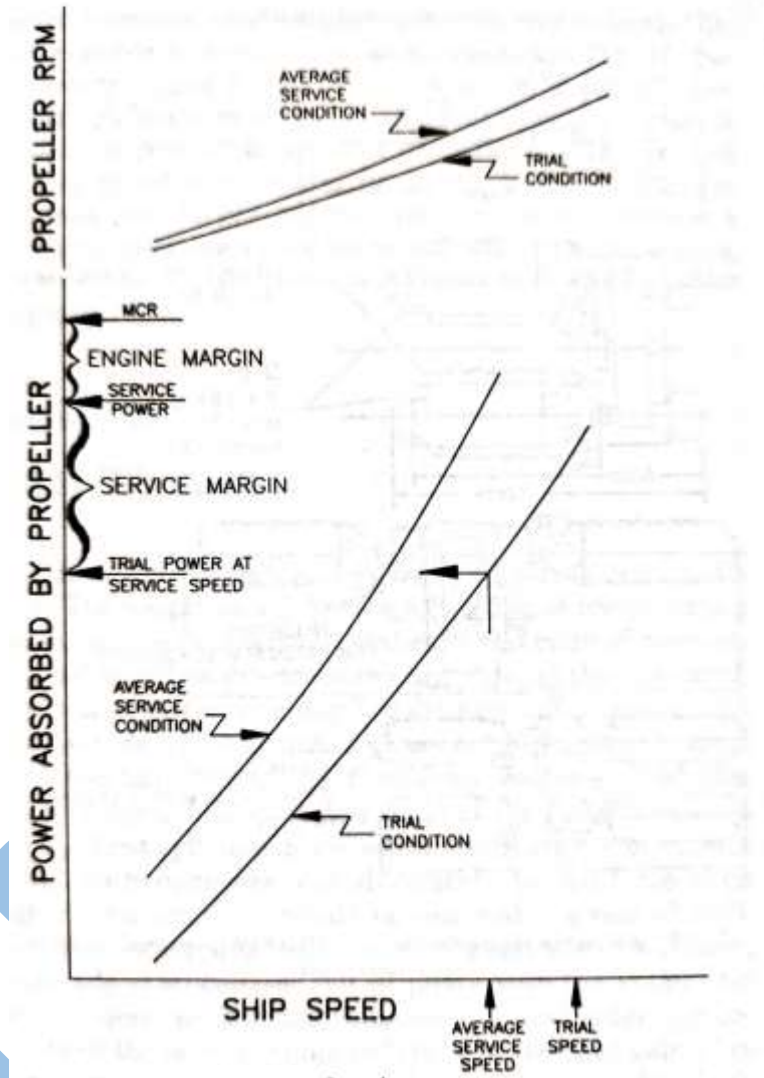

Speed-power curves

(Courtesy: Resistance and Propulsion of Ships, Sv.Aa Harvald (2013)and Marine Engineering, Harrington (Editor) SNAME (1992))
</td>
<td></td>
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<tr>
<td>E</td>
<td>

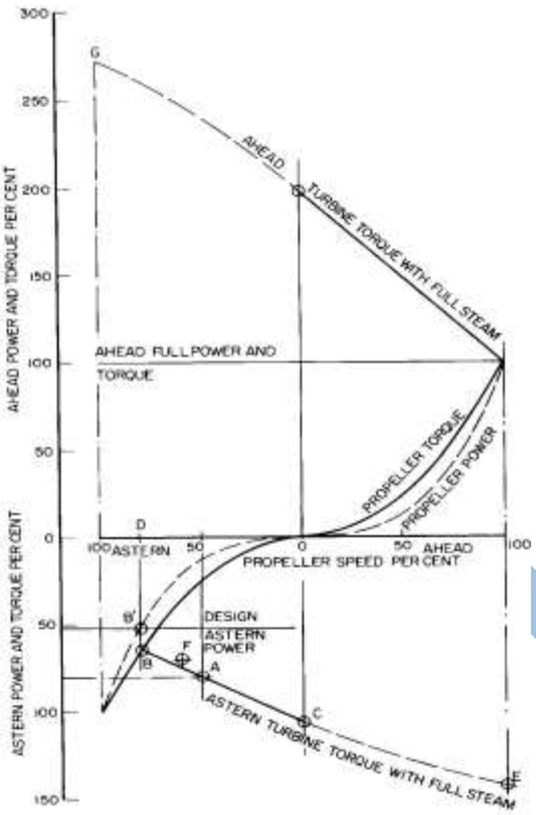
Specific Learning Objectives:

1. Refer to Theory Subject 603.

Propulsion Characteristics of Steam Plant:

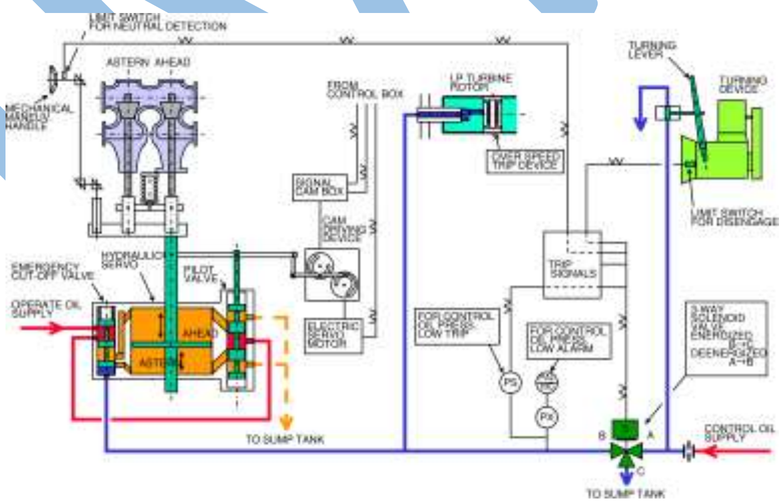
Explain the following and work on examples with data for selection of engine with parameters for a LNG vessel/crude tanker.

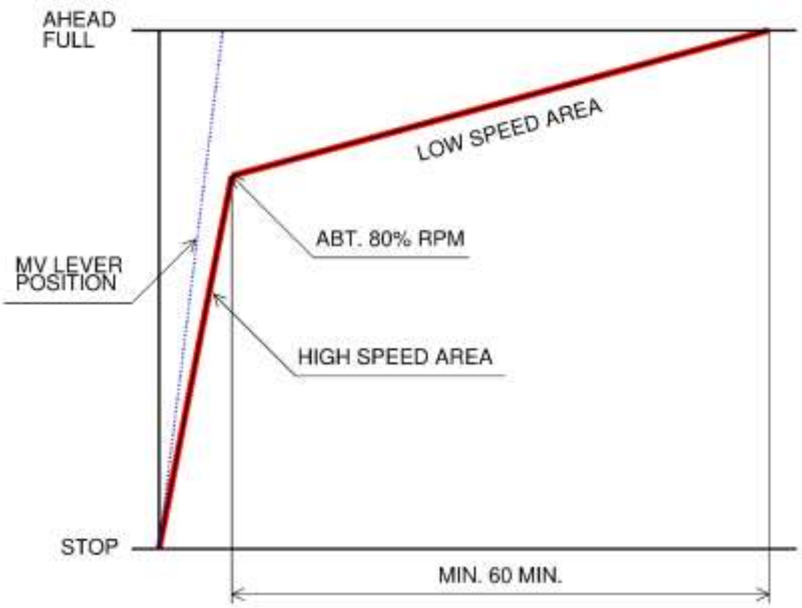
- Theoretical steam rate (TSR)
- Actual steam rate (ASR)
- Steam turbine governor control
- Performance of marine steam turbines at reduced power and at overload
- Nozzle control
- Combined throttling and nozzle control
- Bypass overload
- Reversal and Astern running
- Astern turbines
</td>
<td>3</td>
</tr>
</table>

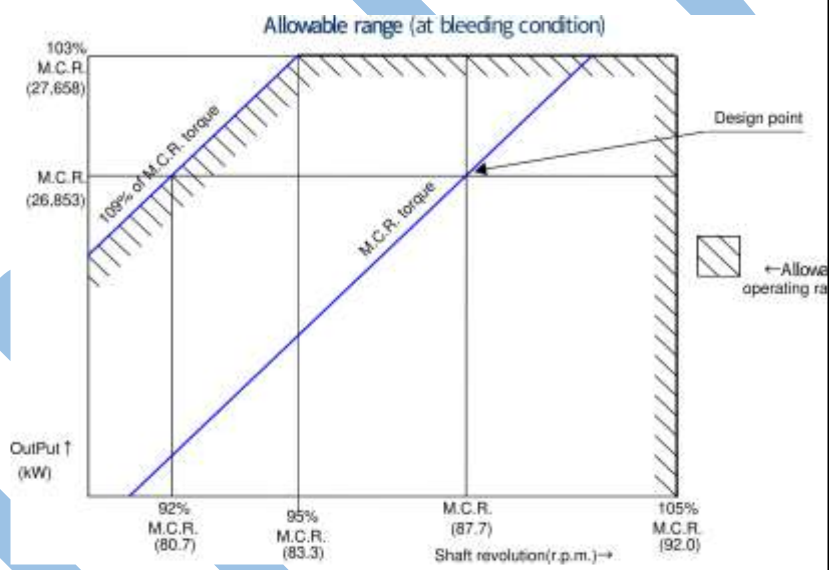


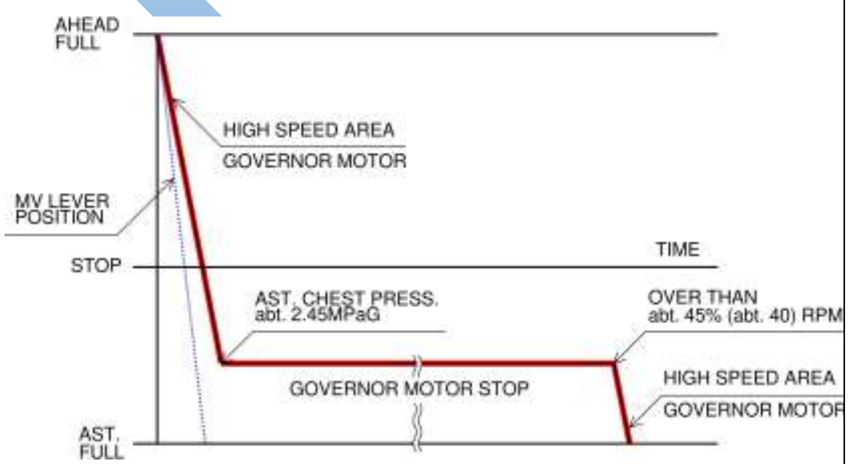
Ahead and astern turbine and propeller characteristics

(Courtesy: Marine Steam Engines and Turbines – SC McBirnie (1980))




AHEAD FULL
LOW SPEED AREA
ABT. 80% RPM
MV LEVER POSITION
HIGH SPEED AREA
STOP
MIN. 60 MIN.


Allowable range (at bleeding condition)
103% M.C.R. (27,658)
M.C.R. (26,853)
109% of M.C.R. torque
M.C.R. torque
Design point
←Allowa
operating ra
OutPut ↑ (kW)
92% M.C.R. (80.7)
95% M.C.R. (83.3)
M.C.R. (87.7)
105% M.C.R. (92.0)
Shaft revolution(r.p.m.)→


AHEAD FULL
HIGH SPEED AREA
GOVERNOR MOTOR
MV LEVER POSITION
TIME
STOP
AST. CHEST PRESS. abt. 2.45MPaG
OVER THAN abt. 45% (abt. 40) RPM
GOVERNOR MOTOR STOP
HIGH SPEED AREA
GOVERNOR MOTOR
AST. FULL

TYPE: KAWASAKI UA-400

Cross compound, impulse, double reduction geared marine turbine.

MAIN PARTICULARS:

		M.C.R.
Output	26,853 kW	
Revolution	H.P. Turbine	4,945 r.p.m.
	L.P. Turbine	3,264 r.p.m.
	Propeller	87.7 r.p.m.
Steam Pressure	5.74 MParG at maneuv. valve inlet	
Steam Temperature	520 °C ditto	
Condenser vacuum	5.07 KPaA (722 mmHg) at cond. top at Normal & maximum output with 27°C sea water inlet temperature	
Astern max. torque	80% of the M.C.R. ahead torque at 50% of the M.C.R. ahead r.p.m.	
Astern allowance max. continuous r.p.m.	70% of the M.C.R. ahead r.p.m. (61 r.p.m.)	
Ahead rotating direction	Clockwise looking from aft. side	
Main shaft critical speed at torsional vibration	29.62 r.p.m. & 58.47 r.p.m.	
Critical speeds of rotor (converting into mainshaft)	H.P. Turbine	abt. 64.0 r.p.m.
	L.P. Turbine	abt. 122.5 r.p.m.

(Courtesy: Kawasaki)

F

Specific Learning Objectives:

1. Refer to Theory Subject 603.

Propulsion characteristics gas turbines:

Explain the following and work on examples with data for selection of engine with parameters for a cruise ship:

1. Torque – rev/min and power – rev/min characteristics
2. Engine Rating
3. Fuel rate characteristics
4. Exhaust flow and temperature
5. Corrections

Axial compressor performance and matching (including dieselengines)

3

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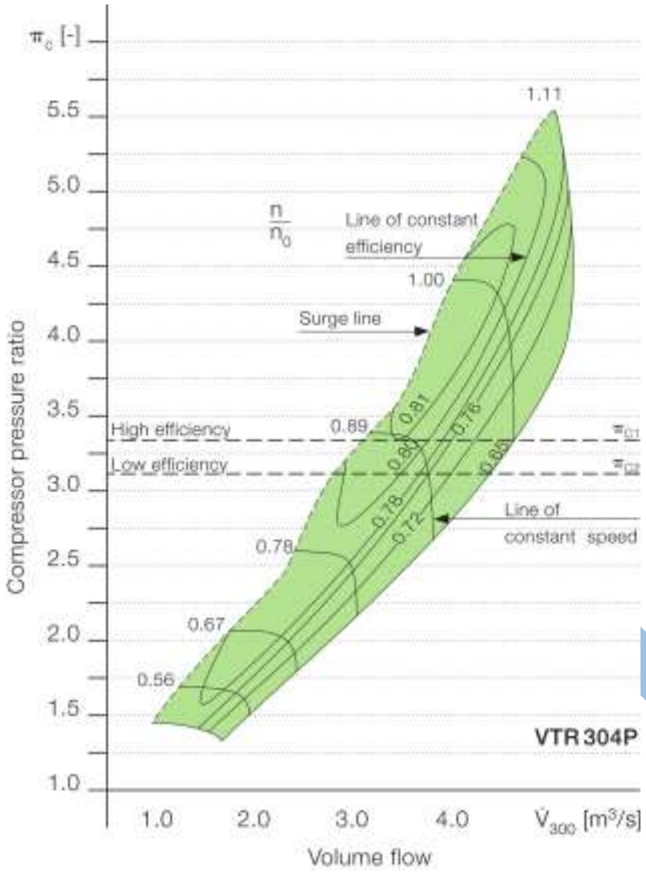
<tr><td></td><td>

Compressor characteristic.</td><td></td></tr>
<tr><td>G</td><td>Specific Learning Objectives:
1. Refer to Theory Subject 603.

Propeller Curve Operation and CPP operation:
Explain the following and work on examples with data for selection of engine with parameters for a feeder container ship:
1. CPP requirements for Propulsion Control System
2. Combinator mode for operation without shaft generator, orwith shaft generator and frequency control system. Any combinator curve including a suitable light running margincan be set in field A
3. Optional mode used in connection with shaft generators. During manoeuvring the combinator curve is freely selected in Field A. At sea, the engine is operated at constant speedon Line 12, between point F and CMCR</td><td>4</td></tr>
<tr><td>H</td><td>Specific Learning Objectives:
1. Refer to Theory Subject 603.

Ship Propeller and Machinery Interaction:
Explain the following and work on examples with data for selection of engine with parameters for different types of ships (Naval vessels may be considered):
1. Power – system principles
2. Matching Engine and Propeller; Multiple Engines
3. Off design operation – Low speed operation
4. Towing loads/Auxiliary loads
5. CODAG and CODOG</td><td>3</td></tr>
<tr><td></td><td>Total</td><td>30</td></tr>
</table>

Subject Name/Code: Technical Report Writing and Engineering Models (P) /609

Instructional Hours

Practical	: 25 hours
Total contact hours	: 25 hours
Credits	: 1

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam (Written/Presentation/Model assessment)	: 50%

Note: Records of exercises/Model making must be maintained.

Additional Information on Subject:

Relates to STCW Function.

Recommended Text:

1. Rizvi, M Ashraf. (2017). Effective Technical Communication. 2nd Edition McGraw Hill, New Delhi.
2. Kumar, Sanjay, and Pushp Lata. (2014). English for Effective Communication. Oxford University Press.

Reference:

1. Ship's Engine/Auxiliaries manuals.
2. Ship's Equipment Manuals.
3. Ship’s PMS examples.
4. Model making Videos.

Table of Topics

Section	Topics	Hours (P)
A	**Report writing on Engineering Publications** **Subtopic:** Engineering Publication and Report Writing	15
B	**Model Making on Marine Engineering areas** **Subtopic:** Engineering model making: decision making, planning and demonstrating	5
C	**Mathematical modelling using Simulink** **Subtopic:** Mathematical modelling using Simulink for an electrical/ mechanical system or component	5
	Total	**25**

Learning Objectives	P
A Report writing on Engineering Publications	
General Learning Objective: **(IMO 7.04.,2014: F1/1.2/1.2.1) P 37-51; P 52-53; P 62; P 84; P 126; P 170)** Understand approaches to using engineering publications and write Reports; interpret, analyse, describe, explain and produce reports. **Subtopic:** 1.1 Engineering Publication and Report Writing	
Specific Learning Objectives: 1.1 Engineering Publication and Report Writing 1.1.1 Discuss ABC (Accuracy, Brevity and Clarity) for Report Writing 1.1.2 Discuss the structure of an interpretive report 1.1.3 Identify, organize and list the points from the given document applying unity and coherence 1.1.4 Interpret and analyse the documents related to the engineering publications 1.1.5 Describe different aspects of report writing using documents related to the engineering publications 1.1.6 Write a report on the topic related to the engineering publications 1.1.7 Write a Report on status/malfunctioning of engine room machinery (main and auxiliary machinery) to Shipping Company/Superintendent 1.1.8 Write a maintenance Report based on given data proposing renewal/replacement/retrofit it of machinery etc. 1.1.9 Write a Report on the status of Pollution Prevention machinery 1.1.10 Discuss a preparation of a Report on a Technical issue as a Group (Case study/Group discussion mode may be adopted) (Use references for the engineering publications)	15

B - Model Making on Marine Engineering areas	
General Learning Objective: Build and demonstrate an engineering model related to the maritime environment and technology. **Subtopic:** 1.1 Engineering model making: decision making, planning and demonstrating	
Specific Learning Objectives: 1.1 Engineering model making: decision making, planning and demonstrating 1.1.1 Describe the process of decision making on the topic of model making 1.1.2 Explain the process of model making on the selected topic- topic selection, team selection, planning and execution 1.1.3 Develop an engineering model on the selected topic 1.1.4 Demonstrate the engineering model on the selected topic 1.1.5 Write a report on the given topic	5
C - Mathematical modelling using Simulink	
General Learning Objective: Develop a mathematical model using Simulink for an electrical/mechanical system or component. **Subtopic:** 1.1 Mathematical modelling using Simulink for an electrical/mechanical system or component	
Specific Learning Objectives: 1.1 Mathematical modelling using Simulink for an electrical/mechanical system or component 1.1.1 Explain the application of Simulink in mathematical model making. 1.1.2 Develop a mathematical model using Simulink for an electrical/mechanical system or component 1.1.3 Demonstrate the model using Simulink on the selected topic. 1.1.4 Write a report on the given topic	5

Subject Name/Code: Practical Hydraulics and Pneumatics (P)/610

Instructional hours:

Practical	: 45 hours
Total contact hours	: 45 hours
Credits	: 2

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Practical Exam	: 50%

Additional Information on Subject:

1. Pre-requisites: Fluid mechanics fundamentals, Construction & Operating principles of positive displacement pumps, Thermodynamics of air compression, Construction & operation of air compressors and service/control air system.

Recommended Text:

1. Andrew Parr – Hydraulics and Pneumatics, 3rd Edition, Elsevier.
2. Vickers Industrial Hydraulics Manual, Vickers.

Table of Topics

Section	Topics	Hours (P)
A1-A8	Hydraulics **Sub topics**: Introduction to Hydraulics, Hydraulic System Components, Hydraulic Fluids, Hydraulic Piping and Sealing, Filters, Servo and Proportional Valves, Maintenance & Troubleshooting, Industrial Hydraulic Circuits	31
B1-B5	Pneumatics **Sub topics**: Introduction to Pneumatics, Pneumatic System Components, Maintenance & Troubleshooting, Industrial Pneumatic Circuits, Simulation tools	14
	Total	**45**

Learning Objectives	P
A. Hydraulics **General Learning Objective (GLO):** To understand and operate hydraulic systems. (Vickers Industrial Hydraulics Manual) **(IMO 7.02 -1.3.3.12, 7.01-2.1.5; IMO 7.04 -1.4.1.09, 1.4.1.10, 2.2.3.8, 3.2.7)** **Sub-topics and SLOs** 1 Introduction to Hydraulics: Relationship between force & pressure, Pascal's Law 2 Hydraulic System Components 3 Hydraulic Fluids 4 Hydraulic piping and sealing 5 Filters 6 Servo valves & Proportional valves 7 Maintenance & troubleshooting in Hydraulic systems 8 Industrial Hydraulic Circuits	
Specific Learning Objectives: Explain the following: **1. Introduction to Hydraulics: Relationship between force & pressure, Pascal's Law** 1.1 Non-compressibility of liquids 1.2 Pressure intensification explained with Conservation of Energy principle 1.3 Definition of Hydraulics, Purpose of hydraulic systems, Hydraulic system for power transmission, 1.4 Basic components of a hydraulic system 1.5 Block Diagram of a hydraulic system 1.6 Advantages of Hydraulic system, On-board applications 1.7 How pressure is created in a hydraulic system, Pressure drop through an orifice, Pressure drop increases with reduced pipe diameter 1.8 Flow velocity through pipes, 1.9 Relationship between hydraulic pressure and load on actuator, Relationship between hydraulic fluid flow rate and speed of an actuator 1.10 Pipe size requirements of hydraulic systems, Pipe size ratings 1.11 Power and Torque output of a hydraulic actuator 1.12 Concept of Absolute and Gauge pressure	2

Specific Learning Objectives: Explain the following: **2.Hydraulic System Components: Types, construction, purpose and graphical symbols of the hydraulic system components.** 2.1 Hydraulic system reservoir: Internal baffle plate, oil return line, return line magnetic filters, oil drain line, pump suction with strainer, air breather and filler, oil gauge glass, manhole/hand hole for access, thermometer, drain plug/valve, Size/capacity of reservoir, heat transfer area 2.2 Filters: Filters & strainers, purpose, Location & types 2.3 Heat exchangers: Purpose, location & types, Natural convection cooling, forced cooling – air cooled, water cooled 2.4 Pumps: Types of pumps – Vane type-balanced and un-balanced type, gear pump, lobe pump, radial piston pump, axial piston pump, fixed delivery &variable delivery variants of pumps. Construction & working of swash plate type of pump, Pressure compensation, Pressure compensated swash plate type pump. Pump ratings, displacement, delivery, volumetric efficiency 2.5 Accumulators: Weighted, Bladder, Piston and other types of accumulators – Construction, Purpose and operation of accumulators 2.6 Direction Control Valves: Construction, operation, application and graphical symbols of various types of DCVs – poppet, rotary spool & sliding spool type, based on no. of flow paths-2-way, 3-way, 4-way etc., based on method of actuation cam, manual, mechanical, solenoid, pneumatic, hydraulic or combination. Check valve, pilot operated check valves. Spool centre positions for linear spool DCVs 2.7 Flow control – Needle valves, Check-choke valves, Pressure & temperature compensated flow control, Meter-in, Meter-out and bleed-off flow control 2.8 Pressure control – Relief Valves-Simple and compound relief, unloading valve, Sequence valves, Counter balance valves, Pressure reducing valves, Regulating valves, Brake valves 2.9 Actuators: Linear, Rotary & Semi rotary actuators 2.10Linear actuators: Overview, application and graphical symbols of Single acting, double acting – differential & non-differential cylinders, ram type and piston type actuators, solid type & telescoping type cylinders. Cushioned and variable cushioning cylinders 2.11Rotary actuators (motors): Displacement, torque and pressure ratings of hydraulic motors Types of motors: Gear, vane, axial piston, radial piston motors, Pressure compensation 2.12Distributors, Pipes & Hoses 2.13Instrumentation: Pressure gauges, pressure switches, thermometers, flow meters 2.14Examples of Actual hydraulic circuit with all major components 2.15Cut-away sections of components explained	9.5
Specific Learning Objectives: Explain the following: **3. Hydraulic Fluids** 3.1 Purpose/significance of hydraulic fluid 3.2 Properties-definition & significance of Viscosity-Absolute & Kinematic, SAE number, Viscosity Index, Pour point, Lubricity, Oxidation Resistance, Rust & Corrosion Prevention, Demulsibility, Additives 3.3 Additives-compatibility with seals 3.4 Types of hydraulic fluids: Fire resistant – Water-glycols, Water-oil emulsions, Synthetics 3.5 Storage, handling, maintenance 3.6 Condition monitoring of hydraulic fluids: Debris analysis, Viscosity, Water percentage tests	2

Specific Learning Objectives: Explain the following: **4.Hydraulic piping and sealing** 4.1 Tubing, Sealing of tubes by Flaring, Sleeve or O-ring compression fittings 4.2 Straight thread O-ring connector, Ferrule compression fitting 4.3 Flexible hoses – construction, pressure rating, sealing, safety 4.4 Pipes– Taper threads, Compression O-ring seals 4.5 Sealing of hydraulic components: Types of sealing mechanism. Static seals, Dynamic seals, Importance of back-up rings in hydraulic sealing, Example of Fuel pump seals with back-up rings, Lip seals, Cup seals, T-seals, Piston rings, Labyrinth seals, V-type compression seal, Seal materials, Seal maintenance	2.5
Specific Learning Objectives: Explain the following: **5.Filters** 5.1 Types of filters based on flow and location of filter- Pressure line filters, return line filters, by-pass filters, Full flow filters, Proportional flow filter, Surface filters, depth filters, edge type filters, Filters with indicators 5.2 Mesh Size-Nominal and Absolute rating 5.3 Beta Ratio, 5.4 Pressure rating 5.5 Flow rating 5.6 Pressure drop across filters 5.7 Filter protection against blocking 5.8 Types of filtering material – Mechanical filters, Absorbent filters, Adsorbent filters	3.5
Specific Learning Objectives: Explain the following: **6.Servo valves & Proportional valves** 6.1 Servo Valves-Purpose, construction, operation 6.2 Servo Valves- Types- Mechanical, Electro-hydraulic servo valves 6.3 Proportional DCVs	1.5
Specific Learning Objectives: Explain the following: **7.Maintenance & troubleshooting in Hydraulic systems (Hydraulic Hints &Trouble Shooting Guide, Vickers)** 7.1 Excessive noise 7.2 Excessive heat 7.3 Incorrect flow 7.4 Incorrect pressure 7.5 Faulty, Jerky or sluggish operation 7.6 Contamination control 7.7 Aeration 7.8 Leakage control	2
Specific Learning Objectives: Explain the following: **8.Industrial Hydraulic Circuits** 8.1 Unloading circuits 8.2 Extension and retraction of a linear cylinder	8

8.3 Meter-in and meter-out flow control 8.4 Lifting and lowering a load cylinder 8.5 Pilot operated DCV 8.6 Check valve significance in holding a load 8.7 Pilot operated check valve 8.8 Clamping and Sequencing circuits 8.9 Counterbalance circuits 8.10 Braking circuit 8.11 Rotary motor	
B. PNEUMATICS **General Learning Objective (GLO):** Understand and operate pneumatic systems. (Hydraulics & Pneumatics by Andrew Parr) **(IMO 7.02 -1.3.3.12, 7.01-2.1.5)** **(IMO 7.04 -1.4.1.09, 1.4.1.10, 2.2.3.8, 3.2.7)**	
Specific Learning Objectives: Explain the following: **1.Introduction to Pneumatics** 1.1 Definition, Purpose 1.2 Typical Pneumatic system components, block diagram of Pneumatic system 1.3 Comparison of Hydraulic and Pneumatic system 1.4 Application of Pneumatics in Industry and on board ships	1
Specific Learning Objectives: Explain the following: **2.Pneumatic system components** 2.1 Compressors: Overview of types of Compressors-Reciprocating type-single acting, double acting, single stage, two-stage, tandem type; Screw type, Vane type, Lobe type, Centrifugal type. Unloaders, Air compressor safeties and instrumentation 2.2 Oil separators 2.3 Reservoirs: Construction, mountings and instrumentation 2.4 Air treatment: Filters, Driers, Lubricators, Pressure Regulators, FRC unit, FRL unit 2.5 Relief valves 2.6 DCVs, Other control valves – Logic valves, check valves, time delay valves 2.7 Actuators – Linear, Rotary, semi-rotary 2.8 Graphic symbols of various components	4
Specific Learning Objectives: Explain the following: **3.Maintenance & troubleshooting in Pneumatic system** 3.1 Excessive moisture 3.2 Oil carryover 3.3 Dust 3.4 Safety, alarms and trips Poor compressor performance – specific cases of dirty intercooler, after cooler or suction/discharge valve leaky 3.5 DCV wear out and seal leakage 3.6 Actuator internal and external leakages and seal wear out	2
Specific Learning Objectives: Explain the following: **4.Industrial Pneumatic circuits** 4.1 Shuttle valve operation- operating a cylinder from two locations	5

4.2 Embossing application 4.3 Sequencing Circuit-Oscillating cylinder 4.4 Memory Function circuit 4.5 Delay function circuit 4.6 Flow control circuit 4.7 Logic circuits – AND, OR, NOT function circuits 4.8 Practical Starting and Manoeuvring interlock circuit-MAN B&W	
Specific Learning Objectives: Demonstrate the following: **5.Simulation tools** Overview and exposure to hydraulic and pneumatic system simulation using simulation software like Automation Studio, Fluidsim, SimulationX	2

SEMESTER 7

Subject Name/Code: Piping and Pumping Systems: Design and Operation /701

Instructional hours:

Lecture	: 30 hours
Tutorial	: 15 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, practical in workshops and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Pre-requisites**:** Basic engineering drawing and workshop technology.

Recommended Text:

1. Board of Editors: Pumps: Principles & Practice, Jaico Publishing House.
2. Board of Editors: Pipes & Pipelines: Principles & Practice, Jaico Publishing House.

Reference:

1. A. Nourbakhsh, A. Jaumotte, C. Hirsch & H. B. Parizi: Turbo-pumps & Pumping Systems, Springer.
2. H. D. McGeorge: Marine Auxiliary Machinery, Butterworth-Heinemann.
3. T. L. Henshaw: Reciprocating Pumps, OSTI, USA.
4. A. J. Stepanoff: Centrifugal & Axial Flow Pumps, Krieger Publishing Company.
5. Crawford, J. (2016). Marine and Offshore Pumping and Piping Systems. United Kingdom: Elsevier Science.
6. Flow of fluids through valves, fittings and pipe, Metric Edition – SI Units, CRANE Co., New York (1982), Technical Paper No. 410M.
7. Pumps, S. (2013). Sulzer Centrifugal Pump Handbook. United Kingdom: Elsevier Science.
8. Marine Engineering – by group of authorities, Editor: Roy L Harrington, ISBN: 0-939773-10-4, SNAME (USA).

Table of Topics

Section	Topics	Hours (L:T)
A	Pumping System Principles **Sub Topics**: Principles of Pumping System	4:0
B	Pump Types **Sub Topics**: Various types of pumps and their design	10:5
C	Major System Components & Features **Sub Topics**: Various components and design features of piping systems	10:4
D	Operation of Pumping Systems **Sub Topics:** Operational requirements and issues of pumping systems	2: 3
E	Operating Faults **Sub Topics**: Faults during operation of pumps	4: 3
	Total	**30: 15**

Learning Objectives	L : T
A. Pumping System Principles **General Learning Objective** Understand the function of a pump, losses of head & factors affecting pump performance. **Sub topics & SLOs** 1. 1 Function of a pump 1.2 Losses of head in a pumping system 1.3 Factors affecting pump performance	
Specific Learning Objectives: **IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46** **1.1 Function of a pump** 1.1.1 State that the function of a pump is to transfer fluid between two given points	0.5 : 0
Specific Learning Objectives: **IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46** **1.2 Losses of head in a pumping system** 1.2.1 List the losses of head in a pumping system	2 : 0
Specific Learning Objectives: **IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46** **1.3 Factors affecting pump performance** 1.3.1 State that the viscosity of the fluid to be pumped must be within the range specified in the pump design. 1.3.2. State that performance deteriorates if the viscosity of the fluid increases 1.3.3 State that performance will deteriorate if the temperature of the liquid being handled approaches that at which vapour is produced at the pressure in the suction pipe	1.5 : 0

B. Pump Types

General Learning Objective

Understand working principles of various pumps on board with Sketch, materials used, types of shaft seals, characteristics of performance, bearings, couplings and safety precautions.

Sub Topic: Various types of pumps and their design

Sub-sub topics & SLOs

1.1. Types of pumps used on ships and their purposes
1.2. Principles and construction of centrifugal pumps
1.3. Characteristics of a centrifugal pump
1.4. principle of an ejector pump
1.5. Water ring air pump
1.6. Axial-flow pump
1.7. Materials used for major parts of pumps
1.8. Shaft gland packing, mechanical seal & lip seal
1.9. Pump bearings and methods of lubrication
1.10. Muff and flange type couplings, and their alignment
1.11. Positive displacement pumps: working principle, relief valve, characteristics, safety
1.12. Rotary displacement pumps: working principle of a gear pump, rotary vane pump, and a screw-displacement pump; fault finding, safety procedure

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Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46

1.1. types of pumps used on ships and their purposes

1.1.1 Name the types of pumps generally used on ships and the purposes for which they are normally used

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Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46;
IMO MC 7.04/2014: F3/3.2.3/3.1/3.2/3.3/3.4/3.5/Page 144

1.2. Principles and construction of centrifugal pumps

1.2.1Explain the principles of a centrifugal pump, referring to the purpose of:
– the impeller
– the diffuser or volute
1.2.2 Make a single line sketch of a vertical single-entry centrifugal pump
1.2.3 Explain what is meant by a ‘single-entry' and a ‘double entry' impeller
1.2.4 Describe the arrangement of a vertical multi-stage single-entry centrifugal pump
1.2.5 Describe special duty pumps and requirements (e.g., cargo pumps; Framo pumps etc.)

Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46

10: 5

1.3. Characteristics of a centrifugal pump

1.3.1 Describe the characteristics of a centrifugal pump, referring to:
- suction lift
- priming
- discharge pressure
- vapour or gas in the fluid being pumped

1.3.2 Describe the important fits and clearances in centrifugal pumps, and how to measure and adjust them

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Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46

1.4. Principle of an ejector pump

1.4.1 Explain the principle of an ejector pump

Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46;
IMO MC 7.02/2014: F1/1.4.1/1.1/Page 66

1.5. Water ring air pump 1.5.1 State that, if there is no positive head at the inlet to a centrifugal pump, a priming device must be used 1.5.2 Explain why and when priming and/or air extraction is necessary and Make single line Sketch of a water ring air pump 1.5.3 Make a single line sketch of a central priming system and explain its working and advantages	
Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46 **1.6. Axial-flow pump** 1.6.1 Describe the principles of operation of an axial-flow pump 1.6.2 Describe the type of duty best suited to an axial-flow pump	
Specific Learning Objectives: IMO MC 7.04/2014: F3/3.2.5/5.1/5.3/Page 148-149 **1.7. Materials used for major parts of pumps** 1.7.1 Explain what materials are used for constructing major parts of the following equipment of pumps: -impeller, casing, shaft, casing ring, sleeve, gear, screw, piston/bucket ring	
Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.5.1/Page 63; **IMO MC 7.04/2014: F3/3.1.7/Page 141** **1.8. Shaft gland packing, mechanical seal & oil seal** 1.8.1 Explain the construction, working of a soft-packed gland with a single line drawing 1.8.2 Explain the construction, working of a simple mechanical seal with a single line drawing 1.8.3 Explain the construction, working of an oil seal with a single line drawing 1.8.4 Explain the attention necessary of ensure the satisfactory operation of shaft gland packing and seals	
Specific Learning Objectives: IMO MC 7.04/2014: F3/3.2.5/5.1/5.3/Page 148-149 **1.9. Pump bearings and methods of lubrication** 1.9.1 Bush (plain) bearing 1.9.1.1 Explain the arrangements and design characteristics of bush type pump bearings 1.9.1.2 Explain methods of lubrication and ideal properties of lubricating oil 1.9.1.3 Describe the reasons for using linings of white metal, copper-led alloys, lead bronzes tin bronzes, gun metals and aluminium based alloys 1.9.2 Ball and Roller bearings 1.9.2.1Explain the arrangements and design characteristics of ball type and roller type pump bearings. 1.9.2.2 Compare the load-carrying abilities of ball and roller bearings. 1.9.2.3 Compare the ability of ball and roller bearings to carry radial and axial loads. 1.9.2.4 State the type of bearing suitable for shafts subject to angular misalignments 1.9.2.5 Describe how ball and roller bearings are lubricated 1.9.2.6 State the proportion of available volume to be filled when using grease 1.9.2.7 State the maximum height of lubricant in a stationery bearing when using oil	
Specific Learning Objectives: **1.10. Muff and flange type couplings, and their alignment** 1.10.1 Explain the arrangement of muff and flange type couplings, and the principles of checking and correcting alignment	
Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46; **IMO MC 7.04/2014: F3/3.2.3/3.1/3.2/3.3/3.4/3.5/Page 144** **1.11. Positive displacement pumps: working principle, relief valve, characteristics, safety**	

1.11.1 Explain the basic action of a displacement pump 1.11.2 Explain the necessity for a relief valve to be fitted in the discharge of any displacement pump 1.11.3 State that when a pump is handling oil or other hazardous material any discharge from the relief valve must be contained within the pumping system 1.11.4 Describe, with the aid of diagrams, how a reciprocating displacement pump works 1.11.5 Explain the purpose of an air vessel fitted to the discharge 1.11.6 Describe the characteristics of a reciprocating pump, referring to: – suction lift – priming – discharge pressure - vapour, or gas, in the fluid being pumped 1.11.7 Describe the important fits and clearances in reciprocating pumps, and how to measure and adjust them 1.11.8 Describe fault finding, safety procedures wrt reciprocating pumps	
Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46; IMO MC 7.04/2014: F3/3.2.3/3.1/3.2/3.3/3.4/3.5/Page 144 **1.12 Rotary displacement pumps: working principle of a gear pump, rotary vane pump, and a screw-displacement pump; fault finding, safety procedure** 1.12.1 Explain the principle of rotary displacement pumps 1.12.2 Sketch a single line diagram to show the principle parts of a gear pump and explain its working 1.12.3 Sketch a single line diagram to show the principle parts of a rotary vane pump and explain its working 1.12.4 Sketch a single line diagram to show the principle parts of a screw-displacement pump and explain its working 1.12.5 Describe fault finding, safety procedures wrt rotary displacement pumps	
C. Major System Components & Features **General Learning Objective** Understand piping layouts requirements, fittings, pressure ratings of pipes, materials used, colour coding of pipes and constructional features. **Sub Topic: Various components and design features of piping systems** **Sub-sub topics & SLOs** 1.1 Essentials of piping layout 1.2 Various pipe fittings 1.3 Pressure ratings 1.4 Materials used for sealing joints to join lengths of pipes together 1.5 Pipe colour-coding 1.6 Main constructional features, applications, and materials of valves used on board	
Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.9/Page 54 **1.1 Essentials of piping layout** 1.1.1 Describe main features of layout of system piping, including draining, venting, supporting (to reduce vibration) and expansion and contraction arrangements.	10: 4
Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.9/Page 54; IMO MC 7.04/2014: F3/3.1.7/Page 141 **1.2 Various pipe fittings** 1.2.1 Describe types of flanges & their attachment to the pipes, gaskets for fluids common to ships, blanking of flanges 1.2.2 Describe standard fittings (bends, reducers, T & angle branch pieces, bulkhead penetrations, instrument bosses and pockets)	
Specific Learning Objectives:	

1.3 Pressure ratings 1.3.1 Describe pipe dimensions (Dn, OD, ID) and pressure ratings (Schedule No)	
Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.9/Page 54; IMO MC 7.04/2014: F3/3.1.7/Page 141 **1.4 Materials used for sealing joints to join lengths of pipes together** 1.4.1 Describe materials used for construction of pipes carrying fluids: steam, seawater, fire main, bilge, ballast, starting air and control air 1.4.2 Describe materials used for sealing joints (gaskets) to join lengths of pipes together carrying fluids: steam, seawater, fire main, bilge, ballast, starting air and control air	
Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.9/Page 54 **1.5 Pipe colour-coding** 1.5.1 Describe pipe system marking/colour-coding	
Specific Learning Objectives: **IMO MC 7.04/2014: F3/3.2.5/5.1/5.3/Page 148-149;** **IMO MC 7.04, 2014: F1/1.4.1/1.9/Page 54;** **IMO MC 7.04/2014: F3/3.2.3/3.1/3.2/3.3/3.4/3.5/Page 144** **1.6 Main constructional features, applications, and materials of valves used on board** 1.6.1 Describe the main constructional features, applications, and materials of the types of valves found on board ship: 1.6.1.1 Globe valve and SDNRV 1.6.1.2 Angle valve, Angle- check valve and foot valve 1.6.1.3 Gate valve 1.6.1.4 Ball and plug valve 1.6.1.5 Butterfly valve 1.6.1.6 Quick-closing valve 1.6.1.7 Relief valves 1.6.1.8 pressure/temperature/flow-regulating valves. 1.6.2 Describe valve pressure class and markings. 1.6.3 Describe miscellaneous fittings: changeover sea chest, mud-box	
D Operation of Pumping Systems **General Learning Objective** Understand pumping operations, starting and stopping of pumps and performance loss of pumps **Sub Topic: Operational requirements and issues of pumping systems** **Sub-sub topics & SLOs** 1.1 Routine pumping operations 1.2 Procedure for starting and stopping positive displacement pumps, axial-flow pumps and centrifugal pumps 1.3 Loss of performance of a pump	
Specific Learning Objectives: IMO MC 7.04, 2014: F1/1.4.1/1.6/Page 45-46; IMO MC 7.04, 2014: F1/1.5.2/Page 63 **1.1 Routine pumping operations** 1.1.1 State that permission should be obtained before any fluids are moved which might affect the stability of the ship and cause pollution overboard 1.1.2 State the need to understand the pipe lines constructing pumping systems to be daily used in order to maintain the normal operation of the plant 1.1.3 State that the status of valves concerned in both manual and automatic pumping systems must be periodically checked	2: 3

1.1.4 State that any operation of pumping systems should be recorded in such a routine works record book	
Specific Learning Objectives: **IMO MC 7.04, 2014: F1/1.5.1/Page 63** **1.2 Procedure for starting and stopping positive displacement pumps, axial-flow pumps and centrifugal pumps** 1.2.1 Describe or performs the correct procedure for starting up and stopping: - positive-displacement pumps - axial-flow pumps - centrifugal pumps, making reference to: - suction valves - discharge valves - priming	
Specific Learning Objectives: **IMO MC 7.04, 2014: F1/1.5.1/Page 63; IMO MC 7.02/2014: F1/1.4.1/1.1/Page 66** **1.3 Loss of performance of a pump** 1.3.1 Explain possible reasons for a loss of performance of a pump	
E. Operating Faults **General Learning Objective** Understand precautions and procedures for cooling sea water system wrt air ingress and dirty filters. **Sub Topic: Faults during operation of pumps** **Sub-sub topics & SLOs** 1.1 Precautions & procedures for cooling seawater system in case of air ingress & clogged strainers	4: 3
Specific Learning Objectives: **IMO MC 7.02/2014: F1/1.4.1/1.1/Page 66** **1.1 Precautions & procedures for cooling seawater system in case of air ingress & clogged strainers** 11.1 Explain precautions/procedures to be taken for the cooling seawater system in case of air ingress. 1.1.2 Explain precautions/procedures to be taken for the cooling seawater system in case of clogged strainers/filters.	

Subject Name/Code: PLC and Automation Control /702

Instructional Hours

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	**:** 3

Teaching Methods

The course shall be conducted with classroom lectures, practical and self–learning.

Assessment Methods **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Fundamentals of Microprocessor and Microcontroller, Ram, B. Dhanpat Rai.
2. Programmable Logic Controller Regh, JA Pearson.
3. Marine Control Technology 4h Edition; By J. Majumder, Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN: 9789352139682.
4. Applied Marine Control and Automation; By J. Majumder, Elstan A. Fernandez, Mahesh Patil; Publisher: Shroff Publishers and Distributors; Year: 2019; ISBN: 9789352139194.

Reference:

1. Digital Control System and State Variable; By Gopal M; Publisher Tata McGraw Hill.
2. Digital Control System by Kuo B.C.; Publisher Oxford University Press, London.
3. Marine Control Practice by D.A. Taylor, Publisher Butterworth and Co. Ltd. London.

Table of Topics

Section	Topics	Hours (L)
A1	**Diesel Engines** **Sub-Topics:** Monitoring and Control of Main Diesel Engines	3
B1	**Steam Turbines** **Sub-Topics:** Monitoring and Control of Steam Turbines	2
C1	**Gas Turbines** **Sub-Topics:** Monitoring and Control of Gas Turbines	2
D1	**Generator and Distribution System** **Sub-Topics:** Monitoring and Control of Generator and Distribution System	3
E1	**Steam Boiler** **Sub-Topics:** Monitoring and Control of Steam Boilers	3
F1	**Oil Purifier** **Sub-Topics:** Monitoring and Control of Oil purifiers	2
G1	**Refrigeration and Air Conditioning System** **Sub-Topics:** Monitoring and Control of Refrigeration and Air Conditioning Systems	2
H1	**Pumping and Piping System** **Sub-Topics:** Automation, Monitoring and Alarms of Pumping and Piping System	2
I1	**Steering Gear System** **Sub-Topics:** Salient Features for the Control of Steering Systems	3
J1	**Cargo Handling Equipment and Deck Machinery** **Sub-Topics:** Functions and Mechanisms of Automatic Control for Deck Machinery	3
K1	**Automatic Control Engineering and Safety Devices** **Sub-Topics:** Electrical and Electronic Instrumentation and Control Equipment	15
L1	**Programmable Logic Controllers** **Sub-Topics:** Salient Features of Programmable Logic Controllers (PLC)	3
M1	**Microcontrollers** **Sub-Topics:** Salient Features of Micro Controllers	2
	Total	**45**

Learning Objectives	L
A Diesel Engines **General Learning Objectives** • Understand the correlation of components for the automatic control of diesel engines • Understand the various modes of operation • Know the safety features incorporated in Diesel Engine control systems **Topic: Diesel Engines** **Sub-Topics:** 1.1 Monitoring and Control of Main Diesel Engines	
A1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.4 – 4.1) **1.1 Monitoring and Control of Main Diesel Engines** 1.1.1 describe system components and configuration for main engine automatic control 1.1.2 Describe the meaning of the following functions used for main engine automatic control including operation/control mechanism: - automatic changeover from air running to fuel running - start failure - start impossible - wrong way - speed run-up program by revolution, local and/or combination control, including bypass program for critical speed - crash/emergency astern program - speed control under rough/calm sea condition - variable injection timing - variable exhaust valve timing - safety (automatic shutdown, automatic slowdown) system	2
1.1.3 Describe the function and mechanism of the electro-governing system for revolution control	1

Learning Objectives	L
B Steam Turbines **General Learning Objectives** • Understand the correlation of components for the automatic control of diesel engines • Understand the various modes of operation • Know the safety features incorporated in Steam Turbine control systems **Topic: Diesel Engines** **Sub-Topics:** 1.1 Monitoring and Control of Steam Turbines	
B1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.4 – 4.2) **1.1 Monitoring and Control of Steam Turbines** 1.1.1 Describe system components and configuration for main steam turbine automatic control 1.1.2 Describe the meaning of the following functions used for the main steam turbine automatic control, including operation/control mechanism: - start impossible - wrong way - speed run-up program by revolution, load and/or combination control - crash/emergency astern program - automatic rollover - safety (automatic shutdown) system	2

Learning Objectives	L
B Steam Turbines **General Learning Objectives** • Understand the correlation of components for the automatic control of diesel engines • Understand the various modes of operation • Know the safety features incorporated in Steam Turbine control systems **Topic: Diesel Engines** **Sub-Topics:** 1.1 Monitoring and Control of Steam Turbines	
C Gas Turbines **General Learning Objectives** • Understand the correlation of components for the automatic control of gas turbines • Understand the various modes of operation • Know the safety features incorporated in Gas Turbine control systems **Topic: Gas Turbines** **Sub-Topics:** 1.1 Monitoring and Control of Gas Turbines	
C1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.4 – 4.3) **1.1 Monitoring and Control of Gas Turbines** 1.1.1 Describe system components and configuration for main gas turbine automatic control 1.1.2 Describe the meaning of the following functions used for main gas turbine automatic control, including operation/control mechanisms: - start impossible - wrong way - speed run-up program by revolution, load and/or combination control - crash / emergency astern program - automatic rollover - safety (automatic shutdown, automatic slowdown system)	2

D Generator and Distribution System **General Learning Objectives** • Understand the power generation and distribution system configuration • Understand the various modes of operation with respect to the generator and the switchboard and its components • Know the safety features incorporated in the generation and distribution systems **Topic: Diesel Engines** **Sub-Topics:** 1.1 Monitoring and Control of Generator and Distribution System	
D1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.1) **1.1 Monitoring and Control of Generator and Distribution System** 1.1.1 Describe system components and configuration for generator and distribution system automatic control	1

1.1.2 Describe the following functions used for generator and distribution system automatic control, including operation/control mechanisms: - fully automatic control for generator and distribution system, including automatic starting and stopping prime mover - automatic synchronizing - automatic load sharing - optimum load sharing - large motor start blocking - preference trip - protective/safety functions built in Automatic/Main Circuit Breaker (ACB and VCB) - automatic voltage (AVR) and frequency control	2
E Steam Boiler **General Learning Objectives** • Understand the correlation of components for the automatic control of boilers • Understand various sub systems and their control loops • Know the safety features incorporated in Boiler control systems **Topic: Steam Boiler** **Sub-Topics:** 1.1 Monitoring and Control of Steam Boilers	
E1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.2) **1.1 Monitoring and Control of Steam Boilers** 1.1.1 Describe system components and configuration for steam boiler automatic control	1
1.1.2 Describe following functions used for steam boiler automatic control including operation/control mechanisms: - automatic Combustion Control (ACC), including steam pressure control, fuel oil flow control and air flow control - automatic feed water control - automatic steam temperature control - protective/safety functions for steam boiler	2

F Oil Purifier **General Learning Objectives** • Understand the sequence of operation and modes of control for purifiers • Understand the various sub systems and their control loops • Know the safety features incorporated in purifiers **Topic: Oil Purifier** **Sub-Topics:** 1.1 Monitoring and Control of Oil purifiers	
F1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.3) **1.1 Monitoring and Control of Oil purifiers** 1.1.1 Explain the automation, monitoring and alarms of oil purifiers: - temperature control - automatic start - automatic desludging: - partial desludging - total desludging - monitoring and alarms: - low/high temperature - water content - leakage monitoring	2

- treated oil flowing into heavy liquid side - non-closure of bowl - discharge detector for monitoring sludge discharge	
G Refrigeration and Air Conditioning System **General Learning Objectives** • Understand the automatic control circuit for Refrigeration and AC systems • Understand the importance of cut-outs and alarms for both Refrigeration and Air Conditioning systems **Topic: Refrigeration and Air Conditioning System** **Sub-Topics:** **1.1 Monitoring and Control of Refrigeration and Air Conditioning Systems**	
G1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.4) **1.1 Monitoring and Control of Refrigeration and Air Conditioning Systems** 1,1.1 Explain the automation, monitoring and alarms in refrigeration systems: - if pump down cycle used on board for refrigeration system: - automatic shutdown of compressor when all cold rooms attain temperature by shutting off of solenoid valves and low pressure cut out in suction line - when one more cold rooms temperature rises and solenoid valve/s open and suction pressure rises, thereby suction cut in operates and automatic start of compressor - automatic shutdown and alarm in case of high pressure in discharge line. Manual reset for restarting of compressor - automatic shutdown of compressor and alarm in case of low pressure of lubricating oil - timer control for destroying of evaporator coils of meat room and fish room 1.1.2 Explain that capacity control may be used on board for refrigeration compressor 1.1.3 Explain automatic control of steam spray for accommodation air conditioning heating system	2

H Pumping and Piping System **General Learning Objectives** • Understand the automatic control of pumps and monitoring / control systems in piping • Correlate the knowledge of a basic system with ship-based equipment **Topic: Pumping and Piping System** **Sub-Topics:** 1.1 Automation, Monitoring and Alarms of Pumping and Piping System	
H1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.5) **1.1 Automation, Monitoring and Alarms of Pumping and Piping System** 1.1.1 Explain the automation, monitoring and alarms of pumping and piping system: - automatic start of standby pumps - automatic start/stop of hydrophore pumps - automatic water level control of boiler by feed pumps - automatic cargo stripping system on-board tankers - automatic heeling system	2
I Steering Gear System **General Learning Objectives** • Understand the automatic control of steering systems including auto-pilot system • Understand the importance and function of Emergency Steering • Know the safety features incorporated in steering control systems	

H Pumping and Piping System **General Learning Objectives** • Understand the automatic control of pumps and monitoring / control systems in piping • Correlate the knowledge of a basic system with ship-based equipment **Topic: Pumping and Piping System** **Sub-Topics:** 1.1 Automation, Monitoring and Alarms of Pumping and Piping System	
Topic: Steering Gear System **Sub-Topics:** 1.1 Salient Features for the Control of Steering Systems	
I1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.6) **1.1 Salient Features for the Control of Steering Systems** 1.1.1 Explain the automation, monitoring and alarms of steering systems: - main and emergency steering systems	1
- autopilot system - regaining of steering capability in case of single failure of the hydraulic system	2
J Cargo Handling Equipment and Deck Machinery **General Learning Objectives** • Understand the automatic control systems for cargo-handling equipment and deck machinery • Understand the importance and function of auto shutdown of cargo pumping operations • Know the safety features incorporated in cargo handling equipment and deck machinery **Topic: Cargo Handling Equipment and Deck Machinery** **Sub-Topics:** 1.1 Functions and Mechanisms of Automatic Control for Deck Machinery	
J1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.7) **1.1 Functions and Mechanisms of Automatic Control for Deck Machinery** 1.1.1 Explain the automation, monitoring and alarms of - self-tensioning mooring winches	1

1.1.2 Explain the automation, monitoring and alarms of: - automatic shutdown of cargo pumping on abnormal operating conditions of inert gas system on board tankers - automatic shutdown of cargo pumping/loading on tankers and gas carriers	2
K Automatic Control Engineering and Safety Devices **General Learning Objectives** • Understand the importance of process control • Understand the importance and function of all commonly used sensors and controllers on a ship **Topic: Automatic Control Engineering and Safety Devices** **Sub-Topics:** 1.1 Electrical and Electronic Instrumentation and Control Equipment	
K1 Specific Learning Objectives: (IMO 7.02,2014: 2.1 – 1.3) **1.1 Electrical and Electronic Instrumentation and Control Equipment** 1.1.1 Explain the basic concepts of: - open and closed control loops - process control - essential components in process control loops	1
1.1.2 Explain the operation and use of sensors and transmitters in shipboard systems - resistance temperature devices - thermocouples - ambient temperature compensation	1
- flow and pressure measurement	1
- level measurement	1
- viscosity measurement - torque measurement	1
- force balance transmitters - oil/water interface and oil in water monitoring	1
- the pneumatic flapper/nozzle system - pneumatic 20-100 kPa, analogue 4 to 20 mA signals, pneumatic pilot relays - control air supply	1
- operational amplifiers - electrical supply	1
1.1.3 discuss controllers and basic control theory - disturbances and time delay and means to reduce them - two steps, proportional, integral, and derivation control actions	1
1.1.4 control loop analysis - temperature control systems	1
- level control systems	1
- pressure control systems	1
- split range and cascade control	1
- single, two and three element controls	1
1.1.5 Explain the operations and use of governors - need for governors - governor terms, concepts and operation - hydraulic governors - digital governors, power sharing - governing systems	1

L Programmable Logic Controllers **General Learning Objectives** • Understand the operation of a Programmable Logic Controller • Understand the importance and operation of HMIs • Know the basics of checking program validity **Topic: Programmable Logic Controllers** **Sub-Topics:** 1.1 Salient Features of Programmable Logic Controllers (PLC)	
L1 Specific Learning Objectives: (IMO 7.02,2014: 2.2.4 – 4.1) **1.1 Salient Features of Programmable Logic Controllers (PLC)** 1.1.1 Explain basics of PLC operation 1.1.2 Compare between hard-wired and programmable control operation 1.1.3 State the advantages of PLCs 1.1.4 Explain binary number conversion 1.1.5 Explain digital logic gates and demonstrate its practical applications 1.1.6 Identify input and output modules and configuration of PLCs 1.1.7 Explain ladder logic and PLCs programming 1.1.8 Explain human machine interface and alteration of parameters in the programme 1.1.9 Identify basic software version and control of access 1.1.10 Explain maintenance of electronic control equipment and PLC Controlled processes	2
M Microcontrollers **General Learning Objectives** • Understand the operation of a microcontroller • Understand the need for analogue to digital conversion and the methods to do so • Know the basics of communication between a microcontroller and a PC **Topic: Microcontrollers** **Sub-Topics:** 1.1 Salient Features of Micro Controllers	
M1 Specific Learning Objectives: (IMO 7.02,2014: 2.2.4 – 4.2) **1.1 Salient Features of Micro Controllers** 1.1.1 provides an introduction to microcontroller 1.1.2 Explain basics of a microcontroller 1.1.3 Explain analogue to digital convertor 1.1.4 List digital interfaces 1.1.5 Explain serial peripheral interface	2

Subject: Name/Code: Management Principles of Ship Operation/ 703

Instructional hours:

Lecture : 60 hours

Total contact hours : 60 hours

Credits : 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments) : 30%

Final Exam : 70%

Recommended Text:

1. Ship Operations and Management, Institute of Chartered Shipbrokers, 2017, ISBN 978-1-911328-05-6.
2. Shipping Operations Management, I.D. Visvikis, P.M. Panayides, Springer, WMU Studies in Maritime Affairs 4. ISBN 978-3-319-62365-8.
3. Mitchell P., Management for seafarers. (London, Videotel Marine International, 1997).

Reference:

1. International convention on Standards of training, certification and Watchkeeping for STCW1978 as amended 2011 edition. (ISBN978-92-801-15284).
2. Swift, Capt. A.J., Bridge Team Management – A Practical Guide. The nautical Institute, London, 1993 (ISBN 1-870077-14-8).
3. Yukl G. A., Leadership in organizations. (Harlow: Pearson, 2013).
4. Management: Text and cases, V.S.P. Rao, Excel Books.
5. Managerial Economics, Piyali Ghosh, Geetika, McGraw Hill.
6. R4 INTERNATIONAL SAFETY MANAGEMENT CODE (ISM Code) AND GUIDELINES ON IMPLEMENTATION OF THE ISM CODE (2010 Edition) Code IB117E ISBN 978-92- 801-51510.
7. R59 GUIDELINES ON FATIGUE (2002 Edition) Code I968E ISBN 978-92-801-51282.
8. R60 IMO/ILO GUIDELINES FOR THE DEVELOPMENT OF TABLES OF SEAFARERS' SHIPBOARD WORKING ARRANGEMENTS AND FORMATS OF RECORDS OF SEAFARERS' HOURS OF WORK OR HOURS OF REST (1999 Edition) Code I973E ISBN 978-92-801-60956.
9. B1 ANDERSON, P. – ISM CODE: A GUIDE TO THE LEGAL AND INSURANCE IMPLICATIONS. LONDON, LLOYD'S OF LONDON PRESS. (ISBN: 1-859-786-21-9).

Recommended Videos:

1. V23 CRISIS MANAGEMENT Code No. 507.
2. V25 THE INTERNATIONAL SAFETY MANAGEMENT CODE No.524.
3. V36 PERSONAL SAFETY ON PASSENGER SHIPS Code No.563.
4. V42 MARINE RISK ASSESSMENT–THE FLEET Code No.735.
5. V43 MANAGEMENT ON BOARD – PART 1 Code No.607.
6. V44 GETSMART: ORGANISATION AND PLANNING–PART 2 Code No.608.
7. V45 GET RESULTS: PLANNING FOR PROFIT–PART 3 Code No.609.
8. V46 TEAM WORK – PART 4 Code No.610.
9. V47 MOTIVATING INDIVIDUALS–PART 5 Code No.611.
10. V48 COMMUNICATION – PART 6 Code No.612.

Table of Topics

Section	Topics	Hours (L)
A	Engine room Management	8
B	Safety measures	5
C	Shipboard Personnel Management	10
D	Related international maritime conventions and national legislation	3
E	Task and workload management	8
F	Application of effective resource management at a management level	10
G	Decision making techniques	7
H	Development, implementation and oversight of standard operating procedures	1
I	Application of team work and leadership skill	2
J	Training Methods	6
	Total	**60**

Learning Objectives	**L**
A. General Description of shipboard operational management	
General Learning Objective Understand engine room resource management in ship operation; maintaining safe engineering watches. **Sub Topic: Engine room Management** **(IMO 7.04,2014: F1/1.1.4)** Explain the following: 1.1 ERM principles based on Bridge Resource Management (BRM)/ERM principles described in STCW Code, Ch. VIII, section A-VIII/2, part 3, para 8 1.2 ERM in terms of maintaining the safe engineering watch including why ERM is necessary 1.3 Resources considered to be included in ERM 1.4 Resource management in a specific manner taking examples such as personnel management, information management and management of installations/equipment 1.5 Necessity to practice ERM 1.6 Practicing ERM: allocation, assignment and prioritization of the resources, effective communication, assertiveness and leadership 1.7 Obtaining and maintaining situational awareness 1.8 Consideration of team experience	
Specific Learning Objectives **1.1 Explain ERM principles based on Bridge Resource Management (BRM)/ERM principles described in STCW Code, Ch. VIII, section A-VIII/2, part 3, para 8** 1.1.1 Explain ERM principles 1.1.2 Explain its history 1.1.3 Mention corresponding STCW code	1
Specific Learning Objectives 1.2 **Explain ERM in terms of maintaining the safe engineering watch including why ERM is necessary** 1.2.1 Explain ERM in terms of maintaining Safe engineering watches 1.2.2 Explain necessity of ERM	1
Specific Learning Objectives	

1.3 **Explain the resources considered to be included in ERM** 1.3.1 Explain different resources to be included in ERM 1.3.2 Importance of each resource and their interaction	1
Specific Learning Objectives 1.4 **Explain the resource management in a specific manner taking examples such as personnel management, information management and management of installations/equipment** 1.4.1 Explain personal Management, Information management and equipment management	1
Specific Learning Objectives 1.5 **Explain what is necessary to practice ERM** 1.5.1 Necessity of practicing ERM citing example of incidents from ships	1
Specific Learning Objectives 1.6 **Explain what is meant by the following in practicing ERM: allocation, assignment and prioritization of the resources, effective communication, assertiveness and leadership** 1.6.1 Explain following terms - Allocation, Assignment, Prioritization of resources, effective communication, assertiveness and leadership	1
Specific Learning Objectives 1.7 **Obtaining and maintaining situational awareness** 1.7.1 Explain the processes of obtaining and maintaining situational awareness with case studies	1
Specific Learning Objectives 1.8 **Consideration of team experience** 1.8.1 Describe what is team experience its advantages in ship operation management 1.8.2 Explain how sharing of experiences is encouraged to the advantage of all on board	1
B Safety Measures **General Learning Objectives** Understand safety measures to be taken for repair and maintenance including the safe isolation of shipboard machinery and equipment required before personnel are permitted to work on such machinery or equipment. **(IMO 7.04,2014: F 3, 3.2.1)**	

Specific Learning Objectives 1.1 Explain ISM code, and its need 1.2 Explain briefly how a SMS (Safety Management System) should be established 1.3. List the documents included in a typical SMS 1.4. List documents, checklists and others for safety measures for fabrication and repair and explain their specific purposes 1.5. Explain safety measures to be taken during repairs and maintenance work 1.6. State that safety measures to be taken for repair and maintenance can be identified through proper risk assessment 1.7. State that safety measures based on SMS should be applied to identified risks 1.8. Explain that toolbox talks prior to repair and maintenance are effective for taking necessary safety measures 1.9. Explain that safety measures include use of protective equipment, preparation of proper lighting, anti-slipping measures, preparation of safety procedures, setting up a safety barrier, preparation of a safe working platform, mechanical/ electrical isolation of machinery to be repaired/maintained, and prior checks based on SMS 1.10. Explain that particular safety measures in accordance with machinery feature may be necessary	5
C. Shipboard Personnel Management Principles of controlling subordinates and maintaining good relationships and crew employment **(IMO 7.02,2014: F4 :4.5.1)** **General Learning Objectives** Understand Shipboard Personnel Management including principles of controlling subordinates and maintaining good relationships and crew employment **Specific Learning Objectives** 1.1 Identify sources of authority and power 1.2 Discuss theories on how effective authority and power may be enhanced or diminished by management level officers on ships 1.3 Review theories in cultural awareness and cross-cultural communication 1.4 Discuss strategies that management level officers could adopt to enhance their effectiveness in managing crews of different culture 1.5 Review theories in human error, situational awareness, automation awareness, complacency and boredom 1.6 Discuss strategies that management level officers can adopt to optimize situational awareness and to minimize human error and complacency of individuals and teams 1.7 Discuss strategies that management level officers can adopt to enhance leadership and teamwork 1.8 Discuss theories of personnel motivation and relates these to shipboard situations encountered by management level officers 1.9 Explain that an individual's motivation and wellbeing may be affected by both real and perceived influences on board ship and at home 1.10 Discuss strategies that management level officers could adopt to optimize the motivation of individuals and teams 1.11 Discuss theories on coaching individuals and teams to improve performance 1.12 Discuss approaches to managing and improving the performance of oneself, individuals and teams	

1.13 Prepare for and conducts a simulated formal performance review 1.14 Identify the impact of repeated harassment including bullying on individuals 1.15 Recognizes indications that crew members may be physically or mentally unwell or badly demotivated describe strategies that can be adopted when a crew member is believed to be physically or mentally unwell or badly demotivated 1.16 Describe strategies that management level officers can take to ensure that crew remain physically well and are encouraged to remain physically active 1.17 Explain the need for management level officers to be fully familiar with the requirements of national law relating to crew employment and of all crew agreements in place on the ship 1.18 Discuss the process for signing on and discharging crew under national law 1.19 Discuss the need to ensure that new crew are appropriately certificated, competent and familiarized with the safety management system, security plan, working procedures and equipment of the ship 1.20 Explain that procedures for conducting investigations and applying consequences in disciplinary situations are governed by national law, codes of conduct, employment agreements and company procedures 1.21 Explain the process for investigating and applying consequences in disciplinary situations under relevant national law and procedures 1.22 Explain the formal process for addressing continuing levels of unacceptable performance by a crew member under national law 1.23 Explain the process for investigating and responding to incidents of harassment or bullying of crew members under national law 1.24 Explain requirements for handling crew wages, advances and allotments when this is done by management level officers on board ship	10
D Related international maritime conventions and National legislation ISM Code, STCW Convention (IMO 7.02,2014: F4 :4.5.1) **General Learning Objectives** Understand related International Maritime Conventions and National Legislation, ISM Code, STCW Convention. **Specific Learning Objectives** 1.1 Explain the principles underlying the ISM Code 1.2 Describe the content and application of the ISM Code 1.3 Explain the principles underlying the STCW Convention 1.4 Describe the content and application of the STCW Convention 1.5 Explain how to implement the regulations for ensuring fitness for duty 1.6 State that seafarers new to a particular type of vessel require ship specific shipboard familiarization 1.7 Describe what shipboard familiarization may involve for watch keeping officers 1.8 Describe what tasks or duties elementary basic safety familiarization involves for a watch keeping officer 1.9 Describe how to organize shipboard training and how to maintain records 1.10 State that penalties are prescribed for breaches of STCW 95 requirements and that these are determined by the flag State 1.11 State that National legislation is required to implement the provisions of an international convention 1.12 State that for STCW 1978, as amended, National legislation is subject to scrutiny and checking by IMO appointed persons 1.13 State National legislation may differ from one flag to another	3
E Task and workload management (IMO 7.02,2014: F4 :4.5.1) **General learning objective**	

Learn to effectively manage the workload and task distribution to avoid overloading and underutilizing crew members	
Specific Learning Objectives 1.1 Review theories on applying task and workload management from IMO model course 1.39, Leadership and teamwork explain that the scope of activity and conflict between activities managed by management level officers is broader than for operational level officers and requires greater task and workload management ability 1.2 Plans the task and workload allocation for significant shipboard activities so that the following are considered: - Human limitations - Personal abilities - Time and resource constraints - Prioritization - Workload, rest and fatigue 1.3 Discuss strategies to monitor the effectiveness of task and workload management during an activity and to adjust the plan as necessary 1.4 Discuss strategies to ensure that all personnel understand the activity to be undertaken and their tasks in this 1.5 Discuss whether the encouragement of a challenge and response environment is appropriate to the task and workload management of particular shipboard tasks 1.6 Discuss the importance of debriefs and reflection after activities that have been conducted to identify opportunities for improving task and workload management	8
F Application of effective resource management at management level **(IMO 7.02,2014: F4 :4.5.4)** **General Learning Objectives** Understand how to effectively apply resource management at management level **Specific Learning Objectives** 1.1 Review theories on effective communication 1.2 Demonstrate effective communication in simulated or real situations involving communications on board ship and between ship and shore 1.3 Discuss how management level officers can encourage other personnel to use effective communications 1.4 Review theories on effective resource allocation, assignment and prioritization 1.5 Demonstrate the effective allocation, assignment and prioritization of resources when managing simulated or real shipboard activities 1.6 Review theories on decision making that considers team experience demonstrate the ability to involve team member effectively in decision making when managing simulated or real shipboard activities 1.7 Review theories on assertiveness and leadership 1.8 Demonstrate the ability to obtain and maintain situational awareness when managing complex simulated or real shipboard activities 1.9 Review theories on the use of short- and long-term strategies 1.10 Demonstrate the ability to apply short- and long-term strategies when managing simulated or real shipboard activities 1.11 Discuss appropriate leadership styles and levels of assertiveness for management level officers in a range of shipboard activities 1.12 Demonstrate the ability to apply appropriate leadership styles and levels of assertiveness when managing simulated or real shipboard activities 1.13 Review theories on obtaining and maintaining situational awareness	10
G. Decision Making Techniques (IMO 7.02,2014: F4 :4.5.5) **General Learning Objective**	

Understand decision making techniques **Sub topics & SLOs** 1.1 Situation and risk assessment 1.2 Identify and generate options 1.3 Select course of action 1.4 Evaluation of outcome effectiveness	
Specific Learning Objectives **1.1 Situation and risk assessment** 1.1.1 Review theories of situation and risk assessment 1.1.2 Discuss formal and informal approaches to risk assessment 1.1.3 Identify typical risks that management level officers may have to assess 1.1.4 Demonstrate the ability to effectively assess risk in the planning and conduct of simulated or real shipboard activities	2
Specific Learning Objectives **1.2 Identify and generate options** 1.2.1 Review theories on identifying and generating options 1.2.2 Demonstrate the ability to identify and generate options when making decisions as a management level officer in simulated or real shipboard activity	2
Specific Learning Objectives **1. 3 Selecting course of action** 1.3. 1 Review theories on selecting the course of action in making decisions 1.3.2 Demonstrate the ability to select appropriate courses of action when making decisions as a management level officer in simulated or real shipboard activity	2
Specific Learning Objectives **1.4 Evaluation of outcome effectiveness** 1.4.1 Explain how to carry out the evaluation of outcome effectiveness and the importance of doing it	1
H. Development, implementation and oversight of standard operating procedures **General Learning Objective** Know how to develop, implement and oversight of standard operating procedure **Specific Learning Objectives** 1.1.1 Discuss approaches to developing standard operating procedures(SOPs) 1.2.2 Explain the methods to implement the SOPs 1.3.3 Explain why it may be desirable for there to be oversight and approval of many SOPs	1
I. Application of teamwork and leadership skills **General learning objective** Understand teamwork and leadership skills **Specific Learning Objectives** 1.1 Use a team by giving directions and taking the lead 1.2 Application of task and workload management	2

J. Training methods: (IMO 7.02,2014: F4 :4.5.1) **General Learning Objectives** Understand various training methods that can be employed effectively its effect on attitude, in skills and knowledge. Preparation needed for preparation for start of training and method to motivate the crew. **Specific Learning Objectives** 1.1 Review training methods that could be adopted on board ship 1.2 Discuss the effectiveness of training methods that can be adopted for training: – in attitude – in skills – in knowledge 1.3 Describe the preparation needed before the start of a training session 1.4 Discuss methods for ensuring that crew are motivated to participate fully in training 1.5 Demonstrate how to conduct a training session for a given topic 1.6 List the areas in which training is required by regulation including the requirements of SOLAS 1.7 Identify other topics where training might be desirable 1.8 Deliver a training session to other members of the class 1.9 Discuss the resources that may be available on-board ship that can be used for training	6

Subject Name/Code: Maritime Law and Ship's Business/704

Instructional hours:

Lecture	: 45 hours
Tutorial	: 15 hours
Total contact hours	: 60 hours
Credits	: 4

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Additional Information on Subject:

1. Additional requisites: MARPOL, BWS and AFC (Marine Pollution Prevention and Safety).

Recommended Text:

1. Shipping Practice, Stevens, Edwards, Sterling Book house Pvt. Ltd.
2. Managerial Economics, Piyali Ghosh, Geetika, McGraw Hill.

Reference:

1. Indian Merchant Shipping Act.
2. UNCLOS 1982.
3. Commentary on SOLAS, Bhandarkar Publications.
4. International Convention on Load Line 1966 as amended, IMO Publication.
5. Code of Safe Working Practices for Merchant Seafarers, 2015 Edition, Maritime & Coast Guard Agency.
6. International Ship and Port Facility Security Code, 2003. IMO Publications.
7. BMP5: Best Management Practices to Deter Piracy and Enhance Maritime Security in Red sea, Gulf of Aden, Indian Ocean and Arabian sea, Witherby.
8. Maritime Labour Convention, 2006, ILO Publication.
9. International Medical Guide for Ships, 3rd Edition. WHO Publications.
10. International Convention on Salvage, 1989.
11. Convention on limitation of Liability for Maritime Claims 1976.
12. Civil Liability Convention 1992.
13. International Convention on civil liability for Bunker oil pollution damage, 2001.
14. London Dumping Convention 1972.
15. Marine Insurance, Reeds 2005.

Table of Topics

Section	Topics	Hours (L:T)
A1-A2	Maritime Law **Sub-Topics:** Introduction, UNCLOS	5:2
B1-B2	Conventions on Safety **Sub-Topics:** SOLAS, Load Line Convention	14:3
C1-C2	Safety and Security **Sub-Topics**: Code of Safe Working Practices for Merchant Seaman, ISPS Code	5:2
D1-D2	Labour and Health **Sub-Topics**: Maritime Labour Convention, International Health Regulations	5:2
E1-E4	Miscellaneous Conventions **Sub-Topics**: Salvage Convention, LLMC, Oil Pollution Compensation, London Dumping Convention	6:2
F1-F2	Important Organisations **Sub-Topics**: Classification, Port State Control	4:2
G1-G3	**Shipping Business** **Sub-Topics**: General Average, Marine Insurance, Charter party	6:2
	Total	**45:15**

Learning Objectives	L: T
A1: Introduction to Maritime Law	
General Learning Objective Understand the role of international conventions in formulating Maritime Law, Introduction to important maritime conventions, Need of survey and certification and penal sanctions. **Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.2)** 1.1 Explain the need of Maritime Law 1.2 Explain the source of Maritime law is International Convention 1.3 Explain how implementation of maritime law is done through national legislation 1.4 Explain the role of UN, IMO and ILO 1.5 Explain the role of Flag state and Port state in implementation of Law. 1.6 Introduction to SOLAS, MARPOL, STCW and MLC 1.7 Explain the need of Survey and Certification 1.8 Explain PSC Inspection and penalties	2: 1
A2: UNCLOS **General Learning Objective** Understand the role of international conventions on the Law of the Sea, 1982. Various Zones and their limits. Responsibility of state. **Topic: Introduction to maritime law** **Subtopics & SLOs:** 2.1 Introduction of UNCLOS 2.2 Various zones and limits 2.3 Responsibility of State	
Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.1)	2: 1

2.1 Introduction of UNCLOS 2.1.1 Explain the need of UNCLOS 2.1.2 Explain why it is referred as Umbrella Convention. **2.2 Various zones and limits** 2.2.1Explain Baseline and Straight Baseline 2.2.2 Explain Territorial Sea and its limits 2.2.3 Explain Internal Waters 2.2.4 Explain Contiguous zone 2.2.5 Explain Exclusive Economic Zone 2.2.6 Explain Continental shelf 2.2.7 Explain High Seas	
Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.1) **2.3 Responsibility of State** 2.3.1 Explain Innocent Passage 2.3.2 Explain Criminal and Civil Jurisdiction on board a foreign vessel 2.3.3 Explain Freedom of the High Seas 2.3.4 Explain Piracy and right of hot pursuit 2.3.5 Explain Pollution and Dumping 2.3.6 Describe how settlement of disputes is done	1: 0
B1: SOLAS **General Learning Objective** Understand the role of international conventions for the Safety of Life at Sea, 1974 as amended **Sub topics & SLOs:** 1.1 Introduction to SOLAS 1.2 Subdivision and Stability 1.3 Fire Protection, detection and Extinction 1.4 LSA and arrangements 1.5 Carriage of Grain 1.6 Carriage of Dangerous Goods	
Specific Learning Objectives: **1.1 Introduction to SOLAS (IMO 7.04, 2014: Competence 4.6.1 /1.3)** 1.1.1 Explain the need of SOLAS 1.1.2 Explain the factors which lead to convening of 1914 International SOLAS convention 1.1.3 Explain Tacit acceptance amendments procedure and development of SOLAS 1974 1.1.4 Explain general obligations of contracting governments. 1.1.5 Explain important definitions such as Passenger ship, cargo ship, tanker, age of ship, international voyage. 1.1.6 Explain role of Flag state and Port state in implementing SOLAS 1.1.7 List the surveys conducted on passenger ship and cargo ship and certificates issued and their validity. 1.1.8 Describe the requirements of LSA survey, Radio Survey, Hull and Machinery survey. 1.1.9 Describe Initial survey, renewal survey and periodic survey (annual and intermediate)	2: 1
Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.3) **1.2 Subdivision and Stability** 1.2.1 Define Length, Breadth, Draught, Bulkhead, Deck, Margin Line, Permeability of a space, Machinery space, Passenger spaces, Watertight, Subdivision length, Trim 1.2.2 Explain Floodable length, factors of subdivision and unsymmetrical flooding 1.2.3 Explain intact stability and data required for the same	2: 1

1.2.4 Explain the importance of Load line marking 1.2.5 Explain water tight doors and its types, provisions regarding watertight doors 1.2.6 Explain provisions regarding side scuttles and deadlights 1.2.7 Explain contents of damage control plan 1.2.8 Explain the requirement for detection of water leakage	
Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.3) **1.3 Fire Protection, detection and Extinction** 1.3.1 Explain the basic principles of the regulation on fire protection 1.3.2 Describe Standard Fire test and properties of Class A and B Divisions 1.3.3 Define Main vertical zones, accommodation spaces, public spaces, service spaces, cargo spaces, ro-ro space, Machinery space cat. A and Control station 1.3.4 Explain regulations for Fire Hydrant, Hoses and Fire Pumps 1.3.5 Describe Fire Control Plan and its contents 1.3.6 Explain the maintenance and operation of Portable extinguishers 1.3.7 Explain the maintenance and operation of Fixed firefighting system including Carbon dioxide, Foam and water mist 1.3.8 Describe fire alarm and detection system regulations 1.3.9 Explain Fire patrol 1.23.10 State special requirements for ships carrying dangerous goods	3: 1
Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.3) **1.4 LSA and arrangements** 1.4.1 Define the following: Certified Person, Float-free launching, Inflatable appliance, Inflated appliance, Launching appliance or arrangement, rescue boat, survival craft 1.4.2 Explain inspection and certification by Flag State 1.4.3 Explain Muster List and its constituents 1.4.4 Explain emergency instruction and where are they displayed 1.4.5 List Life Saving Appliances and Explain how these are maintained and operated such as inflatable life rafts, lifejackets, rescue boats and HRU, life boat including falls 1.4.6. Explain how abandon ship drill is carried out and contents of training manual 1.4.7. Explain inspection and survey of life saving appliances	2: 0
Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.3) **1.5 Carriage of Grain** 1.5.1 List the intact stability requirements for a ship carrying bulk cargo 1.5.2 Explain the hazards involved in carriage of grains and its mitigation 1.5.3 Explain the content of grain loading information	1: 0
Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.3) **1.6 Carriage of Dangerous Goods** 1.61 Explain the regulations concerning carriage of dangerous goods in packaged form- IMDG Code including classification of goods. Specifications of documents, PSN 1.6.2 Explain the regulations concerning carriage of dangerous goods in bulk- IBC Code 1.6.3 Explain the regulations of International Gas Carrier Code- IGC Code 1.6.4 List the survey requirements of a Chemical Tanker	2: 0
B2: Load Line Convention **General Learning Objective** Understand the role of International Convention on Load Lines 1966 as amended **Sub topics & SLOs:** 2.1. Introduction of LLC 2.2. Important Definitions & Markings 2.3. Survey and Certification	
Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.3)	2: 0

2.1. Introduction of LLC 2.1.1 Explain the need of Load Line Convention 2.1.2 Explain in which ships convention applies **2.2. Important Definitions & Markings** 2.2.1 Describe Freeboard, Freeboard Deck, Superstructure, Deck line 2.2.2 Sketch and Describe Load Line Markings **2.3. Survey and Certification** 2.3.1 Describe the items to checked during load line survey 2.3.2 Explain features of Load Line Certificate, validity, who issues and when it can be cancelled 2.3.3 Describe provisions for closing appliances for ventilators, air pipes of tanks 2.3.4 Explain how safety of crew on weather deck is ensured 2.3.5 Explain the features of closing of openings in crew's quarters, machinery space, cargo spaces	
C1 Code of Safe Working Practices for Merchant Seaman **General Learning Objective** Understand the role of code of safe working practices of merchant seaman **Sub-sub topics & SLOs:** 1.1 Introduction to Code 1.2 Occupational Safety and Safety Culture 1.3 Personal Safety 1.4 Permit to Work System 1.5 General Safety Precautions	
Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.3) **1.1 Introduction to Code** 1.1.1 Explain the need and purpose of the code 1.1.2 Explain the duties of ship-owner and seafarer w.r.t code. **1.2 Occupational Safety and Safety Culture** 1.2.1 Describe safe working culture 1.2.2 Explain Occupational Safety 1.2.2 Explain the objective and various techniques of Risk Assessment. **1.3 Personal Safety** 1.3.1 Describe the use of various Personal Protective Equipment used on board 1.3.2 Describe the features of Induction training for a new joiner on ship 1.3.3 Explain precautions taken while handing heavy loads 1.3.4 Explain the role of Safety Committee and Safety Officials on board 1.3.5 Explain importance of personal hygiene on board. 1.3.6 Explain the precautions for heavy weather and cold weather **1.4 Permit to Work System** 1.4.1 Explain the need and features of Permit to Work system 1.4.2 Describe features of following permits: Enclosed space entry, Hot work, working aloft / over side, Electrical isolation including High Voltage **1.5 General Safety Precautions**	3: 1

1.5.1 Explain precautions taken for the following: Line handling, Electric safety, Mechanical safety, Chemical and Biohazard safety 1.5.2 Describe portable oxygen analyser, explosimeter, multi gas detector	
C2: International Ship and Port Facility Security Code (ISPS Code) **General Learning Objective** Understand the role of International Ship and Port Facility Security Code (ISPS Code) **Sub- topics & SLOs** 2.1 Introduction to Code 2.2 Ship Security Plan 2.3 Security Levels 2.4 Declaration of Security 2.5 Ship Security Alert System 2.6 Piracy & BMP5	
Specific Learning Objectives: (IMO 7.04, 2014: Competence 4.6.1 /1.3) **2.1 Introduction to Code** 2.1.1 Explain the need and purpose of the code and its implementation 2.1.2 Explain the obligations of contracting governments and Companies / Ship w.r.t code **2.2 Ship Security Plan** 2.2.1 Describe features of Ship Security Plan 2.2.2 Explain the role of CSO and SSO 2.2.3 Describe various training and drills carried out on board **2.3 Security Levels** 2.3.1 Explain different security levels 2.3.2 Describe the actions taken in different security levels by ship **2.4 Declaration of Security** 2.4.1 Explain the need and features of Declaration of Security **2.5 Ship Security Alert System** 2.5.1 Describe the features of Ship Security Alert System. 2.5.2 Describe the need and features of AIS **2.6 Piracy & BMP5** 2.6.1 Explain the effects of Piracy on Shipping Industry. 2.6.2 Describe the features of best management Practices to deter Piracy (BMP 5)	2: 1

D1 Maritime Labour Convention 2006 **General Learning Objective** Understand the role of Maritime Labour Convention 2006 **Sub-sub topics & SLOs:** 1.1 Introduction to Convention 1.2 Title 1: Minimum requirements for seafarers to work on a ship 1.3 Title 2: Conditions of employment 1.4 Title 3: Accommodation, recreational facilities, food and catering 1.5 Title 4: Health protection, medical care, welfare and social security 1.6 Title 5: Compliance and enforcement	
Specific Learning Objectives: (IMO 7.02, 2014: Competence 4.2 /1.6.2) **1.1 Introduction to Convention** 1.1.1 Explain the role of International Labour Organisation 1.1.2 Explain the need and purpose of the Maritime Labour Convention 1.1.3 Describe the seafarer's employment rights and social rights **1.2 Title 1: Minimum requirements for seafarers to work on a ship** 1.2.1 Explain the regulation for minimum age of seafarer 1.2.2 Explain the purpose of medical fitness certificate 1.2.3 Explain the regulations for Training and Placement **1.3 Title 2: Conditions of employment** 1.3.1 Explain how fair employment agreement is ensured. 1.3.2 Explain the regulations for wages, rest hours, leave, repatriation 1.3.3 Explain the regulations for seafarers' compensation, manning levels and skill development. **1.4 Title 3: Accommodation, recreational facilities, food and catering** 1.4.1 Explain the regulations for Accommodation and recreation facilities 1.4.2 Explain the regulation for Food and catering **1.5 Title 4: Health protection, medical care, welfare and social security** 1.5.1 Explain how medical care is provided to seafarer on board. 1.5.2 Describe duties of ship owner w.r.t. occupational safety and health 1.5.3 Explain Shipowner's liabilities in case of sickness, injury or death of seafarer. 1.5.4 Explain Social Security **1.6Title 5: Compliance and enforcement** 1.6.1 Describe the responsibilities of flag state in implementation of MLC 1.6.2 Explain Inspection and certification of MLC 1.6.3 Explain complaints procedure 1.6.4 Explain responsibilities of Port state 1.6.5. Explain the responsibility of Labour Supplier	3: 1

D2 International Health Regulations **General Learning Objective** Understand various International Health Regulations **Sub topics & SLOs:** 2.1 Arrival documents and procedures 2.2 Plague, Cholera and Yellow fever	
Specific Learning Objectives: **(IMO 7.02, 2014: Competence 4.2 /1.5)** **2.1 Arrival documents and procedures** 2.1.1 Explain the role of WHO in Shipping 2.1.2 Define Arrival of ship, Free Pratique, Isolation, Quarantine, Epidemic etc. 2.1.3 Describe features of International Medical Guide for Ships 2.1.4 Describe features of Maritime Declaration of Health **2.2 Plague, Cholera and Yellow fever** 2.2.1 Describe the regulations for control of Plague, Cholera and Yellow fewer 2.2.2 Explain how the spread of communicable disease on ship is achieved 2.2.3 Explain the important contents of Medical Chest on board 2.2.4 Describe the features of Medical Care Room / Hospital on board	2: 1
E1 International Convention on Salvage 1989 **General Learning Objective** Understand Salvage **Topic: Salvage Regulations** **Sub-topics & SLOs:** 1.1Salvage 1.2 International Convention on Salvage	
Specific Learning Objectives: **(IMO 7.02, 2014: Competence 4.2 /1.6.3)** **1.1 Salvage** 1.1.1 Define Salvage. 1.1.2 Explain Duty of Life Salvage 1.1.3 Explain the duties and rights of Salvor 1.1.4 Explain the principle of 'No Cure No Pay' **1.2 International Convention on Salvage** 1.2.1 Describe the features of Salvage Convention 1.2.2 Explain the features of LOF 1.2.3 Explain the criteria for assessing reward 1.2.4 Explain SCOPIC 1.2.5 Explain Salvor's Maritime Lien	2: 0

E2 Convention on Limitation of Liability for Maritime Claims 1976 **General Learning Objective** Understand Limitation of Liability for Maritime Claims **Topic: Limitation of Liability for Maritime Claims** **Sub topics & SLOs:** 2.1 Limitation of Liability	
Specific Learning Objectives: **(IMO 7.02, 2014: Competence 4.2 /1.6.4)** **2.1 Limitation of Liability** 2.1.1 Explain the meaning of Liability 2.1.2 Explain liability of ship-owner towards life and property 2.1.3 Explain why the liability of ship-owner is limited 2.1.4 Describe the limits of liability of ship-owner with respect to Property Claims 2.1.5 Describe the limits of liability of ship-owner with respect to Loss of Life and Personal Injury Claims	1: 1
E3 Oil Pollution Compensation Conventions **General Learning Objective** Understand Compensation Conventions in case of Oil Pollution by Ships **Topic: Compensation Conventions in case of Oil Pollution by Ships** **Sub-topics & SLOs:** 3.1 CLC 69 & 92 3.2 Fund and Supplementary Fund & Bunker Convention	
Specific Learning Objectives: **(IMO 7.02, 2014: Competence 4.2 /1.8)** **3.1 CLC 69 & 92** 3.1.1 Explain the financial impact of Oil Pollution. 3.1.2 Describe the important features of Civil Liability Convention 1969 3.1.3 Describe the changes in above convention in 1992 **3.2 Fund and Supplementary Fund & Bunker Convention** 3.2.1 Describe the features of Fund Convention. 3.2.2 Describe the features of Supplementary Fund Convention. 3.2.3 Describe the features of Bunker Convention	2: 1
E4 London Dumping Convention **General Learning Objective** Understand London Dumping Convention **Topic: London Dumping Convention** **Sub-sub topics & SLOs:** 4.1 London Dumping Convention	
Specific Learning Objectives: **(IMO 7.02, 2014: Competence 4.2 /1.8)** **4.1 London Dumping Convention** 4.1.1 Explain the need of the convention 4.1.2 Describe the features of the Three annexes 4.1.3 Describe the 1996 protocol	1: 0

F1 Classification Society **General Learning Objective** Understand Classification **Topic: Classification** **Sub-sub topics & SLOs** 1.Classification Society	
Specific Learning Objectives: (IMO 7.02, 2014: Competence 4.2 /1.6.5) **1.Classification Society** 1.1.1 Explain the need of the classification 1.1.2 Explain Recognised Organisation 1.1.3 Describe the role of Classification Society in approving plan, supervising ship building, Testing of material and equipment 1.1.4 Describe the features of survey conducted by classification society for hull and safety 1.1.5 Explain continuous survey of machinery 1.1.6 Explain features of Annual, docking and special survey 1.1.7 Explain 'Condition of Class' 1.1.8 Explain the impact of suspension and withdrawal of class on ship operation	2: 1
F2: Port State Control **General Learning Objective** Understand role and responsibility of Port State **Sub topics & SLOs:** 2.1 Port State Control	
Specific Learning Objectives: (IMO 7.02, 2014: Competence 4.2 /1.7) **2.1 Port State Control** 2.1.1 Explain the need of the inspection of ship by Port state 2.1.2 Explain primary responsibility of Port State with respect to shipping 2.1.3 Explain MOU and list different MOU and participant countries 2.1.4 Explain Concentrated Inspection Campaign 2.1.5 Describe the features of inspection conducted by Port State Control when a ship visits the port 2.1.6 Explain meaning of 'clear grounds' for inspection and its significance 2.1.7 Describe the deficiencies which can lead to detention	2: 1
G1: General Average and Marine Insurance **General Learning Objective** Understand General Average and Marine Insurance **Sub-topics & SLOs:** 1.1 General average 1.2 Marine Insurance 1.3. Protection and Indemnity	
Specific Learning Objectives: (IMO 7.02, 2014: Competence 4.2 /1.6.6) **1.1 General average**	3 : 1

1.1.1 Define General Average Act 1.1.2 Explain how is GA Compensated **1.2 Marine Insurance** 1.2.1 Explain the need of Insurance 1.2.2 Explain the Principles of Insurance as per MIA 1963 such as UGF, Insurable Interest, Indemnity, Proximate Cause, Subrogation and Contribution 1.2.3 Explain the Practices of Insurance such as Warranty, Institute warranties, Duty of Assured, Sue and labour, Actual Total Loss and Constructive Total loss 1.2.4 Explain Voyage, Time and Floating Policies 1.2.5 Describe the perils usually covered in Hull & Machinery and Cargo Policies **1.3. Protection and Indemnity** 1.3.1 Explain the need of Protection and Indemnity Insurance 1.3.2 Describe the working and duties of P&I clubs 1.3.3 List the perils covered by P&I Clubs	
G2: Charter parties **General Learning Objective** Understand Chartering **Sub-topics & SLOs:** 2.1 Types of Charter 2.2 Important Features of Charter parties	
Specific Learning Objectives: **(IMO 7.02, 2014: Competence 4.2 /1.6.7)** **2.1 Types of Charter** 2.1.1 Explain the concept of chartering 2.1.2 Explain Bareboat, Voyage and Time Charter with responsibilities of Charterer and Ship Owner. 2.1.3 Explain Freight and Hire **2.2 Important Features of Charter parties** 2.2.1 Explain Lay days and cancelling date (Lay can). 2.2.2 Explain Lay time, Demurrage and Despatch. 2.2.3 Explain Notice of Readiness. 2.2.4 Explain Delivery and Redelivery along with On-Hire and Off-Hire survey 2.2.5 Explain Off hire.	3: 1

Subject Name/Code: Marine Materials /705

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Written Exam	: 70%

Recommended Text:

1. Material Science, S K Hajra Choudhury, Media Book.
2. Raghavan V, (2015), Material Science and Engineering A first course, Prentice Hall of India.
3. Materials for marine machinery, S. H. Frederick and H. Capper; Institute of Marine Engineers; ISBN: 0900976-42-x.

Reference:

1. William D Callister & David G Rethweisch, (2013), Materials science and Engineering an Introduction, John Wiley and Sons.
2. Narula G.K., Narula K.S., & Gupta V.K., (2007), Material science, Tata Mc Graw Hill.
3. Shenoi and J.F. Wellicome, (1993), Composite Materials in Maritime Structures: Volume 1 Fundamental Aspects, Cambridge University Press.
4. Rajendran.V, (2011), Material Science, Tata Mc Graw Hill.
5. Robert L. Reuben, (1994), Materials in Marine Technology, Springer-Verlag.

Table of Topics

Section	Topics	Hours (L)
A	Crystal Structure	9
B	Polymers and Composites	9
C	Solid Solutions and Phase diagrams	9
D	Heat Treatment	9
E	Materials in Marine Industry	9
	Total	**45**

Learning Objectives	L
General Learning Objective Understand the employment of different materials and their uses in marine industry including material selection, treatment techniques, corrosion control and Composites. Competence 3.1 **(IMO/ 7.04 / 2014 1.1) Pg.123 -131)**	
A Crystal Structure **Specific Learning Objectives** Explain the following: 1.1 Atomic structure- Atomic bonding in solids, Unit cells and Space lattices, Crystal structures 1.2 Concept of amorphous, single and polycrystalline structures 1.3 Miller Indices, Crystal Defects, point, line, surface and volume defects 1.4 Allotropy of Carbon – Structure of Diamond, Graphite, C-60 etc.	9
B Polymers and Composites Competence 3.1 **(IMO /7.04 / 2014 / 1.3) pg.131)** **Specific Learning Objectives** Explain the following: 1.1 Introduction – Classification of Polymers – Types of Polymerizations – Preparation 1.2 Properties and uses of some important polymers – Fabrication of plastics 1.3 Rubber – Synthetic rubbers –Composites, Difference between thermoplastics and thermosetting plastics 1.4 Types of resins, glass and carbon fibres, different types of fabrics and mats such as Chopped Stranded Mats (CSM), Woven Roving (WR) their properties - FRP, GRP materials	9
C Solid Solution and Phase Diagram Competence 3.1 **(IMO / 7.04 / 2014/2.1) pg.123 134)** **Specific Learning Objectives** Explain the following: 1.1 Types of Solid solutions – Hume-Rothery ratio – Intermediate phases – Solid solution alloys 1.2 Phase Diagrams- Introduction –Cooling curves 1.3 Gibbs Phase rule – Classification of equilibrium diagrams 1.4 Eutectic – Peritectic reactions – Equilibrium diagram for common non–ferrous alloys and ferrous alloys 1.5 Micro constituents of iron - Iron–Carbon equilibrium diagram, TTT diagram	9
D Heat Treatment Competence 3.1 **(IMO / 7.04 / 2014 / 2.1) pg.131** **Specific Learning Objectives** Explain the following: 1.1. Definition – Purpose of heat treatment 1.2 Effect of thermal cycles on their micro-structure Heat treatment techniques	9

	1.3 Annealing – Normalizing – Hardening –Tempering 1.4 Mar tempering – Austempering 1.5 Case Hardening and Surface Treatment 1.6 Carburizing - Cyaniding – Nitriding, Flame Hardening etc.	
E	**Materials in Marine Industry** Competence 3.1 (**IMO / 7.04 / 2014 / 2.1) pg.123 -13)** **Specific Learning Objectives** Explain the following: 1.1 Chromium, Ceramic, Titanium, PTFE in Shipboard Systems. Characteristics of above materials. 1.2 Introduction to different types of materials used in shipbuilding 1.3 Selection of Materials in Shipbuilding and Marine Engineering: Boilers, Steam and Gas turbine, Purifiers and Diesel engine components, Pumping Machinery, Components and Piping System, Engine seating. Propellers and Rudders. Composition, Strength value and other requirement for materials used	9

Subject Name/Code: Fuels and Lubricants/706

Instructional hours:

Lecture	: 45 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. M. Popovich and Haring., Fuels and Lubricants., John Wiley & Sons, Inc.
2. R.L. Bechtold, Alternative Fuels Guidebook, SAE Publication.

Reference:

1. ISO Standards pertaining to Fuels & lubricants.
2. Alternate fuels, Dr. S.S. Thipse, Jaico Publications.
3. Shipping Company Guidelines for Fuels & Lubricants.

Table of Topics

Section	Topics	Hours (L)
A	Introduction to fuels	12
B	Lubricants	9
C	Combustion process and rating of fuels & Performance of CI & SI engines	9
D	Alternate fuels	9
E	Properties, gradation and additives of lubricants	6
	Total	**45**

Learning Objectives	L
General Learning Objectives: Understand the selection of proper fuel and lubricants, their functioning, applications and care. **A Introduction to Fuels** **Specific Learning Objectives** Explain the following: **1 Introduction, classification of fuel, characteristics of a good fuel** 1.1 Advantages and Disadvantages of solid, liquid and gaseous fuels 1.2 Calorific value, Theoretical calculation of calorific value 1.3 Coal, classification, varieties, analysis of coal, carbonization 1.4 Requisites of good metallurgical coke, difference between coal, coke, and charcoal, Manufacture of metallurgical coke, hydrogenation of coal 1..5 Theory of original and accumulation of crude oil, Methods of searching of crude oil, recovery of crude oil, classification of crude oil, 1.6 Classification of various hydrocarbons, structures of hydrocarbons 1.7 Fractional distillation and classification of refinery products 1.8 Liquid fuels, classification of petroleum, refining of petroleum, cracking, synthesis of gasoline, refining of Petrol etc., Blending and treatment of gasoline 1.9 Knocking, leaded petrol, reforming, diesel oil, diesel index etc., 1.10 Gaseous fuels, Natural gas, CNG, LPG, producer gas, water gas etc., 1.11 Combustion, Explosives range or limits of inflammability, ignition temperature, spontaneous combustions, fuel gas analysis and combustion calculations 1.12 Use of ISO Standards (e.g., ISO8217 etc.)	12

B Lubricants **Specific Learning Objectives** Explain the following: **1 Introduction, Functions of a lubricant, classification of lubricants** 1.1 Distillation process to get lubricating oil from crude oil, various treatment to the lubricating oil 1.2 Types of grease and its characteristics 1.3 Fluid film or Hydrodynamic lubrication, Thin film or boundary lubrication, extreme pressure lubrication 1.4 Mineral oils, extraction of lubricating oils from petroleum, Blended or compounded oils or additive to lubricants 1.5 Synthetic lubricants, solid lubricants such as graphite, Molybdenum sulphide, semi solid lubricants, emulsions etc., 1.6 Properties of lubricants, viscosity, flash and fire point, Pensky-Marten's experiments, cloud and pour points with various stages of cooling 1.7 Aniline point, carbon residue test, neutralization number. 1.8 Saponification number, oiliness, selection of lubricants, etc.	9
C Combustion Process and rating of fuels & Performance of CI & SI engine **Specific Learning Objectives** Explain the following: **1 Introduction to combustion, normal and abnormal combustion, factors affecting normal Combustion** 1.1 Ignition lag, factors affecting it, pre ignition and its effects 1.2 Detonation its effects and factors effecting it and prevention 1.3 Combustion in CI engine, phase of combustion in CI engine 1.4 Factors affecting combustion in CI engine, ignition lag and factors affecting it 1.5 Diesel knock and its effects, factors affecting it and its prevention 1.6 Rating of fuels, octane number merits and demerits of higher-octane fuel and normal octane fuel 1.7 Various desirable properties of CI engine fuels, their effect on engine performance, additives of diesel etc., 1.8 Various desirable properties of SI engine fuels, additives of gasoline, their effect on engine performance	9
D Alternate fuels **Specific Learning Objectives** Explain the following: **1 Availability and properties of alternate fuels, general use of alcohol, LPG, Hydrogen, ammonia, CNG, LNG and vegetable oils** 1.1 Bio diesel, biogas, merits and demerits of various alternate fuels, introduction to alternate energy sources. Like EV, hybrid, fuel cell and solar cars 1.2 Properties of engine fuel, alcohols and gasoline blends, performance in SI engine 1.3 Methanol and gasoline blends, combustion characteristics in CI engines, emission characteristics 1.4 DME, DEE properties performance analysis, performance in SI & CI Engines 1.5 Transesterification-Bio-diesel production from Vegetable oils and waste cooking oil-High blend levels of bio-diesel-Testing 1.6 Bio Diesel-Oxidation Stability-Performance in Engines, Properties of biofuels and their importance in the context of IC Engines 1.7 Vegetable Oils: Various vegetable oils for engines, esterification, performance in engines, performance and emission characteristics, bio diesel and its characteristics 1.8 Layout of an electric vehicle, advantages and limitations, specifications, system components, electronic control system high energy, and power-controlled batteries	9
E Properties gradation and additives of lubricant **Specific Learning Objectives**	

Explain the following: **1 Various properties of Lubricating oil** 1.1 Gradation of lubricating oil 1.2 Introduction of ISO cleanliness code 1.3 Functions and types of additives of lubricating oil 1.4 Measurement of various properties of fuels and lubricants 1.5 Safety precautions while measuring properties of fuels and lubricants	6

Subject Name/Code: Sea Trials, Dry docking, Shipyard/707

Instructional hours:

Lecture	: 30 hours
Tutorial	: 15 hours
Total contact hours	: 45 hours
Credits	: 3

Teaching Methods

The course shall be conducted in a combination of classroom/online lectures, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 30%
Final Exam	: 70%

Recommended Text:

1. Dry-docking & shipboard maintenance: a guide to industry; David J House; Witherby; ISBN: 978-1856092456.
2. Ship Construction: DJ Eyres, GJ Bruce, Seventh edition 2012 Elsevier Ltd.
3. Merchant Ship Construction, Dr DA Taylor, Fourth Edition 1998, IME Publication.

Reference:

1. Ship's Sea Trial & Dry Docking Reports.
2. Shipping Company Procedures Manual for Dry docking etc.
3. The Specialist Committee on Trials and Monitoring Final Report and Recommendations to the 22nd ITTC.
4. Guidelines for Sea Trials of Motor Vessels, GL 2012, Published by: Germanischer Lloyd SE, Hamburg.
5. SHIP HYDROMECHANICS Part I: Introduction, April 2002, J.M.J. Journée and Jakob Pinkster, Delft University of Technology.
6. IMO Resolution A.997(25) Adopted on 29 November 2007 (Agenda item 11), Survey Guidelines Under the Harmonized System of Survey and Certification, 2007.

Table of Topics

Section	Topics	Hours (L:T)
A1-2	Sea Trials **Sub Topic:** Speed/Power Trials and Analysis, Manoeuvrability Trials and Analysis	12: 1
B1-3	Dry docking **Sub Topic:** Methods of dry-docking of ships, Procedure to dry dock ship, Maintenance routines in dry dock	12:9
C	Shipyard **Sub Topic:** Modern shipbuilding Process, Layout of Shipyard, Fabricated components, Fabrication of assembly, sub- assembly, Unit Fabrication, Outfitting and machinery installation, Ship Launching, Role of surveyors in ship construction, Ship design using computers	6:5
	Total	**30:15**

Learning Objectives	L : T
A. Sea Trials	
General Learning Objective Understand the purpose of trials, procedure of trials and report preparation. **A1 Sub Topic: Speed /Power Trials and Analysis** **Sub-sub topics & SLOs** 1.1 State of the ship before trials 1.2 Trial Site Criteria 1.3 Environmental conditions 1.4 Selection of tests 1.5 Measurements taken during trials 1.6 Operation of ship during trials 1.7 Analysis of measured data 1.8 Various corrections applicable 1.9 Report preparation	
Specific Learning Objectives: **1.1 State of the ship before trials** 1.1.1 State that the following are to be recorded before the trials for use during analysis of results and discuss their importance. (a) Hull condition (b) Propeller condition (c) Draft, trim and displacement	0.5: 0
Specific Learning Objectives: **1.2 Trial Site Criteria** 1.2.1 State that the following criteria are to be considered while selecting a site for trials (a) adequate depth of water (b) as small a current variation as possible (c) as small a tidal influence as possible (d) The site will be of adequate size to allow room for ample manoeuvring and to preclude the impact of traffic on the trials 1.2.2 State that, in case trials are performed with a reduced water depth with respect to the above criteria, a correction for shallow water should be applied	0.5: 0
Specific Learning Objectives:	0.5: 0

1.3 Environmental conditions 1.3.1 State that the following are to be recorded before the trials for applying corrections to results if required (a) Wind speed and direction (b) Waves and sea state (c) Water temperature (d) Current speed and direction (e) Air temperature and atmospheric pressure 1.3.2. State the limits for above environmental conditions 1.3.3 State that corrections are applied to the results if the above environmental conditions are beyond the limits given	
Specific Learning Objectives: **1.4 Selection of tests** 1.4.1 State that the purpose of these trials is to determine the effect of displacement on the ship's speed/power characteristics 1.4.2 State that tests should normally be conducted at design displacement 1.4.3 State that follow-up tests are conducted using the same rpm/engine load settings used at the design displacement but at displacements at least 10% different than design 1.4.4 State that the data are also utilized in conjunction with fuel economy studies	1: 0
Specific Learning Objectives: 1.5 **Measurements taken during trials** 1.5.1 State that the following parameters are to be recorded during the trials (a) Ship speed through the water (b) Shaft torque (c) Shaft revolutions 1.5.2 State that the following parameters are to be recorded during the trials in order to correct trial data, if required, and to provide a more precise evaluation of the behaviour of the ship during the speed runs. (a) Ship track (b) Rudder angle (c) Ship heading 1.5.3 Discuss the instrumentation used for measurements (a) to (f) above	1: 0
Specific Learning Objectives: 1.6 **Operation of ship during trials** 1.6.1 Discuss the criteria for finalisation of the following (a) Choice of Run Direction (b) Choice of Number of Points to Define Speed/Power Curves (c) Choice of Number of Opposite Runs (d) Length of Approach or Steady Approach Conditions (e) Length/Duration of Run (f) Ship Conduct During Speed/Power Runs	1: 0
Specific Learning Objectives: 1.7 **Presentation of measured data** 1.7.1 State that Results of speed/power runs are usually given as average figures over the run duration. 1.7.2 Discus following acquisition and data reduction strategies have to be adopted, especially when dealing with computer-based acquisition systems. (a) Choice of Measurement Sampling (b) Data filtering (c) Run data presentation as time histories	1: 0
Specific Learning Objectives:	1: 0

1.8 **Various corrections applicable** 1.8.1 State that whatever correction is applied to the trial results, the procedures must be clearly referenced and documented. 1.8.2 Discuss the corrections due to environmental conditions (a) Correction for added resistance due to wind (b) Correction for added resistance due to waves (c) Correction for shallow water (d) Correction due to water temperature 1.8.3 Discuss the corrections due to Ship Conditions (a) Correcting Power and RPM for Different Displacement and Trim (b) Derive speed / power / rpm for contractual conditions	
Specific Learning Objectives: 1.9 **Report preparation** 1.9.1 State that the trial report breakdown should be as follows: (a) Trial Report Summary (b) Description of the Instrumentation (c) Description of the Trial Site (d) Trial Program (e) Environmental Conditions During the Trials (f) Trial Results (g) Conclusions 1.9.2 Discuss the information to be furnished against each of the above	1: 0
A2 Sub Topic: Manoeuvrability Trials and Analysis **Sub-sub topics & SLOs** 2.1 State of the ship before trials 2.2 Trial Site Criteria 2.3 Environmental conditions 2.4 Description of tests and their purpose 2.5 Measurements taken during trials	1 : 0
Specific Learning Objectives: **2.1 State of the ship before trials** 2.1.1 State that the following are to be recorded before the trials for use during analysis of results and discuss their importance. (a) Hull condition (b) Propeller condition (c) Draft, trim and displacement	0.5: 0
Specific Learning Objectives: **2.2 Trial Site Criteria** 2.2.1 State that the Manoeuvrability of a ship is strongly affected by interactions with the bottom, banks and passing vessels, current and tidal influence and therefore Manoeuvring trials are generally conducted at the same site as the speed/power trials. 2.2.2 State that the following criteria are to be considered while selecting a site for trials (a) adequate depth of water (b) as small a current variation as possible (c) as small a tidal influence as possible (d) The site will be of adequate size to allow room for ample manoeuvring and to preclude the impact of traffic on the trials 2.2.3 State that, IMO standards require that the water depth should exceed four times the mean draft of the ship 2.2.4 State that, in case trials are performed with a reduced water depth with respect to the above criteria, a correction for shallow water should be applied	0.5: 0

Specific Learning Objectives: **2.3 Environmental conditions** 2.3.1 State that Environmental conditions should always be reported even though they may be considered to have no influence on ship behaviour 2.3.2 State that Manoeuvring trials should be performed in the calmest possible weather conditions 2.3.3 Quote IMO Resolution A.751 (1993) for prescribed maximum environmental conditions to carry out the manoeuvring trials 2.3.4. State the Trials should not be conducted with a true wind speed greater than Beaufort 5 2.3.5 State that the trials should be carried out in sea state less than 4	0.5 : 0
Specific Learning Objectives: **2.4 Description of tests and their purpose** 2.4.1 Summarize the different types of manoeuvring tests recommended or required by various organizations. (a) Turning test (b) Z manoeuvre test (c) Modified Z-manoeuvre test (d) Direct spiral test (e) Reverse spiral test (f) Pull-out test (g) Stopping test (h) Stopping inertia test (i) New Course keeping test (j) Man-overboard test (k) Parallel Course Manoeuvre test (l) Initial turning test (m) Z Manoeuvre test at Slow speed (n) Accelerating turning test (o) Acceleration/deceleration tests (p) Thruster test (q) Minimum revolution test (r) Crash ahead test 2.4.2 Describe the purpose of each test 2.4.3 Describe the standard procedures on how to conduct the tests	1 : 1
Specific Learning Objectives: 2.5 **Measurements taken during trials** 2.5.1 State that data are collected to evaluate manoeuvring performance 2.5.2 State that in addition to general measurements described in speed trials, the following parameters are to be recorded during the trials (a) Heading (b) Position (c) Speed (d) Rudder angle (e) Revolution (f) Rate of turn (g) Torque (h)Ship speed through the water 2.5.3 Discuss the instrumentation used for measurements (a) to (f) above	1: 0

B. Dry docking **General Learning Objective** Understand the methods of dry-docking of ships, preparation/procedures for dry-docking, Stability during dry docking **B1 Sub Topic**: **Methods of dry-docking of ships** **Sub-sub topics & SLOs** 1.1 Discuss the requirement to have various sizes and types of dry docks 1.2 List the various types of dry-dock as 1.2.1 Graving dock 1.2.2 Synchro lift systems 1.2.3 Hydro lift system 1.2.4 Floating dock systems 1.2.5 Slip way systems	1 : 1
Specific Learning Objectives: **1.2.1 Graving dock** 1.2.1.1 Describe the features of graving docks 1.2.1.2 Discuss the advantages and disadvantages 1.2.1.3 Discuss division of the dock by caisson	1 : 1
Specific Learning Objectives: 1.2.2 **Synchro-lift systems** 1.2.2.1 Describe the features of synchro lift systems 1.2.2.2 Discuss the advantages and disadvantages	0.5 : 0
Specific Learning Objectives: 1.2.3 **Hydro-lift systems** 1.2.3.1 Describe the features of hydro lift systems 1.2.3.2 Discuss the advantages and disadvantages	0.5: 0
Specific Learning Objectives: **1.2.4 Floating dock systems** 1.2.4.1 Describe the features of floating docks 1.2.4.2 Discuss the advantages and disadvantages 1.2.4.3 Discuss the constructional features of the floating docks	1 :: 1
Specific Learning Objectives: **1.2.5 Slip-way systems** 1.2.5.1 Describe the features of slips and operations 1.2.5.2 Differentiate between docking and building slips 1.2.5.3 Describe slip operation for smaller vessels	1 : 1
B2 Sub Topic: Procedure to dry dock ship **Sub topics and SLOs** 2.1 Process of taking the ship into a dry dock 2.2 Types of dock blocks and their arrangement 2.3 Reasons for a ship to enter dry-dock	1 : 1
Specific Learning Objectives Explain the following: **2.1 Process of taking the ship into a dry dock**	1 : 1

2.1.1. Preparation by the ship's crew 2.1.2 Documentation for dock preparation 2.1.3 Communication between the ship company/crew and the dry dock personnel 2.1.4 Actions and precautions by the ship master before entering the dry dock	
Specific Learning Objectives **2.2 Types of dock blocks and their arrangement** 2.2.1 Discuss the docking block structure 2.2.2 Discuss various types of dock blocks and their arrangements	1 : 0
Specific Learning Objectives **2.3 Reasons for a ship to enter dry-dock** 2.3.1 Discuss reasons for a ship to enter dry-dock	1 : 0
B3 Sub Topic: Maintenance routines in dry dock **Sub-sub topics and SLOs** 1.1 Hull work 1.2 Routines on Rudder, Propeller, Bow thruster	1 : 1
Specific Learning Objectives 1.1**Hull work** 1.1.1 List the standard tasks to be undertaken as follows: (a) Clean the ship's bottom, which could include high-pressure water or grit blasting (b) Paint and recoat the underwater area and boot topping of the hull (c) Clean and paint the chain locker (d) Range and inspect the anchors and cables (e) Inspect and paint draught marks, plimsoll line and freeboard markings (f) Renew sacrificial anodes as and where appropriate (g) Conduct any general steel work repairs, i.e., flame cutting or welding (h) Carry out general repairs to deck and engine room 1.1.2 Discuss the requirements of harmonised survey system and state that the above list could be enhanced as required 1.1.3 Describe the standard hull cleaning and surface preparation methods and their advantages / disadvantages 1.1.4 Describe the methods of hull maintenance by painting 1.1.5 Explain various paint types and other terminologies used in painting 1.1.6 Discuss the general requirements of anchor and chain cable survey and other chain locker	1 : 1
Specific Learning Objectives **1.2 Routines on underwater valves and equipment and system** 1.2.1 Discuss the dry dock survey and maintenance requirements of the following based on harmonised survey system (a) Anti-Roll Stabiliser Units/Bilge Keels and Appendages (b) Bow thruster Units (c) Propeller including shipping and unshipping of keyless propellers and tail end shaft and stern tube (d) Rudder including shipping and unshipping (e) Machinery and equipment related to anchor chain	1 : 1

C. Shipyard	
C1 Sub Topic: Modern shipbuilding Process **General Learning Objective** Understand the stages involved in Modern shipbuilding process **Sub-sub topics and SLOs** 1.1 List the following stages involved in ship building and draw a work flow diagram and Describe them (a) Design office and CAD/CAM (b) Plan approval (c) Ordering of material (d) Storage of material (e) Preservation of material before use – shot blasting and priming etc. (f) Marking, cutting, shaping, bending to prepare for fabrication (g) Sub assembly (h) Block assembly (i) Unit and Block erection (j) Final outfit	1:1
C2 Sub Topic: Modern Shipyard Layout **General Learning Objective** Understand the requirements of facilities required based on stages of ship building and their relative locations **Sub-sub topics and SLOs** 2.1 Discusses the requirements of following and their locations for good workflow 2.2 Steel treatment units and Storage yard 2.3 Machining, cutting, bending and other workshops 2.4 Production bays 2.5 Assembly sections 2.6 Block erection 2.7 Out fitting and painting sections	1:1
C3 Sub Topic: Fabricated components: Fabrication of assembly, sub- assembly, Unit Fabrication **General Learning Objective** Understand the fabrication processes involved in ship construction **Sub-sub topics and SLOs** Explain the following: 3.1 Material preparation-shot blasting and priming 3.2 Manufacture of plates and sections, marking, cutting, machining and shaping 3.3 Subassembly and assembly production 3.4 Units fabrication and delivery to the berth 3.5 Units erection, fairing and welding 3.6 Material handling equipment	1:1
C4 Sub Topic: Outfitting and machinery installation **General Learning Objective** Understand the modern outfitting and machinery installation processes	1:1

Sub-sub topics and SLOs 4.1 Discusses various outfitting processes in ship building 4.2 Routing of cables and pipes – Role of VR 4.2 Pre-outfitting and modular construction 4.3 Machinery foundations and installation of machinery	
C5 Sub Topic: Ship Launching **General Learning Objective** Understand the launching methods used for floating ship after construction **Sub-sub topics and SLOs** Explain the following: 5.1 Floating out 5.2 Slipway end launching 5.3 Slipway sideways launching 5.4 Synchro lift launching	1:0
C6 Sub Topic: Role of surveyors in ship construction **General Learning Objective** Understand the involvement of class surveyors in ship building process **Sub-sub topics and SLOs** Explain the following: 6.1 Plan approvals and issue 6.2 Quality assurance 6.3 Stage inspection during constructions 6.3 Witnessing trials of ship, machinery and systems	1:0
C7 Sub Topic: Computers and Automation in Ship building **General Learning Objective** Discuss the various computer aided processes in ship design and construction **Sub-sub topics and SLOs** Explain the following: 7.1 Computer aided ship design 7.2 VR in ship design 7.3 CNC Machines in shipyard 7.4 Nesting to avoid steel wastages 7.5 Automated and Robotic cutting welding processes 7.6 Hull and propellers optimisation using CFD	0:1

Subject Name/Code: PLC and Automation Control (P) /708

Instructional Hours:

Practical	: 30 hours
Total contact hours	: 30 hours
Credits	: 1

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Exam	: 50%

Recommended Text:

1. Marine Control Technology 4^{h} Edition; By J. Majumder, Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN: 9789352139682.
2. Applied Marine Control and Automation; By J. Majumder, Elstan A. Fernandez, Mahesh Patil; Publisher: Shroff Publishers and Distributors; Year: 2019; ISBN: 9789352139194.

Reference:

1. Digital Control System and State Variable; By Gopal M; Publisher Tata McGraw Hill.
2. Digital Control System by Kuo B.C.; Publisher Oxford University Press, London.
3. Marine Control Practice by D.A. Taylor, Publisher Butterworth and Co. Ltd. London.

Table of Topics

Section	Topics	Hours (P)
A1	**Diesel Engines** **Sub-Topics:** Monitoring and Control of Main Diesel Engines	2
B1	**Steam Turbines** **Sub-Topics:** Monitoring and Control of Steam Turbines	1
C1	**Gas Turbines** **Sub-Topics:** Monitoring and Control of Gas Turbines	1
D1	**Generator and Distribution System** **Sub-Topics:** Monitoring and Control of Generator and Distribution System	1
E1	**Steam Boiler** **Sub-Topics:** Monitoring and Control of Steam Boilers	1
F1	**Oil Purifier** **Sub-Topics:** Monitoring and Control of Oil purifiers	1
G1	**Refrigeration and Air Conditioning System** **Sub-Topics:** Monitoring and Control of Refrigeration and Air Conditioning Systems	1
H1	**Pumping and Piping System** **Sub-Topics:** Automation, Monitoring and Alarms of Pumping and Piping System	1
I1	**Steering Gear System** **Sub-Topics:** Salient Features for the Control of Steering Systems	1
J1	**Cargo Handling Equipment and Deck Machinery** **Sub-Topics:** Functions and Mechanisms of Automatic Control for Deck Machinery	1
K1	**Automatic Control Engineering and Safety Devices** **Sub-Topics:** Electrical and Electronic Instrumentation and Control Equipment	10
L1	**Restoration of Electrical and Electronic Control Equipment to Operating Condition** **Sub-Topic:** Calibration and Adjustment of Transmitters and Controllers	2
M1	**Control System Fault Finding** **Sub-Topic:** Fault Finding Methods for Main Control Systems	3
N1	**Programmable Logic Controllers** **Sub-Topics:** Salient Features of Programmable Logic Controllers (PLC)	2
O1	**Microcontrollers** **Sub-Topics:** Salient Features of Micro Controllers	2
	Total	**30**

Learning Objectives	P
A Diesel Engines **General Learning Objectives** • Understand the correlation of components for the automatic control of diesel engines • Understand the various modes of operation • Know the safety features incorporated in Diesel Engine control systems **Topic: Diesel Engines** **Sub-Topics:** 1.1 Monitoring and Control of Main Diesel Engines	
A1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.4 – 4.1) **1.1 Monitoring and Control of Main Diesel Engines** 1.1.1 Identify system components and configuration / demonstrate operation for main engine automatic control for the following operation / control mechanisms and circuits: - automatic changeover from air running to fuel running - start failure - start impossible - wrong way - speed run-up program by revolution, local and/or combination control, including bypass program for critical speed - crash/emergency astern program - speed control under rough/calm sea condition - variable injection timing - variable exhaust valve timing - safety (automatic shutdown, automatic slowdown) system 1.1.2 Identify and mechanism of the electro-governing system for revolution control	2
B Steam Turbines **General Learning Objectives** • Understand the correlation of components for the automatic control of diesel engines • Understand the various modes of operation • Know the safety features incorporated in Steam Turbine control systems **Topic: Diesel Engines** **Sub-Topics:** 1.1 Monitoring and Control of Steam Turbines	
B1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.4 – 4.2) **1.1 Monitoring and Control of Steam Turbines** 1.1.1 Identify system components and configuration / demonstrate operation for main steam turbine automatic control for the following operation / control mechanisms and circuits: - warming through (main turbines & COPTs etc.) - start impossible - wrong way - speed run-up program by revolution, load and/or combination control - crash/emergency astern program - automatic rollover - safety (automatic shutdown) system	1

C Gas Turbines **General Learning Objectives** • Understand the correlation of components for the automatic control of gas turbines • Understand the various modes of operation • Know the safety features incorporated in Gas Turbine control systems **Topic: Gas Turbines** **Sub-Topics:** 1.1 Monitoring and Control of Gas Turbines	
C1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.4 – 4.3) **1.1 Monitoring and Control of Gas Turbines** 1.1.1 Identify system components and configuration / demonstrate operation for main gas turbine automatic control for the following operation / control mechanisms and circuits: - start impossible - wrong way - speed run-up program by revolution, load and/or combination control - crash / emergency astern program - automatic rollover - safety (automatic shutdown, automatic slowdown system)	1
D Generator and Distribution System **General Learning Objectives** • Understand the power generation and distribution system configuration • Understand the various modes of operation with respect to the generator and the switchboard and its components • Know the safety features incorporated in the generation and distribution systems **Topic: Diesel Engines** **Sub-Topics:** 1.1 Monitoring and Control of Generator and Distribution System	
D1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.1) **1.1 Monitoring and Control of Generator and Distribution System** 1.1.1 Identify system components and configuration 1.1.2 Explain the operation for generator and distribution system for the following operation / control mechanisms and circuits: - fully automatic control for generator and distribution system, including automatic starting and stopping prime mover - automatic synchronizing - automatic load sharing - optimum load sharing - large motor start blocking - preference trip - protective/safety functions built in Automatic/Main Circuit Breaker (ACB and VCB) - automatic voltage (AVR) and frequency control	1

E Steam Boiler **General Learning Objectives** • Understand the correlation of components for the automatic control of boilers • Understand the various sub systems and their control loops • Know the safety features incorporated in Boiler control systems **Topic: Steam Boiler** **Sub-Topics:** 1.1 Monitoring and Control of Steam Boilers	
E1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.2) **1.1 Monitoring and Control of Steam Boilers** 1.1.1 Identify system components and configuration 1.1.2 Explain the operation for steam boiler automatic control for the following operation / control mechanisms and circuits: - automatic Combustion Control (ACC), including steam pressure control, fuel oil flow control and air flow control - automatic feed water control - automatic steam temperature control - protective/safety functions for steam boiler	1
F Oil Purifier **General Learning Objectives** • Understand the sequence of operation and modes of control for purifiers • Understand the various sub systems and their control loops • Know the safety features incorporated in purifiers **Topic: Oil Purifier** **Sub-Topics:** 1.1 Monitoring and Control of Oil purifiers	
F1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.3) **1.1 Monitoring and Control of Oil purifiers** 1.1.1 Explain the operation of automation, monitoring and alarms of oil purifiers: - temperature control - automatic start - automatic desludging: - partial desludging - total desludging - monitoring and alarms: - low/high temperature - water content - leakage monitoring - treated oil flowing into heavy liquid side - non-closure of bowl - discharge detector for monitoring sludge discharge	1

G Refrigeration and Air Conditioning System **General Learning Objectives** • Understand the automatic control circuit for Refrigeration and AC systems • Understand the importance of cut-outs and alarms for both Refrigeration and Air Conditioning systems **Topic: Refrigeration and Air Conditioning System** **Sub-Topics:** • **1.1 Monitoring and Control of Refrigeration and Air Conditioning Systems**	
G1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.4) **1.1 Monitoring and Control of Refrigeration and Air Conditioning Systems**	1

G Refrigeration and Air Conditioning System **General Learning Objectives** • Understand the automatic control circuit for Refrigeration and AC systems • Understand the importance of cut-outs and alarms for both Refrigeration and Air Conditioning systems **Topic: Refrigeration and Air Conditioning System** **Sub-Topics:** • **1.1 Monitoring and Control of Refrigeration and Air Conditioning Systems**	
1.1.1 Explain operation of the automation, monitoring and alarms in refrigeration systems: - if pump down cycle used on board for refrigeration system: - automatic shutdown of compressor when all cold rooms attain temperature by shutting off of solenoid valves and low pressure cut out in suction line - when one more cold rooms temperature rises and solenoid valve/s open and suction pressure rises, thereby suction cut in operates and automatic start of compressor - automatic shutdown and alarm in case of high pressure in discharge line. Manual reset for restarting of compressor - automatic shutdown of compressor and alarm in case of low pressure of lubricating oil - timer control for destroying of evaporator coils of meat room and fish room 1.1.2 Explain automatic control of steam spray for accommodation air conditioning heating system	
H Pumping and Piping System **General Learning Objectives** • Understand the automatic control of pumps and monitoring / control systems in piping • Correlate the knowledge of a basic system with ship-based equipment **Topic: Pumping and Piping System** **Sub-Topics:** 1.1 Automation, Monitoring and Alarms of Pumping and Piping System	
H1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.5) **1.1 Automation, Monitoring and Alarms of Pumping and Piping System** 1.1.1 Explain operation of the automation, monitoring and alarms of pumping and piping system: - automatic start of standby pumps - automatic start/stop of hydrophore pumps - automatic water level control of boiler by feed pumps - automatic cargo stripping system on-board tankers - automatic heeling system	1

I Steering Gear System **General Learning Objectives** • Understand the automatic control of steering systems including auto-pilot system • Understand the importance and function of Emergency Steering • Know the safety features incorporated in steering control systems **Topic: Steering Gear System** **Sub-Topics:** 1.1 Salient Features for the Control of Steering Systems	
I1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.6) **1.1 Salient Features for the Control of Steering Systems** 1.1.1 Explain operation of the automation, monitoring and alarms of steering systems: - main and emergency steering systems - autopilot system - regaining of steering capability in case of single failure of the hydraulic system	1
J Cargo Handling Equipment and Deck Machinery **General Learning Objectives** • Understand the automatic control systems for cargo-handling equipment and deck machinery • Understand the importance and function of auto shutdown of cargo pumping operations • Know the safety features incorporated in cargo handling equipment and deck machinery **Topic: Cargo Handling Equipment and Deck Machinery** **Sub-Topics:** • 1.1 Functions and Mechanisms of Automatic Control for Deck Machinery	
J1 Specific Learning Objectives: (IMO 7.02,2014: 1.3.5 – 5.7) **1.1 Functions and Mechanisms of Automatic Control for Deck Machinery** 1.1.1 Explain the operation of the automation, monitoring and alarms of cargo handling equipment and deck machinery: - self-tensioning mooring winches - automatic shutdown of cargo pumping on abnormal operating conditions of inert gas system on board tankers - automatic shutdown of cargo pumping/loading on tankers and gas carriers	1

K Automatic Control Engineering and Safety Devices **General Learning Objectives** • Understand the importance of process control • Understand the importance and function of all commonly used sensors and controllers on a ship **Topic: Automatic Control Engineering and Safety Devices** **Sub-Topics:** 1.1 Electrical and Electronic Instrumentation and Control Equipment	
K1 Specific Learning Objectives: (IMO 7.02,2014: 2.1 – 1.3) **1.1 Electrical and Electronic Instrumentation and Control Equipment** 1.1.1 Identify components and demonstrate operation for the basic concepts of: - open and closed control loops - process control - essential components in process control loops	1
1.1.2 Explain the operation and use of sensors and transmitters in shipboard systems - resistance temperature devices - thermocouples - ambient temperature compensation	1
- flow and pressure measurement	1
- level measurement	1
- viscosity measurement	1
- torque measurement	
- force balance transmitters	1
- oil/water interface and oil in water monitoring	
- the pneumatic flapper/nozzle system - pneumatic 20-100 kPa, analogue 4 to 20 mA signals, pneumatic pilot relays - control air supply	1
- operational amplifiers - electrical supply	1
1.1.3 Identify the operation and use of final control elements - diaphragm operated control valves - flow/lift characteristics of control valves - control valve actuators and positioners - ‘fails – safe’, ‘fail – set’ strategies - wax element valves - electrically operated valves	1
1.1.4 Explain the operation and use of governors - need for governors - governor terms, concepts and operation - hydraulic governors - digital governors, power sharing - governing systems	1

L Restoration of Electrical and Electronic Control Equipment to Operating Condition **General Learning Objectives** • Understand the function and operating methodology of different components and breakers • Know the basic operation of switchboards and related switchgear **Topic: Restoration of Electrical and Electronic Control Equipment to Operating Condition** **Sub-Topic:** 1.1 Calibration and Adjustment of Transmitters and Controllers	
L1 Specific Learning Objectives: (IMO 7.02,2014: 2.2 - 1.12) **1.1 Calibration and Adjustment of Transmitters and Controllers** 1.1.1 Calibrate and adjust the following: - differential pressure transmitters calibration - electronic temperature transmitter calibration	1
1.1.2 Explain the operation of a PID controller 1.1.3 Demonstrate the tuning a PID controller 1.1.4 For governors and controllable pitch propeller control explain the following: - tests - faults - solutions	1
M Control System Fault Finding **General Learning Objectives** • Know the basic fault-finding control systems like a governor control system • Understand the operating principles of common control systems and the methods to rectify them • Understand how the testing of alarm and monitoring systems is done **Topic: Control System Fault Finding** **Sub-Topic:** 1.1 Fault Finding Methods for Main Control Systems	
M1 Specific Learning Objectives: (IMO 7.02,2014: 2.2) **1.1 Fault Finding Methods for Main Control Systems** 1.1.1 Explain the following: - fault finding methods - governor faults	1
- evaluation and rectification of common control systems	1
- testing alarm and monitoring systems - electric power supply for control systems	1
N Programmable Logic Controllers **General Learning Objectives** • Understand the operation of a Programmable Logic Controller • Understand the importance and operation of HMIs • Know the basics of checking program validity **Topic: Programmable Logic Controllers** **Sub-Topics:** 1.1 Salient Features of Programmable Logic Controllers (PLC)	

N1 Specific Learning Objectives: (IMO 7.02,2014: 2.2.4 – 4.1) **1.1 Salient Features of Programmable Logic Controllers (PLC)** 1.1.1 Identify basic building blocks of PLC operation 1.1.2 Explain the operation of human machine interface and alteration of parameters in the programme 1.1.3 Identify basic software version and control of access 1.1.4 Explain the maintenance of electronic control equipment and PLC Controlled processes 1.1.5 Explain the checking of the programme validity and fault-finding and restoration of process with the help of PLCs	2
O Microcontrollers **General Learning Objectives** • Understand the operation of a microcontroller • Understand the need for analogue to digital conversion and the methods to do so • Know the basics of communication between a microcontroller and a PC **Topic: Microcontrollers** **Sub-Topics:** 1.1 Salient Features of Microcontrollers	
O1 Specific Learning Objectives: (IMO 7.02,2014: 2.2.4 – 4.2) **1.1 Salient Features of Microcontrollers** 1.1.1 Explain how communication with PC is established 1.1.2 Explain code integration	2

Subject Name/Code: Maintenance & Repair of Electrical, Electronic and Automation Systems (P) /709

Instructional Hours:

Practical	: 60 hours
Total contact hours	: 60 hours
Credits	: 2

Teaching Methods

The practical training will be hands-on with focus on safety and skills.

Assessment Methods **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Written tests/MCQs/Projects/Assignments)	: 50%
Final Practical Exam	: 50%

Recommended Text:

1. Maintenance and Troubleshooting of Marine Electrical Systems Volume 1; By Elstan A. Fernandez and Lakshman Singh Yadav; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN: 9788194710608.
2. Troubleshooting of Marine Electrical Systems Volume 2; By Elstan A. Fernandez, Harbhajan Singh and Lakshman Singh Yadav; Shroff Publishers and Distributors; Year: 2020; ISBN: 9789385889851.
3. Marine Electrical Technology; By Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; 9789352139514.

Reference:

1. Testing of Electronic Components on Ships and Land; By Dr. Prosanjeet Sarkar and Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2021; ISBN 9789385889837.
2. Marine Control technology; By J. Majumder and Elstan A. Fernandez; Publisher: Shroff Publishers and Distributors; Year: 2020; ISBN 9789352139682.
3. Electrical Equipment Handbook: Troubleshooting and Maintenance; By Philip Kiameh; Publishers McGraw Hill Professional; ISBN 9780071396035.

Table of Topics

Section	Topics	Hours (P)
A1	**Safety Requirements for Working on Electrical Systems** **Sub-Topics:** Safety and Emergency Procedures	4
B1	**Maintenance and Repair** **Sub-Topics:** Principles of Maintenance, Maintenance and Repair of Generators, Maintenance and Repair of Switchgear, Maintenance and Repair of Electrical Motors, Maintenance and Repair of Starters, Maintenance and Repair of Transformers, Maintenance and Repair of the Electrical Distribution System, Maintenance and Repair of Cables, Maintenance and Repair of Batteries and Associated Equipment	12
C1	**Detection of Electric Malfunction and Measures to Prevent Damage** **Sub-Topics:** Fault Protection, Fault Location	5
D1	**Construction and Operation of Electrical Test and Measuring Equipment** **Sub-Topics:** Construction and Operation of Insulation Tester, Construction and Operation of Continuity Tester, Construction and Operation of Multi Tester, Construction and Operation of Clamp meter	2
E1	**Function and Performance Test and Configuration** **Sub-Topics:** Monitoring Systems, Automatic Control Devices, Protective Devices	11
F1-F2	**Electrical and Simple Electronic Diagrams** **Sub-Topics:** Basics of Electrical and Electronic Diagrams, Interpretation of Circuit Symbols	5
G1	**Troubleshooting of Electrical and electronic Control Equipment)** **Sub-Topics:** Test Equipment, Logical Six Step Troubleshooting Procedure, Generation, Prime Mover Electrical Controls, Main Air Circuit Breaker, Protection of Generators, Electrical Distribution Systems, Motors, Electrical Survey Requirements, Calibrate and Adjust Transmitters and Controllers, Control System Fault finding	11
H1	**Function Test of Electrical, Electronic Control Equipment and Safety Devices** **Sub-Topics:** Function Test of Most Common Electrical Devices Onboard	3
I1	**Troubleshooting of Monitoring Systems** **Sub-Topics:** Revision of Test and Calibration of Sensors and transducers of monitoring system	2
J1	**Software Version Control** **Sub-Topics:** Digital techniques	5
	Total	**60**

Learning Objectives	P
A Safety Requirements for Working on Electrical Systems **General Learning Objectives** • Understand the importance of safety procedures while working with electrical and electronic equipment • Understand the impact of electrical shock on the human body • Know the safety, isolation procedures and interlocks **Topic: Safety Requirements for Working on Electrical Systems** **Sub-Topics:** 1.1 Safety and Emergency Procedures	
A1 Specific Learning Objectives: (IMO 7.04,2014: 2.2.1) **1.1 Safety and Emergency Procedures** 1.1.1 Describe the cause of electric shock, giving the level of current which could be fatal 1.1.2 State the voltage range which is considered safe 1.1.3 Take and also apply safety precautions necessary when working on electrical equipment in practice 1.1.4 Carry out the safety and isolation procedures necessary before commencing work on electrical equipment	2
1.1.5 Demonstrate the use of interlocks fitted to circuit breakers 1.1.6 Identify the dangerous spaces in the vicinity of busbars 1.1.7 Demonstrate safe procedures for working on instrument voltage / current transformer circuits and the such circuits 1.1.8 Identify the protection features normally provided on the doors of switchboard cubicles 1.1.9 Demonstrate that safety and emergency procedures are documented in the ship's safety management system	2

Learning Objectives	P
B Maintenance and Repair **General Learning Objectives** • Know the types of maintenance • Know how to carryout maintenance on equipment • Know the basics of detecting and rectifying faults in both high and low voltage equipment **Topic: Maintenance and Repair** **Sub-Topics:** 1.1 Principles of Maintenance 1.2 Maintenance and Repair of Generators 1.3 Maintenance and Repair of Switchgear 1.4 Maintenance and Repair of Electrical Motors 1.5 Maintenance and Repair of Starters 1.6 Maintenance and Repair of Transformers 1.7 Maintenance and Repair of the Electrical Distribution System 1.8 Maintenance and Repair of Cables 1.9 Maintenance and Repair of Batteries and Associated Equipment	
B1 Specific Learning Objectives: (IMO, 7.042014: 2.2.2 – 2.2 to 2.7) **1.1 Principles of maintenance** 1.1.1 Explain the need for maintenance 1.1.2 Describe briefly what is meant by: - breakdown maintenance - planned maintenance - condition monitoring	1
1.2 Maintenance and Repair of Generators 1.2.1 State the safety and isolation precautions necessary before commencing work 1.2.2 Explain the safety and isolation precautions necessary before commencing work 1.2.3 List the parts to be inspected, their common faults and the necessary remedial action 1.2.4 Identify the parts to be inspected, keeping in mind their common faults and the necessary remedial action 1.2.5 Test and record values of insulation resistance with an insulation tester 1.2.6 Perform routine maintenance and testing of a generator	1
1.3 Maintenance and Repair of Switchgear 1.3.1 Describe the care to be taken when handling circuit breakers 1.3.2 Describe maintenance routines and fault-finding procedures on main circuit breakers 1.3.3 Carry out a maintenance routine on main circuit breakers 1.3.4 Detect and correct faults in circuit breakers	1
1.4 Maintenance and Repair Electrical Motors 1.4.1 List the principal maintenance procedures and equipment for Motor 1.4.2 Carry out the maintenance necessary for a squirrel cage electric motor, paying particular attention to: - dampness, condensation and air flow - dust and oil - external and internal surfaces - frequency of maintenance - deterioration of insulation - cleaning, inspection, renewal and lubrication of bearings 1.4.3 Check the insulation resistance of a three-phase induction motor	1
1.5 Maintenance and Repair of Starters 1.5.1 Lists the principal maintenance procedures and equipment for starters 1.5.2 Carry out the maintenance necessary, and complete reports on starters and controllers with specific reference to:	2

Learning Objectives	P
B Maintenance and Repair **General Learning Objectives** • Know the types of maintenance • Know how to carryout maintenance on equipment • Know the basics of detecting and rectifying faults in both high and low voltage equipment **Topic: Maintenance and Repair** **Sub-Topics:** 1.1 Principles of Maintenance 1.2 Maintenance and Repair of Generators 1.3 Maintenance and Repair of Switchgear 1.4 Maintenance and Repair of Electrical Motors 1.5 Maintenance and Repair of Starters 1.6 Maintenance and Repair of Transformers 1.7 Maintenance and Repair of the Electrical Distribution System 1.8 Maintenance and Repair of Cables 1.9 Maintenance and Repair of Batteries and Associated Equipment	
- casings, corrosion and bonding - contactors, magnet faces, pitting, overheating, spring force, lubrication - connections, cables and leads 1.5.3 Detect and rectify faults in motors, starters and protection equipment	
1.6 Maintenance and Repair of Transformers 1.6.1 Describe the maintenance checks required by a transformer 1.6.2 Demonstrate the maintenance procedures required by a transformer	1
1.7 Maintenance and Repair of the Electrical Distribution System 1.7.1 Estimate the current flowing during given fault conditions 1.7.2 Explain how earth faults occur and the potential danger 1.7.3 Demonstrate what is meant by the following faults: - open-circuit - earth - short-circuit 1.7.4 Explain the effects of an earth fault with an insulated distribution system	2
1.7.5 Identify and understands the working of earth fault instruments 1.7.6 On a given distribution circuit, carry out a logical procedure to detect the location of an earth fault, using earth-fault lamps and an insulation-testing instrument 1.7.7 Explain why the circuit must be switched off when replacing a lamp and Demonstrate switching off power supply and replacing of a lamp 1.7.8 Describe the deterioration common in both lamps and lamp holders and their wire connections 1.7.9 Explain the necessary care to be taken when working on fluorescent lamp circuits 1.7.10 Demonstrate how failed lamps are disposed of 1.7.11 Explain the necessary care when maintaining: - exposed watertight fittings - portable hand lamps 1.7.12 Carry out routine testing and maintenance of lighting circuits and fittings 1.7.13 Detect and rectifies faults likely to be encountered at sea (high voltage) 1.7.14 State that high-voltage systems are normally earthed via a resistor 1.7.15 Identify high-voltage systems earthing resistors 1.7.16 Explain how the presence of earth faults is indicated in a high voltage system with an earthed neutral 1.7.17 Demonstrate routine maintenance and inspection / testing procedures	

Learning Objectives	P
B Maintenance and Repair **General Learning Objectives** • Know the types of maintenance • Know how to carryout maintenance on equipment • Know the basics of detecting and rectifying faults in both high and low voltage equipment **Topic: Maintenance and Repair** **Sub-Topics:** 1.1 Principles of Maintenance 1.2 Maintenance and Repair of Generators 1.3 Maintenance and Repair of Switchgear 1.4 Maintenance and Repair of Electrical Motors 1.5 Maintenance and Repair of Starters 1.6 Maintenance and Repair of Transformers 1.7 Maintenance and Repair of the Electrical Distribution System 1.8 Maintenance and Repair of Cables 1.9 Maintenance and Repair of Batteries and Associated Equipment	
1.8 Maintenance and Repair of Cables 1.8.1 Fit cables through glands into a terminal box, earthing the armouring as appropriate 1.8.2 Solder and crimps terminal sockets to conductors 1.8.3 Measure resistance of cables 1.8.4 Explain the limitation of temporary repairs to insulation 1.8.5 Carry temporary repairs to insulation	1
1.9 Maintenance and Repair of Batteries and Associated Equipment 1.9.1 Explain how emergency lights and back-up power supply lines for the ship's power machinery are tested at frequent intervals 1.9.2 Explain or describe the maintenance of batteries, taking all necessary precautions keeping in mind the gases evolved and other dangers. 1.9.3 Name the gases given off when recharging a lead acid battery, explaining the effect on the electrolyte and how it is remedied 1.9.4 Check the specific gravity of the electrolyte of a lead acid battery and of an alkaline battery and explains its significance 1.9.5 Identify back-up power for remote / automatic control equipment and how they should be continuously monitored and must be checked at frequent intervals 1.9.6 Explain Tests for back-up power of monitoring systems and renewal of its built-in battery at certain intervals 1.9.7 Explain how back-up power for safety / protective devices is supplied from the emergency DC line and how it must be tested carefully at certain intervals 1.9.8 Explain that the power for safety / protective devices is isolated from control systems and other power sources	2

Learning Objectives	P
C Detection of Electric Malfunction and Measures to Prevent Damage **General Learning Objectives** • Understand the importance of fault protection components and systems • Know how to locate faults in electrical and electronic circuits **Topic: Detection of Electric Malfunction and Measures to Prevent Damage** **Sub-Topics:** 1.1 Fault Protection 1.2 Fault Location	
C1 Specific Learning Objectives: (IMO 7.04,2014: 2.2.3) **1.1 Fault Protection** 1.1.1 Explain why fault protection is essential 1.1.2 Explain why fault currents can be extremely high 1.1.3 Name the three types of over-current protection relays and describe the principles of operation of each 1.1.4 Identify the three types of over-current protection relays 1.1.5 Identify the protection provided against: - Short circuits - Small overloads 1.1.6 Identify the component parts of fault-protection equipment 1.1.7 Explain the advantages and disadvantages of high-rupturing capacity fuses 1.1.8 Demonstrate the procedure when replacing a blown fuse 1.1.9 Explain in simple terms, preferential tripping when overload occurs 1.1.10 Identify preferential tripping components 1.1.11 Explain the purpose of under voltage protection of generators and of motors 1.1.12 Identify under voltage protection relays for generators and motors 1.1.13 Explain the purpose of reverse power protection 1.1.14 Identify reverse power protection relays	2
1.1.15 Sketch the layout of a typical main switchboard, indicating the function of the main parts 1.1.16 Identify the main parts of the main switchboard 1.1.17 Explain the danger associated with the spaces in the vicinity of the busbar 1.1.18 Explain the safety precautions in the vicinity of the busbar 1.1.19 Explain the use of transformers for switchboard instruments, stating the voltages and current produced 1.1.20 Describe and Locate the earthing of instruments 1.1.21 Explain the potential danger of instrument voltage / current transformer circuits and the safe procedure for working on such circuits 1.1.22 Explain how status indicator lamps are usually supplied with power 1.1.23 Explain how to adjust, maintain and test the types of fault protections normally encountered	1
1.2 Fault Location 1.2.1 Describe the essential requirements for the automatic operation of marine machinery 1.2.2 Use control and instrumentation terminology in its correct context 1.2.3 Compare pneumatic, hydraulic and electronic-electrical control systems 1.2.4 Describe a simple control loop 1.2.5 Name analogue and digital devices 1.2.6 Locate faults in simple control systems 1.2.7 On locating a fault, how to take action to best prevent damage 1.2.8 State what is necessary to prevent damage from electrical malfunctions such as burned circuit elements, poor contacts, breaking and faulty limit / micro switches	2

<table>
<tr><th>Learning Objectives</th><th>P</th></tr>
<tr><td>D Construction and Operation of Electrical Test and Measuring Equipment
General Learning Objectives
• Understand the operation of test and measuring equipment within the scope of this topic
• Know how to use the test and measuring equipment within the scope of this topic
Topic: Construction and Operation of Electrical Test and Measuring Equipment
Sub-Topics:
1.1 Construction and Operation of Insulation Tester
1.2 Construction and Operation of Continuity Tester
1.3 Construction and Operation of Multi Tester
1.4 Construction and Operation of Clamp meter</td><td></td></tr>
<tr><td>D1 Specific Learning Objectives: (IMO 7.04,2014: 2.2.4)
1.1 Construction and Operation of Insulation Tester
1.1.1 State the operation principles of an insulation tester
1.1.2 Demonstrate the operation of an insulation tester
1.1.3 Take precautions when using an insulation tester
1.1.4 State the range of voltages used for testing ships’ equipment
1.1.5 Use an insulation tester:
- To check the zero reading
- To measure values of phase-to-phase insulation
- To measure values of phase-to-earth insulation
1.1.6 Explain the significance of individual and comparative test readings</td><td rowspan="2">1</td></tr>
<tr><td>1.2 Construction and Operation of Continuity Tester
1.2.1 Use a continuity tester to:
- Check that the equipment is dead
- Measure the resistance of circuits
1.2.2 Enter test readings and relevant comments on an appropriate record card
1.2.3 Explain the significance of individual and comparative test readings</td></tr>
<tr><td>1.3 Construction and Operation of Multi Tester
1.3.1 Use digital and analogue multimeters, taking precautions to:
- Check the accuracy of the meter
- Check for battery failure
- Measure resistance
- Measure voltage
- Measure current
- Test diodes
1.4 Construction and Operation of Clamp meter
1.4.1 State the operation principles of a clamp meter
1.4.2 State the precautions when using a clamp meter
1.4.3 Use a clamp meter to measure current
1.4.4 Use a live-line tester to determine whether equipment is alive or dead</td><td>1</td></tr>
</table>

Learning Objectives	P
E Function and Performance Tests **General Learning Objectives** • Understand the functions of system components for a monitoring system • Understand the function of instrumentation system components like sensors, transducers etc. • Know how to carry out function / performance tests for components within the scope of this topic **Topic: Function and Performance Tests** **Sub-Topics:** 1.1 Monitoring Systems 1.2 Automatic Control Devices 1.3 Protective Devices	
E1 Specific Learning Objectives: (IMO 7.04,2014: 2.2.5 – 5.1 to 5.3) **1.1 Monitoring Systems** 1.1.1 State what a monitoring system or data logger is 1.1.2 Explain how a monitoring system is constructed showing its system configuration. 1.1.3 Demonstrate the operation of the following system components for a monitoring system: - CPU - I/O interface - Monitoring display - Log printer - Alarm printer - Lamp driver - Extension alarm system 1.1.4 Explain briefly how each system component works and its operating mechanism	2
1.1.5 Explain how measured / monitored values can be confirmed if it is correct 1.1.6 Explain how alarm setting values in a monitoring system can be changed 1.1.7 Carry out function / performance tests taking a typical system as an example	1
1.2 Automatic Control Devices 1.2.1 State what components are comprised in various automatic control systems showing their system configurations 1.2.2 Identify the components comprised in various automatic control systems	1
1.2.3 Explain briefly and observes the functions of the following components and their operation mechanisms: - Sensor - Controller - Transducer / converter - Positioner - Regulator - Control valve - Actuator - Relay - Servomotor	1
1.2.4 Describe testing equipment for function / performance of each component cited above 1.2.5 Explain what is meant by mechatronics and how it is utilised in automatic control systems 1.2.6 Explain how function / performance tests for each component cited above can be carried out	
1.2.7 Explain how function / performance of automatic control systems incorporated in the following operation systems can be tested: - Main engine	1

Learning Objectives	P
E Function and Performance Tests **General Learning Objectives** • Understand the functions of system components for a monitoring system • Understand the function of instrumentation system components like sensors, transducers etc. • Know how to carry out function / performance tests for components within the scope of this topic **Topic: Function and Performance Tests** **Sub-Topics:** 1.1 Monitoring Systems 1.2 Automatic Control Devices 1.3 Protective Devices	
- Power generation and distribution - Boiler - Auxiliary machinery	
1.3 Protective Devices 1.3.1 State what is meant by protective / safety devices and how they work in simple terms	1
1.3.2 Explain how protective / safety devices are incorporated in each system in a ship's propulsion machinery stating that protective / safety devices are isolated from their control systems 1.3.3 Locate protective / safety devices are incorporated in each system in a ship's propulsion machinery	1
1.3.4 Locate the following protective / safety devices and observes their operating mechanisms: - Main engine shutdown such as over speed, lubricating oil low pressure, etc. - Prime mover of generator shutdown - Boiler shut down such as low-low water level, non-detection of flame, etc. - Purifier shut down	2
1.3.5 Describe the need for testing functions / performances of protective / safety devices in the ship's statutory survey 1.3.6 Explain briefly how functions / performances of protective / safety devices can be tested	1

Learning Objectives	P
F Electrical and Simple Electronic Diagrams **General Learning Objectives** • Know the electrical and electronic symbols used in respective circuits • Understand the differences between and importance of various electrical and electronic diagrams • Know how to trace diagrams **Topic: Electrical and Simple Electronic Diagrams** **Sub-Topics:** 1.1 Basics of Electrical and Electronic Diagrams 1.2 Interpretation of Circuit Symbols	
F1 Specific Learning Objectives: (IMO 7.04,2014: 2.2.6) **1.1 Basics of Electrical and Electronic Diagrams** 1.1.1 Describe the function of circuit elements presented by the symbols in their circuit diagram 1.1.2 Explain briefly the flow of electrical / electronic current and functions of their circuit diagrams taking simple circuits containing major electrical / electronic symbols as examples 1.1.3 Explain the basic differences between the following electrical diagrams: - block diagram - system diagram - circuit diagram - wiring diagram	1
1.1.4 Describe functions of circuit components 1.1.5 Identify major Electrical and electronic symbols used in their circuit diagrams	1
1.1.6 Describe the construction of simple electrical circuits using relays, timers, contactors and other components	1
1.1.7 Using a given simple diagram, sketch a circuit diagram 1.1.8 From given simple circuit or wiring diagrams, sketch schematic or system diagrams, using correct letter and circuit symbols 1.1.9 Use the diagrams named in the above objective	1
F2 Troubleshooting of Control Equipment (IMO 7.02,2014: 2.2.1) **1.2 Interpretation of Circuit Symbols** 1.2.1 Describe functions of circuit components 1.2.2 Identify simple electrical circuits using relays, timers, contactors and other components	1

Learning Objectives	P
G Troubleshooting of Electrical and Electronic Control Equipment **General Learning Objectives** • Know the safety procedures to be adopted while troubleshooting of electrical and electronic control equipment • Know how to use common test equipment within the scope of this topic • Understand circuits and methods of troubleshooting equipment within the scope of this topic **Topic: Troubleshooting of Electrical and Electronic Control Equipment** **Sub-Topics:** 1.1 Test Equipment 1.2 Logical Six Step Troubleshooting Procedure 1.3 Generation 1.4 Prime Mover Electrical Controls 1.5 Main Air Circuit Breaker 1.6 Protection of Generators 1.7 Electrical Distribution Systems 1.8 Motors 1.9 Electrical Survey Requirements 1.10 Calibrate and Adjust Transmitters and Controllers 1.11 Control System Fault finding	
G1 Specific Learning Objectives: (IMO 7.02,2014: 2.2.1) **1.1 Test Equipment** 1.1.1 Demonstrate the practical use of Meggers, multimeters and CRO 1.1.2 Take care and exercises precautions while carrying out open, short and insulation measurement test	1
1.2 Logical Six Step Troubleshooting Procedure 1.2.1 Identify symptoms 1.2.2 Carry out analysis of symptoms 1.2.3 List probable faulty functions 1.2.4 Localise faulty functions 1.2.5 Localise troubles in the circuit 1.2.6 Carry out failure analysis	
1.3 Generation 1.3.1 Outline the operation of alternators, excitation methods, AVR and auto-synchronising equipment 1.3.2 Identify manual load sharing and modern load sharing equipment	2
1.4 Prime Mover Electrical Controls 1.4.1 Description, identification and operation of control components of the prime mover for the alternator	
1.5 Main Air Circuit Breaker 1.5.1 Operating and servicing	2
1.6 Protection of Generators 1.6.1 Outline the operation of instrumentation and control associated with the electrical protection of the generating plant 1.6.2 Carry out routine maintenance	
1.7 Electrical Distribution Systems 1.7.1 Trace the general layout; identifies problems encountered using neutral configuration 1.7.2 Carry out fault tracing in distribution circuits	2

Learning Objectives	P
G Troubleshooting of Electrical and Electronic Control Equipment **General Learning Objectives** • Know the safety procedures to be adopted while troubleshooting of electrical and electronic control equipment • Know how to use common test equipment within the scope of this topic • Understand circuits and methods of troubleshooting equipment within the scope of this topic **Topic: Troubleshooting of Electrical and Electronic Control Equipment** **Sub-Topics:** 1.1 Test Equipment 1.2 Logical Six Step Troubleshooting Procedure 1.3 Generation 1.4 Prime Mover Electrical Controls 1.5 Main Air Circuit Breaker 1.6 Protection of Generators 1.7 Electrical Distribution Systems 1.8 Motors 1.9 Electrical Survey Requirements 1.10 Calibrate and Adjust Transmitters and Controllers 1.11 Control System Fault finding	
1.8 Motors 1.8.1 Discuss motor features and starting arrangements 1.8.2 Explain troubleshooting methods 1.8.3 Explain speed control of A.C. Motors using solid state devices 1.8.4 Explain the operation and explain faults in soft starters	
1.9 Electrical Survey Requirements 1.9.1 Conducting tests to the requirements of survey	
1.10 Calibrate and Adjust Transmitters and Controllers 1.10.1 Operation of a PID controller 1.10.2 Governors and controllable pitch propeller control 1.10.3 Tests, faults and solutions	2
1.11 Control System Fault finding 1.11.1 Fault finding methods 1.11.2 Locate governor faults 1.11.3 Evaluates and rectification of common control systems 1.11.4 Test's alarm and monitoring systems 1.11.5 Checks electric power supply for control systems	2

Learning Objectives	P
H Function Test of Electrical, Electronic Control Equipment and Safety Devices **General Learning Objectives** • Understand the basics of function testing • Understand function test methods for components within the scope of this topic **Topic: Function Test of Electrical, Electronic Control Equipment and Safety Devices** **Sub-Topics:** 1.1 Function Test of Most Common Electrical Devices Onboard	
H1 Specific Learning Objectives: (IMO 7.02,2014: 2.2.2) **1.1 Function Test of Most Common Devices** 1.1.1 Carry out a function test of the Over Current Relay (OCR)	1

Learning Objectives	P
H Function Test of Electrical, Electronic Control Equipment and Safety Devices **General Learning Objectives** • Understand the basics of function testing • Understand function test methods for components within the scope of this topic **Topic: Function Test of Electrical, Electronic Control Equipment and Safety Devices** **Sub-Topics:** 1.1 Function Test of Most Common Electrical Devices Onboard	
1.1.2 Carry out a function test of the relays and magnetic contactors 1.1.3 Carry out a function test of the timers	
1.1.4 Carry out a function test of the fuses 1.1.5 Carry out a function test of the MCCB 1.1.6 Carry out a function test of the ACB	
1.1.7 Carry out a function test of the diodes 1.1.8 Carry out a function test of the Silicon Controlled Rectifier (SCR) 1.1.9 Carry out a function test of the temperature, pressure and level transmitters	1
1.1.10 Carry out a function test of the over speed protection devices 1.1.11 Carry out a function test of the fire detecting system	1

Learning Objectives	P
I Troubleshooting of Monitoring Systems **General Learning Objectives** • Understand the basics of Calibration • Understand calibration methods for sensors and transducers within the scope of this topic **Topic: Troubleshooting of Monitoring Systems** **Sub-Topics:** 1.1 Revision of Test and Calibration of Sensors and transducers of monitoring system	
I1 Specific Learning Objectives: (IMO 7.02,2014: 2.2.3) **1.4 Revision of Test and Calibration of Sensors and transducers of monitoring system** 1.1.1 Carry out testing and calibration of pressure sensor and transducer 1.1.2 Carry out testing and calibration of temperature sensor and transducer 1.1.3 Carry out testing and calibration of flow sensor and transducer	1
1.1.4 Carry out testing and calibration of level sensor and transducer 1.1.5 Carry out testing and calibration of tachometer sensor and transducer 1.1.6 Carry out testing and calibration of viscometer sensor and transducer	1

Learning Objectives	
J Software Version Control **General Learning Objectives** • Understand the operation of a PLC including its programming • Understand basic software version and control access • Know about fault-finding using PLCs **Topic: Software Version Control** **Sub-Topics:** 1.1 Digital Techniques	
J1 Specific Learning Objectives: IMO 7.02,2014: 2.2.4 **1.1 Digital techniques** 1.1.1 Identify basic logic gates and derived logic gates 1.1.2 Know Boolean algebra	1
1.1.3 Explain principles of operation of digital integrated circuits (TTL, CMOS), adders, flip flops, registers, counters, multiplexers, encoders and decoders	1

Learning Objectives	
J Software Version Control **General Learning Objectives** • Understand the operation of a PLC including its programming • Understand basic software version and control access • Know about fault-finding using PLCs **Topic: Software Version Control** **Sub-Topics:** 1.1 Digital Techniques	
1.1.4 Identify and differentiate between memories like RAM, ROM, PROM, EPROM, UVPROM	
1.1.5 Explain microprocessors, principles of operation, input / output functions, application in marine control systems, programs, alteration of values	1
1.1.6 Explain single integrated circuit containing a core processor, memory and programmable input / output peripherals 1.1.7 Explain program memory in the form of NOR flash or OTP ROM that is also often included on a chip and RAM	1
1.1.8 Explain microcontrollers – designed for embedded applications and real time response of events	
1.1.9 Explain and identify typical input and output devices – switches, relays, solenoids, LEDs, radio frequency devices and sensors for data such as temperature, humidity, light, level, etc. 1.1.10 Describe the use of General-Purpose Input / Output (GPIO)	1
1.1.11 Explain the operation of the analogue to digital converter (ADC) 1.1.12 Explain the operation of the digital to analogue converter (DAC)	

Note:
The list of the MC Courses for Semester 7 are given in the APPENDIX TO SYLLABUS: MICRO CREDIT COURSES

SEMESTER 8

Practical Training with Assignment and Project Work

(In 80)

Afloat/Ship-in-Campus/Approved Workshop/On board

Note: A TARB for the Practical Exercises may be used.

This Syllabus is collated from the combined contribution of many individuals.

Though much efforts have gone into getting this as much correct as possible, there are bound to be errors.

Authors' Names, Publishers' information etc., have been verified as much as possible.

Corrections, inadvertent errors, oversights and scope for improvements may be noted and advised by any and all the users of this work.

4 YEAR

BACHELOR OF TECHNOLOGY [B.Tech]

(MARINE ENGINEERING)

APPENDIX TO SYLLABUS

MICRO CREDIT COURSES

School of Marine Engineering & Technology

INDIAN MARITIME UNIVERSITY

2021

GUIDELINES FOR ELECTIVE MICRO-CREDIT COURSES

1. The Micro Credit Courses on offer during the period of reckoning shall be declared by the School Board of Marine Engineering & Technology from time to time (e.g., start of the Academic Semester etc.).
2. 4 Micro Credit (MC) Courses are to be chosen from the available Baskets. From any basket, only 1 Course to be chosen. MC Courses have to be assimilated primarily through self-study.
3. MC Course materials will be made accessible to students from Semester 5.
4. MC Courses are to be completed in the assigned Semester (presently Semester 7).
5. Elective Micro Credit Courses:
    a. MC Courses based on infrastructure and equipment availability in individual MTIs/campuses (e.g., MATLAB; SolidWorks; CNC machines etc.) may be developed and offered, subject to approval by the School Board.
    b. Expertise available across the Institutes shall be made accessible to the students. Faculty from Institute (who had developed the MCC) and the parent Institute shall facilitate the students.
    c. The study materials must be prepared in a way which is conducive for self-study.
    d. All efforts must be taken to upload relevant content (e.g., Presentations; Course Notes; recordings of the lectures/training exercises, links etc.) in portals and made available to students (e.g., LMS System; Institutes' Library/eLearning portal; Repository etc.).
    e. The content of all such materials must be reviewed annually, updated and records must be submitted to IMU.
6. Assessments: All assessment records shall be submitted to IMU.
    i. Formative assessments (MCQ tests, quizzes etc.): To be completed during mid Semester periods.
    ii. Summative assessments: MCQ based question papers/Subjective Questions etc., may be used for final examinations.
    iii. Summative assessments: Preferably, a project work in the form of a Problem Resolution may be submitted in addition.

    Examples of problems:
    - Dry-dock Studies: Consider about 40+ jobs to be completed; develop a CPM/PERT chart with reasoning.
    - Risk Management: Consider a ship taken over by pirates; mitigation measures; maintain ship and communication with pirates & Company.

Notes:

1. These Guidelines are suggestive only and also not exhaustive.
2. Comprehensive Guidelines on Micro-Credit Courses shall be provided by IMU.
3. Other periodic information (e.g., Courses on offer etc.) shall be provided by the School Board every Semester.

MICRO CREDIT COURSE BASKETS

MC BASKET 1 SHIPYARD STUDIES

Course: Ship Recycling

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom/online discussions and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Ship Familiarisation.

Recommended Text:

1. MISRA, PURNENDU, MUKHERJEE, ANJAN: Ship Recycling: Handbook for Mariners.
2. ROYAL INSTITUTE OF NAVAL ARCHITECTS: Transactions of Royal Institution of Naval Architects.
3. SBP CONSULTANTS AND ENGINEERS PVT. LTD: SBP Handbook of Projects on Wastes.
4. https://shipbreakingplatform.org/resources/library/.

Table of Topics

Section	Topics	Hours (L: SL)
A	Introduction to the global ship recycling industry **Sub-Topics:** history, locations of ship recycling yards, and the material recovered and waste generated from the process.	2:2
B	Introduction to Inventory of Hazardous Materials (IHM) **Sub-Topics:** IHM, its requirements, and how to understand an IHM report.	2:2
C	Development of Ship Recycling Facility Plan (SRFP) as well as Ship-Specific Recycling Plan (SRP) **Sub-Topics:** Prepare a SRFP and a SRP as per the regulations.	2:2
D	Ship Recycling Process and Risk Assessment **Sub-Topics:** The process of ship recycling, from landing/inter-tidal landing to the complete recycling, as well as the risk assessment of the work involved in ship recycling.	1.5: 1.5
E	Hazardous Waste Management **Sub-Topics:** Hazardous waste management, and its SOPs. Hazardous Waste Management	1.5: 1.5
F	Health, Safety and Environmental Monitoring of the Ship Recycling Process **Sub-Topics:** Best practices for the EHS monitoring of the recycling process	1.5: 1.5
G	Carbon Foot printing of the Ship Recycling Process **Sub-Topics:** Explore the carbon footprint of the process, as well as look at responsible ship recycling	1.5: 1.5
	Total	**12: 12**

Learning Objectives	L: SL
A General Learning Objective Introduce the global ship recycling industry, its history, locations of ship recycling yards, and the material recovered and waste generated from the process. **Specific Learning Objectives:** Explain the following: 1.1 Explain what is ship recycling 1.2 History of ship recycling 1.3 Ship recycling destinations; their capacity 1.4 Material recovered from ship recycling and the circular economy 1.5 Waste generated during ship recycling	2:2
B General Learning Objective **Introduction to Inventory of Hazardous Materials (IHM)** **Specific Learning Objectives:** Explain the following: 2.1 Introduction to Inventory of Hazardous Materials (IHM) as per MEPC 269 (68) 2.2 Explain what is IHM and Why it is required 2.3 Requirements of IHM as per HKC and EUSRR 2.4 Understanding IHM report 2.5 Case study (Finding hazardous wastes in the IHM report of a sample vessel)	2:2
C General Learning Objective Development of Ship Recycling Facility Plan (SRFP) as well as Ship-Specific Recycling Plan (SRP) **Specific Learning Objectives:** Explain the following: 3.1 Understanding MEPC 2010 (63) 3.2 Preparation of SRFP	2:2

3.3 Understanding MEPC 196 (62) 3.4 Preparation of SRP using IHM and SRFP	
D General Learning Objective Understand the process of ship recycling, from landing/inter-tidal landing to the complete recycling, as well as the risk assessment of the work involved in ship recycling. **Specific Learning Objectives:** 4.1 Explain Three-step risk assessment 4.2 Explain Case study on risk assessment	1.5: 1.5
E General Learning Objective Understand hazardous waste management, and its SOPs **Specific Learning Objectives:** 5.1 Explain Identification of waste as per IHM 5.2 Explain Safe handling, storage and disposal (Standard Operating Procedures)	1.5: 1.5
F General Learning Objective Understand Health, Safety and Environmental Monitoring of the Ship Recycling Process **Specific Learning Objectives:** 6.1 Explain Best practices for the EHS monitoring of the recycling process	1.5: 1.5
G General Learning Objective Understand Carbon Foot printing of the Ship Recycling Process **Specific Learning Objectives:** 7.1 Explain Best practices for the EHS monitoring of the recycling process	1.5: 1.5

Course: Dry Dock and Shipyard Practices

Instructional hours:

Lecture	: 16 hours
Self-Learning & Preparation	: 8 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning assignments.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Ship Structure and Construction.

Recommended Text:

1. David J House, Dry Docking and Shipboard Maintenance: A Guide for Industry - Second edition, 2016.
2. DJ Eyres, GJ Bruce, Ship Construction, Seventh Edition, 2012.

Table of Topics

Section	Topics and Sub topics	Hours (L:SL)
A	**Dry Dock Types** **Sub-Topics:** Introduction, Graving Docks, Floating Docks, Synchro Lifts, Slipways	2: 0
B	**The Procedure to Dry Dock Ships** **Sub-Topics:** Introduction, Entering ships in dry docks including synchro lift systems, Dock preparation: Dock blocks and their types and arrangement, Reasons to enter dry dock, Tasks prior entering dry dock and utilities required post docking, Documentation required for dry docking, Example Tests and Checks Departing dry dock	4: 2
C	**Dry Dock Operations** **Sub-Topics**: Introduction, Regular and routine tasks in dry docks, Hull cleaning, maintenance and protection, Hull roughness, Paint terminology, Surface preparation techniques for painting, Testing and Maintenance of Anti-Roll Stabiliser Units/Bilge Keels and Appendages, Routines on rudder propeller and tail shaft, Maintenance of thrusters, Tank Operations and Inspection	4: 2
D	**Dry Dock – Safety Procedures** **Sub-Topics:** Introduction, Risk assessment and analysis, Permits to work, High risk areas and precautions: Fire, Entry to enclosed spaces, gas freeing on tankers, Overhead working and heavy lift operations	2: 2
E	**Steelwork and Material Management of the Shipyard** **Sub-Topics:** Shipyard layout and flow chart of work, Preservation of steel plates and pipes against corrosion and storage, Steelwork testing, Design information for production, CAD / CAM in shipyards	4: 2
	Total	**16: 8**

General and Specific Learning Objectives	L: SL
A Dry Dock Types **General Learning Objective** Learn about the types of dry-docks available **Specific Learning Objectives:** 1.1 List the types of dry-docks with brief history 1.2 Describe the Graving dock and its operation 1.3 Describe the synchro lift, its operation and advantages 1.4 Describe the floating dock, its operation and advantages 1.5 Describe slipways	2: 0
B The Procedure to Dry Dock Ships **General Learning Objective** Learn about the procedures to enter the dry-dock, Information documentation for dry-docking and tasks prior entering and departing the dry-dock **Specific Learning Objectives:** 2.1 List the reasons for docking of a ship 2.2 Describe the dock block construction and their types 2.3 Describe and Sketch a typical dock blocks arrangement 2.4 Describe the dry-docking procedure for a graving dock 2.5 List the tasks to be completed prior docking to ensure ship's safety 2.6 List the utilities required during the docking period of ship 2.7 List the documentation to be made ready prior docking	4: 2

C Dry Dock Operations **General Learning Objective** Learn about the regular and routine tasks that are undertaken during the dry-docking period **Specific Learning Objectives:** 3.1 List the Regular and routine tasks in dry docks 3.2 Describe Hull cleaning, maintenance and protection procedures 3.3 Describe importance of Hull roughness 3.4 Gets familiar with underwater hull Paint terminology 3.5 Describe Surface preparation techniques for painting and their advantages / disadvantages 3.6 Explain Testing and Maintenance of Anti-Roll Stabiliser Units/Bilge Keels and Appendages 3.7 Explain Routines on rudder, propeller and tail shaft, Maintenance of thrusters 3.8 Describe the inspection and routine maintenance on the various tanks of the ship	4: 2
D Dry Dock – Safety Procedures **General Learning Objective** Understand risk assessment and safety during the dry-docking period of ship. **Specific Learning Objectives:** 4.1 Discuss the risks involved in the dry-docking of ship and during the work undertaken during the dry-docking period, their assessment 4.2 Discuss the system of work permits to ensure safe working environment 4.3 Discuss safety issues regarding the following high-risk areas a. Fire hazard b. Enclosed space Entry **c.**Overhead and heavy lift working	2: 2
E Steelwork and Material Management of the Shipyard **General Learning Objective** Discuss the shipyard layout and the workflow to ensure efficiency **Specific Learning Objectives:** 5.1 Discuss the infrastructure requirement in a shipyard 5.2 Discuss a typical modern Shipyard layout 5.3 Discuss flow chart of work 5.4 Learn about the preservation of steel plates and pipes against corrosion and their efficient storage 5.5 Describe steelwork testing procedures 5.6 Discuss the Design information for production 5.7 Describe importance of CAD / CAM in shipyards	4: 2

Course/Code: Dredger and Dredging

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Case study/Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Ship types; Port Operations.

Recommended Text:

1. Dredging -A handbook for Engineers- R.N. Bray, A.D. Bates, J.M. Land.

Table of Topics

Section	Topics	Hours (L: SL)
A	Introduction	1: 1
B	Usage of dredging	1: 1
C	Types of dredgers	2: 2
D	Dredging equipment	2: 2
E	Dredging methods	2: 2
F	Pipeline equipment and transportation of soil	2: 2
G	Hopper barges	2: 2
	Total	**12: 12**

<table>
<tr><th>Learning Objectives</th><th>L: SL</th></tr>
<tr><td>A General Learning Objective
Introduction-to Dredging

Specific Learning Objectives:

Explain the following:
1.1 Causes and formations of silt
1.2 Dredging first hydraulic dredgers, first mechanical dredgers, first pipeline, first deck spud dredgers</td><td>1: 1</td></tr>
<tr><td>B General Learning Objective
Learn the Usage of dredging

Specific Learning Objectives:
2.1 Explain various terms like Capital dredging, maintenance dredging, shore pumping, land reclamation, beach nourishment, rain-bowing, trenching, underwater mining, etc.</td><td>1: 1</td></tr>
<tr><td>C General Learning Objective
Learn about various types of Dredgers

Specific Learning Objectives:

Explain the following:
3.1 Trailer suction hopper dredger (TSHD), Cutter suction dredger (CSD), Backhoe dredger, grab dredger, suction pump dredger, Bucket dredger, water injection dredger, etc.</td><td>2: 2</td></tr>
<tr><td>D General Learning Objective
Learn about various Dredging equipment

Specific Learning Objectives:
4.1 Learn the general description of dredger, general arrangement of dredger from structural point, centrifugal pumps, jet pump, hopper construction, under deck arrangement, deck arrangement with gantries, suction tubes, drag head, bottom doors, etc.</td><td>2: 2</td></tr>
<tr><td>E General Learning Objective
Learn about Dredging methods

Specific Learning Objectives

Explain the following:

5.1 Basic types, mechanical dredging, hydraulic dredging, hopper efficiency, physical consideration, model tests, application of drag heads and cutters</td><td>2: 2</td></tr>
</table>

F General Learning Objective Learn about the various methods of transportation of soil **Specific Learning Objectives:** Explain the following: 6.1 Floating pipeline, shore pipes, types of soil and transportation of soil through pipeline; use of booster pumps, composition of solid water mixture, regimes of sediment flow, waste water management and under water pipeline	2: 2
G General Learning Objective Learn about Hopper Barges **Specific Learning Objectives** 7.1 Explain types of hopper barges, deck barge, pontoon barge, split barge, barge with bottom doors, spud pontoon	2: 2

Course: Ship Repair Contracts

Instructional hours:

Lecture	: 14 hours
Self-Learning & Preparation	: 14 hours
Total hours	: 28 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Case study/Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Ship Maintenance & Repair.

Recommended Text:

1. BIMCO SHIP REPAIRCON.
2. BIMCO MINREPCON.

Table of Topics

Section	Topics	Hours (L: SL)
A	Introduction to term 'Contract' and need for having a repair contract in the industry.	1: 1
B	Introduction to BIMCO SHIP REPAIR CONTRACT and other ship repair contracts	1: 1
C	PART 1 OF SHIP REPAIRCON	1: 1
D	PART 2 OF SHIP REPAIR CON. Definitions, Performance and approval of the work	3: 3
E	Supervision and Owners work, Delivery, Redelivery and Acceptance of vessel	2: 2
F	Financial provisions, Liquidated damages, liabilities and Indemnities	2: 2
G	Guarantee, Disruptions and Termination	2: 2
H	Insurance, Sundry provisions, BIMCO dispute resolution clause and BIMCO Notices clause	2: 2
	Total	**14: 14**

Learning Objectives	L:SL
A General Learning Objective Definition of contract and need for a contract for ship repair. Ship repair activities are major economic activities involving large capitals. Both the parties need to be safe guarded **Specific Learning Objectives**: Explain the following: 1.1 Definition of Contract 1.2 Necessity of Repair contract between Ship owners and Repairers	1: 1
B General Learning Objective Introduction to most common repair contracts in the industry. Introduction to BIMCO standard SHIP REPAIRCON **Specific Learning Objectives:** Explain the following: 2.1 Introduction to BIMCO SHIP REPAIRCON 2.2 Understand features of other ship repair contracts	1: 1
C General Learning Objective PART 1 of BIMCO SHIP REPAIRCON. COVER PAGE OF CONTRACT. ALL 20 ELEMENTS OF THE CONTRACT INFORMATION TO BE FILLED IN AND CONTRACT TO BE SIGNED BY BOTH PARTIES **Specific Learning Objectives:** 3.1 Define all elements of Part 1 and its importance	1: 1
D General Learning Objective Part wise study of SHIP REPAIRCON. Definitions of terms used in this contract, Performance of the work and approval **Specific Learning Objectives:** Explain the following: 4.1 Understand definitions of terms used in this contract 4.2 Understand performance of the work is to be completed as per provisions in this contract, must satisfy the regulatory bodies of the parties, and to the reasonable satisfaction of the owner 4.3 Understand dealing with additional works and adjustment in price accordingly	3: 3

E General Learning Objective Understanding the meaning of Supervision and Owners work, Delivery, Redelivery and acceptance of vessel **Specific Learning Objectives** Explain the following: 5.1 Understand delivery and redelivery time as per contract 5.2 Understand under what circumstances owners can arrange their own service providers for repair during the stay at contractor's premises 5.3 Understand duties and responsibilities of owner representative regarding supervision of work	2: 2
F General Learning Objective Study of method of pricing, payment term and Title of the vessel. If the redelivery of the vessel is delayed beyond contract period contractor will accept liquidated damage per day as agreed. liabilities and Indemnities in case of damage to property or loss of life **Specific Learning Objectives:** Explain the following: 6.1 Understand the pricing of work 6.2 Understand the payment of term and charges against delays in payments 6.3 Understand if the delay is caused by either party, how is it to be compensated 6.4 Understand liabilities and indemnities in case of damages to property or loss of life	2: 2
G General Learning Objective Study about Guarantee s provided by the contractors, what constitute disruption causing delays in work and under what circumstances Termination of contract can be revoked **Specific Learning Objectives** Explain the following: 7.1 Understand that Guarantee is limited to workman ship and material supplied by contractors and subcontractors 7.2 Understand any defect resulting in damage to the vessel or part(s) thereof repair obligations will extend to repairing or replacement of such parts 7.3 Understand what disruptions are accepted and what are not acceptable 7.4 Understand under what circumstances Contract can be terminated	2: 2
H General Learning Objective Insurance, Sundry provisions, BIMCO dispute resolution clause @ BIMCO Notices clause **Specific Learning Objectives:** Explain the following: 8.1 Understand that both the parties must have their respective insurances 8.2 Any damages caused to ship owner must be covered under contractors Insurance 8.3 Any damage caused to Contractors properties by ship owner must be covered under ship owner's Insurance 8.4 Any scrap shall be property of contractors except propeller, heavy machinery or tail shaft 8.5 The contract shall be governed by the English Law and any dispute arising out should be referred to arbitration in London	2: 2

MC BASKET 2 SHIP OPERATIONS

Course: Introduction to Liquid Cargo Handling

Instructional hours:

Lecture	: 2 hours
Practical	: 12 hours
Self-Learning & Preparation	: 10 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions, simulator-based practice and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Basic Knowledge of Ship Construction; Ship Operations.

Recommended Text:

1. International Safety Guide for Oil Tankers and Terminals.
2. Safe Oil Tanker operations by Capt. K.S.D Mistree & Mr. BK Sharma.

Table of Topics

Section	Topics	Hours (L: P: SL)
A	Introduction to oil tanker design, on-board systems and equipment **Sub-Topics:** General arrangement & construction of an oil tanker, Tank arrangement and pipeline systems, Cargo pumping equipment and arrangement, Ballast pumping equipment and arrangement, Crude Oil Washing system and arrangement, Tank Cleaning system, Inerting system and ODME.	1: 0: 1
B	Introduction to safety systems on oil tankers **Sub-Topics:** Flammability Diagram, Inert gas, high level and overflow alarms, emergency shutdown of cargo operations, environment protection equipment	0.5: 0: 2
C	Stresses subjected on tankers during cargo operations **Sub-Topics:** Shear Forces, Bending Moments, Sagging and Hogging, maximum acceptable limits of stresses	0.5: 0: 2
D	Loading, Unloading of Cargo and Inerting **Sub-Topics:** Cargo loading and unloading procedure concurrent with inert gas operations	0: 4: 1
E	Ballasting and De-ballasting **Sub-Topics:** Ballasting and de-ballasting procedure concurrent with loading or unloading operations	0: 4: 2
F	Crude Oil Washing **Sub-Topics:** Procedure for Crude Oil Washing operations	0: 2: 2
G	Assessment of cargo loading, unloading operations **Sub-Topics/SLOs**: Procedure for loading, unloading, ballasting, de-ballasting, Inerting, crude oil washing operations	0: 2: 0
	Total	**2: 12: 10**

Learning Objectives	L: P: SL
A General Learning Objective Introduction to oil tanker design, on-board systems and equipment. **Specific Learning Objectives:** Explain the following: 1.1 General arrangement & construction of an oil tanker 1.2 Tank arrangement and pipeline systems 1.3 Cargo pumping equipment and arrangement 1.4 Ballast pumping equipment and arrangement 1.5 Crude Oil Washing system and arrangement 1.6 Tank Cleaning system 1.7 Inerting system 1.8 ODME	1: 0: 1
B General Learning Objective Introduction to safety systems on oil tankers **Specific Learning Objectives:** 2.1 Define Flammability Diagram 2.2 Define Inert gas 2.3 Define Electrostatic hazards 2.4 Define High level and overflow alarms 2.5 Define Emergency shutdown of cargo operations 2.6 Define Environment protection equipment	0.5: 0: 2
C General Learning Objective Stresses subjected on tankers during cargo operations **Specific Learning Objectives:** Describe the following: 3.1 Shear Forces	0.5: 0: 2

3.2 Bending Moments 3.3 Sagging 3.4 Hogging 3.5 Maximum acceptable limits of stresses	
D General Learning Objective Loading, Unloading of Cargo and Inerting **Specific Learning Objectives:** 4.1 State Cargo loading procedure 4.2 State Cargo unloading procedure concurrent with inert gas operations	0: 4: 1
E General Learning Objective Ballasting and De-ballasting **Specific Learning Objectives:** 5.1 Explain De-ballasting procedure concurrent with loading operations 5.2 Explain Ballasting procedure concurrent with unloading operations	0: 4: 2
F General Learning Objective Crude Oil Washing **Specific Learning Objectives:** 6.1 Explain Explosion hazards during COW operations 6.2 Explain COW checklist 6.3 Explain COW Operation and Equipment Manual 6.4 Explain Crude oils unsuitable for COW 6.5 Explain Procedure for Crude Oil Washing operations	0: 2: 2
G General Learning Objective Assessment of cargo loading, unloading operations **Specific Learning Objectives:** Explain the following: 7.1 Handle and safely execute a cargo loading operation concurrent with de-ballasting 7.2 Handle and safely execute a cargo unloading operation concurrent with ballasting, Inerting and COW operations	0: 2: 0

Course: Introduction to Gas Cargo Handling

Instructional hours:

Lecture	: 2 hours
Practical	: 12 hours
Self-Learning & Preparation	: 10 hours
Total hours	: 24 hours

Credits : 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions, simulator-based practice and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Basic Knowledge of Ship Construction; Ship Operations.

Recommended Text:

1. International Safety Guide for Liquefied Gas Tankers and Terminals.
2. Safe Liquefied Gas Tanker operations by Capt. K.S.D Mistree & Mr. BK Sharma.

Table of Topics

Section	Topics	Hours (L: P: SL)
A	Introduction to liquefied gas tanker design, systems and equipment **Sub-Topics:** Types of liquefied gas tankers and tanks, general arrangement, cargo containment systems including materials used in construction and insulation, cargo handling equipment, cargo temperature control systems, ballast system, boil off systems, re-liquefaction systems, Cargo Emergency Shutdown System.	1: 0: 1
B	Knowledge and understanding of hazards and control measures associated with liquefied gas tanker cargo operations **Sub-Topics:** Flammability, Explosion, Toxicity, Reactivity, Corrosivity, Inert gas, electrostatic hazards, polymerizing cargoes	0.5: 0: 2
C	Loading operations **Sub-Topics:** Tank inspection, Inerting, gassing up, cooling down, loading, de-ballasting, closed loop sampling	0.5: 0: 2
D	Cargo management during sea passage **Sub-Topics:** Cooling down, pressure maintenance, boil off, inhibiting	0: 4: 1
E	Unloading operations **Sub-Topics:** Unloading, ballasting, stripping and cleaning, systems to Make the tank liquid free	0: 4: 2
F	Emergency procedures **Sub-Topics:** Cargo operations Emergency Shut Down (ESD) procedure, emergency cargo valve operations, jettisoning of cargo and low temperature brittle fracture	0: 2: 2
G	Assessment of cargo loading, unloading operations **Sub-Topics:** Procedure for loading, unloading, ballasting, de-ballasting	0: 2: 0
	Total	**2: 12: 10**

Learning Objectives	Hours (L: P: SL)
A General Learning Objective Introduction to liquefied gas tanker design, systems and equipment **Specific Learning Objectives:** Explain the following: 1.1 Types of liquefied gas tankers and tanks, general arrangement 1.2 Cargo containment systems including materials used in construction and insulation 1.3 Cargo handling equipment 1.4 Cargo temperature control systems 1.5 Ballast system 1.6 Boil off systems 1.7 Re-liquefaction systems 1.8 Cargo Emergency Shutdown System	1: 0: 1
B General Learning Objective Knowledge and understanding of hazards and control measures associated with liquefied gas tanker cargo operations **Specific Learning Objectives:** State the following: 2.1 Flammability 2.2 Explosion 2.3 Toxicity 2.4 Reactivity 2.5 Corrosivity 2.6 Inert gas 2.7 Electrostatic hazards 2.8 Polymerizing cargoes	0.5: 0: 2

C General Learning Objective Loading operations **Specific Learning Objectives:** 3.1 Define Tank inspection 3.2 Define Inerting 3.3 Define Gassing up 3.4 Define Cooling down 3.5 Define Loading 3.6 Define De-ballasting 3.7 Define Closed loop sampling	0.5: 0: 2
D General Learning Objective Cargo management during sea passage **Specific Learning Objectives:** 4.1 State Cooling down 4.2 State Pressure maintenance 4.3 State Boil off 4.4 State Inhibiting	0: 4: 1
E General Learning Objective Unloading operations **Specific Learning Objectives:** 5.1 Describe Unloading 5.2 Describe Ballasting 5.3 Describe Stripping and cleaning 5.4 Describe Systems to Make the tank liquid free	0: 4: 2
F General Learning Objective Emergency procedures **Specific Learning Objectives:** 6.1 Explain Cargo Operations Emergency Shut Down (ESD) procedure 6.2 Explain Emergency cargo valve operations 6.3 Explain Jettisoning of cargo and low temperature brittle fracture	0: 2: 2
G General Learning Objective Assessment of cargo loading, unloading operations **Specific Learning Objectives:** 7.1 Explain Handle and safely execute a cargo loading operation concurrent with de-ballasting 7.2 Explain Handle and safely execute a cargo unloading operation concurrent with ballasting	0: 2: 0

Subject Name/Code: Introduction to Ship Navigation

Instructional hours:

Lecture	: 2 hours
Practical	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 26 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom Discussions, simulator based training and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Assignments)	: 40%
Assessment on Simulator	: 60%

Additional Information on Subject:

1. Pre-requisites: Basic knowledge of Nautical Terms; Ship Operations.

Recommended Text:

1. IMO Rules of the Road – Bhandarkar Publications.
2. IALA Maritime Buoyage System.
3. Ship Handling – David House.

Table of Topics

Section	Topics	Hours L:P:SL
A	Familiarization with the bridge equipment **Sub-Topics:** Steering Console, Telegraph, Gyro Compass, Radar, ECDIS, Rate of turn Indicator, VHF, GPS, Echo Sounder, Log, Navigational Lights	1: 0: 1
B	Steering Commands and Steering the vessel **Sub-Topics:** Order, Repetition, Execution, Confirmation, steering a Straight-line course, altering to a new course, Steadying the vessel on the new course without overshoot	0.5: 0: 2
C	Turning Circle **Sub-Topics:** Head Reach, Advance, Transfer, Tactical Diameter, effect of UKC	0.5:0: 2
D	Stopping Distances **Sub-Topics:** Stopping Engine, Rudder Cycling, Crash Stop	0:4: 1
E	Plotting own vessels position **Sub-Topics:** Plotting position using Ranges and Bearings, Plotting Position using GPS	0:4: 2
F	By night Identification of Aids to Navigation and other vessels **Sub-Topics:** Identification of Light houses, buoys and Beacons, Navigational Lights	0: 2: 2
G	Assessment of Risk of Collision and Collision Avoidance **Sub-Topics:** Bearing, Range, ARPA, CPA, TCPA, Alteration of Course, Alteration of Speed	0: 2: 0
	Total	**2:12: 12**

Learning Objectives	Hours (L: P: SL)
A General Learning Objective Associate the various Bridge Equipment with their uses **Specific Learning Objectives:** Identify the following equipment and state their primary use 1.1 Helm 1.2 Rudder Angle Indicator 1.3 Gyro Compass 1.4 Compass Repeater 1.5 Rate of Turn Indicator 1.6 Telegraph 1.7 VHF Radio 1.8 Echo Sounder 1.9 Doppler Log 1.10 Course Recorder 1.11 RADAR 1.12 GPS 1.13 AIS 1.14 ECDIS	1: 0: 1
B General Learning Objective Comprehend the various steering orders and demonstrate his understanding by executing these orders in the simulator **Specific Learning Objectives:** Demonstrate the following orders 2.3 Starboard / Port 10	0.5: 0: 2

2.4 Hard Starboard / Port 2.5 Ease to 5/10 2.6 Mid-ships 2.7 Steady 2.8 Steer a straight-line course in open waters by closely monitoring the ships head and by applying the correct helm and counter helm as required to as to maintain the vessel on the same heading 2.9 Alter the course to a new heading including reducing the initial helm Cand also giving the counter helm well in time	
C General Learning Objective Demonstrate the turning ability of the vessel **Specific Learning Objectives:** 3.1 Perform starboard side turn @ full ahead with rudder angles of 35° and 10° 3.2 Ascertain the advance, transfer and tactical diameter. 3.3 Ascertain and appreciate the difference in time taken in both the cases 3.4 Carry out the above modules in shallow water 3.5 Compare the results and check against the manoeuvring characteristics of the vessel	0.5: 0: 2
D General Learning Objective Demonstrate the stopping ability of the vessel **Specific Learning Objectives:** Ascertain the stopping distance upon 4.1 Stopping engines, 4.2 Stopping engines with rudder cycling 4.3 Crash stop 4.4 Compare the results and check against the manoeuvring characteristics of the vessel	0: 4: 1
E General Learning Objective Determine vessels position on the chart **Specific Learning Objectives:** Explain the following: 5.1 Identification of land targets on the Radar 5.2 Obtain Bearings using the Electronic Bearing Line 5.3 Determine the range of an object using the Variable Range Marker 5.4 Plot bearings on the chart using the Compass Rose 5.5 Plot ranges on the chart using the Latitude Scale	0: 4: 2
F General Learning Objective Detect by night the presence of another power-driven vessel and associate the aids to navigation with those marked on the chart **Specific Learning Objectives:** 6.1 Draw the navigation lights of a Power-Driven vessel 6.2 Recollect the various characteristics on a Light house 6.3 Detect the presence of a Power-Driven vessel 6.4 Associate a flashing light with that marked on the chart	0: 2: 2
G General Learning Objective Assess the risk of Collision and carries out the action to avoid collision under supervision in Open Sea conditions **Specific Learning Objectives:** 7.1 Repeat Rule 7 of COLREGS – Risk of Collision 7.2 Repeat Rule 8 of COLREGS – Action to Avoid Collision 7.3 Determine if Close quarter situation is developing 7.4 Acquire Target on the Radar and determine the Closest Point of Approach and the Time to closest point of Approach 7.5 Execute the helm orders given to avoid collision	0: 2: 0

Course: Ballast Water Management System

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom Discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Ship Construction; Ship Operations.

Recommended Text:

1. IMO- BWM - International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004.
2. BWTS-Ballast Water Treat System manual (TechCross, Korea).

Table of Topics

Section	Topics	Hours (L: SL)
A	Introduction: Ballast Water & Management **Sub-Topics:** Basic need of Ballasting/De-Ballasting a ship, Definitions: Harmful Aquatic Organisms and Pathogens, Viable Organism.	2: 2
B	Ballast Water Management Convention **Sub-Topics:** The Convention History, Requirements, Applications	2: 2
C	Management and Control Requirements for Ships **Sub-Topics:** Management Plans, Record Book, Exchange and Sediment Duties.	2: 2
D	Standards for Ballast Water Management **Sub-Topics:** To Understand the different standards applicable for preventing the transfer of invasive species.	2: 2
E	Ballast Water Treatment Systems **Sub-Topics:** Types of Ballast water treatment technologies	4: 4
	Total	**12: 12**

Learning Objectives	Hours (L: SL)
A: Introduction to the Ballast Water & Management **Sub-Topics:** Basic need of Ballast/de-ballast a ship, Definitions. **General Learning Objective** Introduce meaning of Ballast water, need of ballasting and de-ballasting a ship, definitions of important terms **Specific Learning Objectives:** 1.1 Explain what is ballasting/de-ballasting, what is ballast water 1.2 Explain Aquatic bio-invasion, Harmful Aquatic Organisms and Pathogens, Viable Organism, Sediment 1.3 Explain Meaning of Ballast water management	2: 2
B: Ballast Water Management Convention **Sub-Topics:** The Convention History, Requirements Applications **General Learning Objective** Understand the Ballast Water Management Convention by IMO, Discuss History and need of ballast water management **Specific Learning Objectives:** 2.1 Describe Parties to Convention and general obligations 2.2 Describe Application of Ballast water management convention for Flag State: Control of the Transfer of Harmful Aquatic Organisms and Pathogens Through Ships' Ballast Water and Sediments, Sediment Reception Facilities, Survey Certification and Inspection	2: 2
C: Management and Control Requirements for Ships **Sub-Topics**: Plans, Record Book, Exchange and Sediment Duties **General Learning Objective**: Understand the actions by Ship-staff towards management and Control requirement duties **Specific Learning Objectives**:	2: 2

Explain in detail the following: 3.1 Ballast Water Management Plan (Regulation B1, etc.) 3.2 Ballast Water Record Book (Regulation B2, etc.) 3.3 Ballast Water Management for Ships, Ballast Water Exchange and its Criteria, Sediment Management for Ships (Regulation B3,4,5, etc.) 3.4 Duties of Officers and Crew (Regulation B6, etc.	
D: Standards for Ballast Water Management **Sub-Topics:** Ballast water management standards for stopping the spread of invasive aquatic species. **General Learning Objective** Understand Ballast water management is all about all about pollution from ballast water from one location discharged into different ecology. **Specific Learning Objectives:** 4.1 Standard specifying ship to exchange ballast (Regulation D1, etc.) 4.2 Standards specifying maximum amount of viable organism (Regulation D2, etc.)	2: 2
E: Ballast Water Treatment Systems **Sub-Topics:** Types of Ballast water treatment technologies **General Learning Objective** Understand different techniques used in Ballast water treatment. Working principle, maintenance & repair, understanding ship specific manuals. **Specific Learning Objectives:** Explain the following: 5.1 Electrolysis Method 5.2 UV Method 5.3 Chemical Method 5.4 Other methods: Filtration, Inert gas, Magnetic, etc. 5.5 Scientific and Technical Research and Monitoring, Prototype techniques, Future	4: 4

Course: Planned Maintenance System

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Ship Maintenance & Repair.

Recommended Text:

1. Planned Maintenance System- 'SMMS' enterprise suit version 4.1 by Vertex Info Soft Solutions.
2. Reed's General Engineering Knowledge for Marine Engineers, Volume-8, Chapter 12.

Table of Topics

Section	Topics	Hours (L: SL)
A	Introduction to PMS-Planned Maintenance System **Sub-Topics:** Need and understanding Planned maintenance system.	2: 2
B	Aspects of PMS **Sub Topics:** Understand the parts and components of PMS, Departments and Overview.	2: 2
C	Maintenance components of PMS **Sub Topics:** Different components of machineries on-board, repair and maintenance system**.**	2: 2
D	Quality components of PMS **Sub Topics:** PMS components understanding of safety and related reporting systems, HSEQ- components- Health, Safety, Environment and Quality	2: 2
E	Shore components of PMS **Sub Topics:** The overall organisational management structure of shipping company, Procurements, Commercial, HR, Budget, DD-Dry Dock, etc.	4: 4
Total		**12: 12**

Learning Objectives	Hours (L: SL)
A: Introduction to PMS-Planned Maintenance System **Sub-Topics/SLOs:** Need and understanding Planned maintenance system. **General Learning Objective** Understand need of Planned maintenance on-board ships. **Specific Learning Objectives:** 1.1 Explain what a maintenance system is 1.2 Purpose of the shipboard planned maintenance system (PMS) 1.3 Types: Planned, Unplanned, Breakdown, etc. 1.4 PMS a tool for Ship management: Planning and Recording	2: 2
B: Aspects of PMS **Sub Topics:** Understand the components of PMS, Departments and Overview. **General Learning Objective:** Understand the different components with respect to the application of PMS on-board ship. **Specific Learning Objectives:** Explain the following: 2.1 Commercial Aspects-Survey, certification 2.2 Technical Aspects-Machineries and maintenance 2.3 Safety Aspects-Related to Safety, security, critical operations, Risk Assessments, hazard identifications, etc. 2.4 Shore Aspects: Service/Store/Spare/etc. from Shore sides	2: 2
C: Maintenance components of PMS **Sub Topics:** Different components of machineries on-board repair and maintenance system**.** **General Learning Objective:** Understand the categorization of machineries on-board, Jobs of maintenance, repair, servicing, monitoring, etc., Terotechnology (Life cycle maintenance), Replacement policies of spare parts	2: 2

Specific Learning Objectives: Explain the following: 3.1 Machinery categorization 3.2 Navigate through various machineries like Engine, Deck, Electrical, Catering, etc. 3.3 Job details specific to machineries, scheduling and reporting of jobs 3.4 Spare and Inventory management 3.5 Placing of service/spare/sore/etc. requirements through requisitions 3.6 Due and Overdue Jobs understanding planned and unplanned jobs reporting 3.7 Terotechnology (Life cycle maintenance), Replacement policies of spare parts 3.8 Due diligence during working personal execution of generic tasks like 'Inspection' 3.9 Ship maintenance costs and optimal maintenance policies	
D: Quality components of PMS **General Learning Objective** Understand the HSEQ- components- Health Safety Environment and Quality. **Specific Learning Objectives:** Describe the following: 4.1 Risk assessment – meaning and application, for scheduled and unscheduled jobs 4.2 Safety and permit system on-board, Company specific operation manual and relevant forms/checklists 4.3 Identification of Hazards associated with a job, finding control measures and reporting on ships PMS system 4.4 Defect List: Centralized maintenance, record keeping, actions taken record 4.5 Third party inspections: non-conformity records and updating on corrective and preventive measures 4.6 Incident Reporting, follow up, Corrective and Preventive actions	2: 2
E: Shore components of PMS **Sub Topics**: Procurements, Commercial, HR, Budget, DD-Dry Dock etc. **General Learning Objective** Overall organisational management structure of shipping company, Components concerned with legal, commercial and technical monitoring and requirements. **Specific Learning Objectives:** Explain the following: 5.1 The overall organisational management structure of the shipping company 5.2 HR and Payroll management, Manning aspects related to career/appraisal of seafarer 5.3 VIR (Vessel inspection record), Audit reporting 5.4 Flag and Class certification scheduling and recordkeeping, for commercial requirements from owner's ship and cargo, charterers, etc. 5.5 Budget, Finance and vessel performance management for whole fleet of ships 5.6 Procurement: Starting from ships indent raising up to the final delivery of items being used on ships, including Quotations, Purchase orders, Invoices, Payments, etc. Understanding management of budget and all other expenses regular/unscheduled repair/etc. 5.7 Database: Data library for all required vessel and shore procedures/checklists/forms/references/etc. 5.8 DD management- Planning and execution of Dry Dock, Technical/ Commercial aspects, with timely, safely, efficient operations	4: 4
	12: 12

Course: Electromechanical Actuators Drives and Sensors

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Basics of sensing elements, bridges and basic electronics.

Recommended Text:

1. Patranabis, 'Principles of Industrial Instrumentation', Tata McGraw Hill, eleventh reprint (2004).
2. Liptak, 'Instrument Engineers' Handbook: Process Measurement and Analysis', CRC (2003).
3. B. C. Nakra and K. K. Choudhari, 'Instrumentation Measurements and Analysis', Tata McGraw Hill Education.
4. E.O. Doebelin, 'Measurement Systems', McGraw Hill.
5. Andrew Parr, 'Industrial Control hand book', Newnes Industrial Press.
6. S. Rangan, G. R. Sharma and V. S. Mani, 'Instrumentation Devices and Systems', Tata McGraw Hill Publishing Company Ltd., New Delhi.
7. D.V.S. Murty, 'Instrumentation and Measurement Principles', PHI, New Delhi.

Table of Topics

Section	Topics	Hours (L: SL)
A	Sensing various parameters using different sensors and transducers **Sub-Topics:** Basic principles of sensing various parameters, Development of mathematical background of sensor design, Selection of sensors for typical applications	4: 4
B	Different pneumatic and hydraulic Actuators **Sub-Topics:** Different actuators working, Positioners, valves and signal transmitting devices.	4: 4
C	Different types of drives and their control techniques **Sub-Topics:** Different types of AC and DC motors, Different technique for driving AC and DC motors, Speed control techniques for AC and DC motors.	4: 4
	Total	**12: 12**

Learning Objectives	Hours (L: SL)
A General Learning Objective Sensing various parameters using different sensors and transducers **Specific Learning Objectives:** 1.1 Understand the principle and working of different methods for measurement of temperature like Resistance Temperature Detectors (RTD), Thermistor, Thermocouples, Thermopiles, Pyrometers, Temperature IC sensors (AD590 and LM35) 1.2 Study of thermocouple tables (calculation of intermediate temperature and voltage), Lead wire compensation, Cold junction compensation techniques, Protection (Thermo well) 1.3 Understand the principle and working of different methods for measurement of pressure like Manometers, elastic pressure sensors, secondary pressure sensors, differential pressure sensors, force balance type, motion balance type, capacitive (delta cell), ring balance, vibrating cylinder type, high-pressure gauges, vacuum gauges, dead weight and vacuum gauge tester 1.4 Understand the principle and working of different methods for measurement of displacement like Resistive: Potentiometer, Strain gauges, Inductive: LVDT and Eddy current type, Capacitive: Capacitance pickups, Differential capacitive type, Piezoelectric, Ultrasonic transducers and Hall effect transducers, Optical transducers 1.5 Understand the principle and working of different methods for measurement of flow like Turbine, Electromagnetic, Ultrasonic, Vortex shedding, Positive displacement, Anemometers, Mass flow meters 1.6 Understand the principle and working of different methods for measurement of level like Float, Displacer (Torque tube unit), Bubbler, Diaphragm box, DP cell, Ultrasonic, Capacitive, radioactive type, laser type transducers, level gages, resistance, thermal, radar, time domain reflectometry (TDR) / phase difference sensor (PDS), solid level detectors, fibre optic level detectors, Level switch 1.7 Explain Modern Sensors like Film sensors, micro-scale sensors, Particle measuring systems, Vibration Sensors, SMART sensors	4: 4
B General Learning Objective Different pneumatic and hydraulic Actuators **Specific Learning Objectives:** 2.1 Define Actuators 2.2 Describe different types of actuators like Pneumatic actuator, Electro-pneumatic actuator Hydraulic actuator, Electro-hydraulic actuators, Electric actuators 2.3 Explain the working and need of valve positioners and its need 2.4 Explain the working of piezoelectric actuators 2.5 Select a valve for particular application	4: 4

C General Learning Objective Different types of drives and their control techniques **Specific Learning Objectives:** 3.1 Explain different types of drives 3.2 Explain working principle, characteristics and application of D. C. motors, Position Servo, Miniature DC Motors. Printed Circuit DC Motors. Brushless DC Motor 3.3 Explain working principle, characteristics and application of Single-Phase Motors, Types of single-phase motors (Split Phase Motor, Capacitor start, Capacitor Start-Capacitor Run, Permanent Split-Capacitor Motor) 3.4 Explain working principle, characteristics and application of AC Synchronous Motors (PM), Shaded Pole Motor, Universal motors 3.5 Explain pneumatic motors, hydraulic motors- continuous and limited rotation	4: 4

MC COURSE BASKET 3 DIGITAL DESIGN AND MODERN TOOLS

Course: Mathematical Software for Engineering Applications

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Basic knowledge and mathematical representation of Electrical, Control and Mechanical systems.

Recommended Text:

1. MATLAB Guide, Third Edition by Desmond J. Higham, Nicholas J. Higham.
2. MATLAB for Engineering Applications by William Palm.
3. MATLAB and SIMULINK for Engineers by Agam Kumar Tyagi.
4. MATLAB and SIMULINK: Introduction to Applications by Partha S. Mallick.

Table of Topics

Section	Topics	Hours (L: SL)
A	Electrical system design using MATLAB-SIMULINK. **Sub-Topics:** Different waveforms, signals, Differential equation modelling.	3: 3
B	Control System design using MATLAB-SIMULINK. **Sub-Topics:** PID controller, Spring-Mass-Damper system. Stability analysis using Root locus, Bode plot and Nyquist plot methods, time response and frequency response characteristics	3: 3
C	Marine Machinery System Dynamics -MATLAB-SIMULINK. **Sub-Topics:** Stress-strain graph for Tension-test specimen, Equivalent vector, moment of Inertia of engine components, engine kinematics and dynamics, Engine-static balance and dynamic balance, Marine engine- primary balance and secondary balance, optimum firing order for appropriate engine dynamics and balance.	3: 3
D	Marine Machinery Vibration Analysis -MATLAB-SIMULINK. **Sub-Topics:** Response of the free, damped, forced 1-DOF Marine Machinery systems. Response of the MDF Marine Machinery systems (Longitudinal, transverse, torsional) and evaluate Natural frequencies and mode shapes, node locations for all modes, barred speeds.	3: 3
	Total	**12: 12**

Learning Objectives	Hours (L: SL)
A General Learning Objective Electrical system design using MATLAB-SIMULINK. **Specific Learning Objectives:** Describe the following: 1.1 Generation of different waveforms like sine wave, square wave, saw tooth waves using MATLAB PROGRAMMING 1.2 Generation of different signals like step, ramp, parabolic and impulse using MATLAB PROGRAMMING 1.3 Generation of square wave from sine wave using if-else block, ports, subsystem blocks and signal routing switch in SIMULINK 1.4 Find solution and forming Mathematical Model of a differential equation using SIMULINK	3: 3
B General Learning Objective Control System design using MATLAB-SIMULINK. **Specific Learning Objectives:** 2.1 Design and Tuning of a PID controller using SIMULINK 2.2 Analyse the Performance of SPRING-MASS-DAMPER System using SIMULINK 2.3 Plot ROOT LOCUS, BODE-PLOT and NYQUIST PLOT and comment on Stability Analysis parameters like PM, GM, GCO, PCO of a control system using SIMULINK 2.4 Plot Transient response using MATLAB PROGRAMMING and obtain different time response characteristics of a control system using MATLAB PROGRAMMING	3: 3
C General Learning Objective Marine Machinery System Dynamics -MATLAB-SIMULINK. **Specific Learning Objectives:** 3.1 Develop a generic MATLAB program (script file) that plots a stress-strain relational graph for the results obtained from typical tension test for dog-bone shaped specimen 3.2 Develop a generic MATLAB program (script file) that determine the magnitude and direction of the resultant of a number of force vectors or couple vectors acting on a system 3.3 Develop a generic MATLAB program (script file) that evaluates the area moment of inertia of the I-Section of the connecting rod and mass moment of inertia of inertia of the connecting rod for the given engine input dimensions	3: 3

3.4 Develop a generic MATLAB program (script file) that calculates and plots the displacement, velocity, and acceleration of the piston for one revolution of the crank shaft for the given engine input parameters like engine speed etc. 3.5 Develop a generic MATLAB program (script file) that calculates and plots the variation of Engine primary inertia forces and Engine secondary inertia forces during every rotation of crank shaft for the given engine input parameters 3.6 Develop a generic MATLAB program (script file) that examines the system involving rotating components like gears, cams, pulleys, sprockets etc. for balance and finds the magnitude and location of un-balance in the system and also determine the balance masses to be placed in order to achieve both Static balance and Dynamic balance 3.7 Develop a generic MATLAB program (script file) that examines a marine engine with a definite Firing order for balance and finds the magnitude and location of un-balance in the engine and also determine the balance masses to be placed in order to achieve both primary and Secondary engine balance 3.8 Program should also find the optimum Firing sequence from the point of engine best dynamics and balance	
D General Learning Objective Marine Machinery Vibration Analysis -MATLAB-SIMULINK **Specific Learning Objectives:** 4.1 Simulate the response of a **MARINE MACHINERY** that can be modelled as 1-DOF subjected to a) NO EXTERNAL FORCING FUNCTION using **MATLAB/Simulink**. b) EXTERNAL FORCING FUNCTION using **MATLAB/Simulink** 4.2 Simulate the response of a **MARINE MACHINERY** that can be modelled as 1-DOF OVER-DAMPED, CRITICAL DAMPED, UNDER-DAMPED SYSTEMS using **MATLAB/Simulink** 4.3 Simulate the response of a **MARINE ENGINE** that can be modelled as 1-DOF vibrating system subjected to HARMONIC EXCITATION, STEP INPUT using **MATLAB/Simulink** 4.4 Simulate the response of a **MOTOR-COUPLING-CENTRIFUGAL PUMP** that can be modelled as 3-DOF torsional system subjected to HARMONIC EXCITATION, using **MATLAB/Simulink** to determine node locations for all modes, Natural frequencies and mode shapes 4.5 Simulate the response of a **DIRECT DRIVE PROPULSION PLANT** (Main engine directly drives the propeller) that can be modelled as MDOF torsional system using **MATLAB/Simulink** to determine node locations for all modes, Natural frequencies and mode shapes, barred speeds (Critical speeds) 4.6 Simulate the response of a **PROPULSION PLANT WITH REDUCTION GEAR** (Main engine drives the propeller through the reduction gear box) that can be modelled as MDOF torsional system using **MATLAB/Simulink** to determine node locations for all modes, Natural frequencies and mode shapes, barred speeds (Critical speeds) 4.7 Simulate the response and evaluate Natural frequencies and mode shapes, node locations for all modes of a **MARINE MACHINERY** Systems that can be modelled as MDF using **MATLAB/Simulink**	3: 3

Course: Elementary Course in Finite Element Analysis

Instructional hours:

Lecture	: 12 hours
Self-Learning& Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. The objective of the course is to apprise the students about the basics of the Finite Element Technique, a numerical tool for the solution of different classes of problems in solid mechanics.
2. Major emphasis will be given on the solution of problems related to Marine applications such as stresses in the trusses, beams and different types of structures.
3. Different Finite element analysis methodologies will be covered for 1-D and 2-D problems
4. Pre-requisites: Mechanics of machines; Strength of Materials.

Recommended Text:

1. J. N. Reddy, An Introduction to the Finite Element Method, Tata McGraw Hill Publishing Company Ltd., 3rd Edition, 2005, New Delhi.
2. P. Seshu, Finite Element Analysis, Prentice Hall of India Private Limited, 2nd Edition, 2004.
3. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall of India Private Limited, 2nd Edition, 1997, New Delhi.
4. C. S. Krishnamoorthy, Finite Element Analysis, Tata McGraw Hill.
5. David V. Hutton, Fundamentals of Finite Element Analysis, McGraw Hill.
6. D. Maity, Computer Analysis of Framed Structures, I. K. International Pvt. Ltd. New Delhi.
7. Erik G. Thompson, Introduction to the Finite Element Method: Theory, Programming and Applications, John Wiley.
8. H. C. Martin and G. F. Carey, Introduction to Finite Element Analysis - Theory and Application, New York, McGraw Hill.

Table of Topics

Section	Topics	Hours (L: SL)
A	**Introduction to Finite Element Analysis** **Sub-Topics** Explain the following: 1. Introduction 2. history 3. basic concepts of FEM 4. Mathematical Modelling of field problems in Engineering 5. Governing Equations and Steps in Finite Element Analysis	1: 1
B	**Integral Formulations and Variational Methods** **Sub-Topics** Explain the following: 1. Weighted integral form 2. Weighted Residual Methods 3. Variational Methods 4. Variational Formulation of Boundary Value Problems	1: 1
C	**FEM through 1-D problems and FEM modelling of Truss and bending of Beams** **Sub-Topics** Explain the following: 1. One Dimensional Second Order Equations 2. Discretization – Element types- Linear and Higher order Elements 3. Derivation of Shape functions and Stiffness matrices and force vectors- Assembly of Matrices 4. Solution of problems from solid mechanics and heat transfer. 5. Stiffness of Truss Members 6. Analysis of Truss 7. Stiffness of Beam Members 8. Finite Element Analysis of Continuous Beam 9. Plane Frame Analysis	2: 2
D	**Time dependent problems** **Sub-Topics** Explain the following: 1. Initial and Eigen Value problems 2. Eigen value problems and time dependent problems	2: 2
E	**Numerical Integration** **Sub-Topics** Explain the following: 1. Natural co-ordinate systems 2. Isoparametric elements 3. Shape functions for iso parametric elements 4. One and two dimensions 5. Numerical integration and application to plane stress problems	2: 2
F	**Two-dimensional scalar variable problems** **Sub-Topics** Describe the following: 1. Second Order 2D Equations involving Scalar Variable Functions 2. Variational formulation 3. Finite Element formulation 4. Triangular elements 5. Shape functions and element matrices and vectors. 6. Application to Field Problems /Thermal problems	2: 2

G	**Two-dimensional vector variable problems** **Sub-Topics** Describe the following: 1. Equations of elasticity 2. Plane stress, plane strain and axisymmetric problems 3. Body forces and temperature effects 4. Stress calculations and Plate and shell elements	2: 2
	Total	**12: 12**

Learning Objectives	**Hours (L: SL)**
1. At the end of the course, the learner should be able to apprise the basics of the Finite Element Technique, a numerical tool for the solution of different classes of problems in solid mechanics. 2. At the end of the course, the learner should be Able to give solution to the problems related to Marine applications such as stresses in the trusses, beams and different types of structures. 3. At the end of the course, the learner should be able to understand the different Finite element analysis methodologies for 1-D and 2-D problems	
A Introduction to Finite Element Analysis **General Learning Objective** Make the learner to know the history of FEA, understand the basic concepts of FEM and Steps in Finite Element Analysis **Specific Learning Objectives:** 1.1 Explain the history of FEA 1.2 Explain the basic concepts of FEM 1.3 Analyse and evaluate the Governing Equations of FEA 1.4 Understand and Summarized basic Steps involved in Finite Element Analysis 1.5 Connect and correlate the Mathematical Modelling of field problems in Engineering	1: 1
B Integral Formulations and Variational Methods **General Learning Objective** Make the learner to understand the integral formulation and application of Variational Methods **Specific Learning Objectives:** 2.1 Describe Weighted integral form and residual methods 2.2 Describe Variational Methods and formulation of boundary value problems	1: 1
C FEM through 1-D problems and FEM modelling of Truss and bending of Beams **General Learning Objective** Make the learner to apply finite element formulations to solve one dimensional problem. **Specific Learning Objectives:** 3.1 Explain physical significance of One Dimensional Second Order Equations 3.2 Explain appraise the different discretization techniques and element types such as linear and higher order elements 3.3 Derive the Shape functions and Stiffness matrices and force vectors 3.4 Study and evaluate the assembly of matrices 3.5 Solve and analyse problems from solid mechanics and heat transfer (1-D). 3.6 Study the stiffness of truss members and analyse the truss under the forces 3.7 Apply the FEM techniques to the continuous beam and to the plane frame	2: 2

D Time dependent problems **General Learning Objective** Make the learner to understand and solve the Eigen value problems and time dependent problems (transient stage problems) **Specific Learning Objectives:** 4.1 Solve the initial and Eigen value problem 4.2 Solve and evaluate the Eigen value problem	2: 2
E Numerical Integration **General Learning Objective** Make the learner to understand the Numerical integration and application to plane stress problems **Specific Learning Objectives:** 5.1 Illustrate the Natural co-ordinate systems 5.2 Explain Isoparametric elements 5.3 Evaluate the shape functions for iso parametric elements 5.4 Apply numerical integration to plane stress problems	2: 2
F Two-dimensional scalar variable problems **General Learning Objective** Make the learner to solve Second Order 2D Equations involving Scalar Variable Functions and related problems **Specific Learning Objectives:** 6.1 Solve Second Order 2D Equations involving Scalar Variable Functions 6.2 State the Variational formulation of triangular element with FEA 6.3 Derive for Shape functions and element matrices and vector 6.4 Solve and analyse the field problem (only scalar variable problem)	2: 2
G Two-dimensional vector variable problems **General Learning Objective** Learner should solve axisymmetric problem. **Specific Learning Objectives:** 7.1 Appreciate the equation of elasticity 7.2 Solve plane stress/strain and axisymmetric problem 7.3 Evaluate the effect of body forces and temperature 7.4 Explain stress calculation and plate and shell elements	2: 2

Course: Computer aided Ship Design

Instructional hours:

Lecture	: 07 hours
Self-Learning & Preparation	: 17 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning on Ship design software.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

A capstone design project designed to give students experience in the preliminary design of a special purpose ship. Using advanced design software and databases, students will be Able to design a vessel according to specified criteria. Student has to do the preliminary design of an assigned merchant vessel and write brief specifications.

1. Pre-requisites: Naval Architecture 1, Naval Architecture 2, Ship Structure and Construction.

Recommended Text:

1. Ship Design and Construction Vol I & II -Thomas Lamb (SNAME).
2. The Principles of Naval Architecture Series -J. Randolph Paulling (SNAME).
3. Design Principles of Ships and Marine Structures -S. C. Misra.
4. Ship Design and Performance for Masters and Mates -Dr C.B. Barrass.
5. Ship Design for Efficiency and Economy -H. Schneekluth and V. Bertram.

Table of Topics

Section	Topics	Hours (L: SL)
A	Introduction to Ship Design Process **Sub-Topics:** Design Spiral, Phases of Ship design, Feasibility study, Concept design, preliminary design, Ship design tools.	1: 2
B	Parametric Design **Sub-Topics:** Initial hull form coefficients, Early estimates of hydrostatic particulars, Parametric estimation of weights and centres, Hydrodynamic performance estimation, Subdivision and Compartments, Capacities.	1: 3
C	Development of Hull form using software tool **Sub-Topics:** Methodology for the Geometric Modelling of the Hull Form, generation of the lines and surfaces of the ship, modelling of bulbous bow, Fairing of lines, transformation of the existing hull.	1: 3
D	Estimation of resistance and powering estimates of the ship using software tool and empirical methods **Sub-Topics:** Use of various applicable empirical methods to estimate the resistance and powering estimates of the ship.	1: 3
E	Generation of General arrangement of the ship using drawing tool **Sub-Topics:** Arrangement of bulkheads, decks, compartments, tanks, machinery and equipment on board.	1: 2
F	Creation of weight, stability and strength estimates in the software tool **Sub-Topics:** Creation of initial weight distribution, estimation of intact and damaged stability of the ship, generation of strength curves to calculate the maximum bending moment.	1: 2
G	Preparation of the Ship design report **Sub-Topics:** Generation of ship design report with detailed information on hull form coefficients, lines plan drawing, hydrostatic curves, general arrangement, report on intact and damaged stability, speed power estimates, and strength curves.	1: 2
	Total	**7: 17**

Learning Objectives	Hours (L: SL)
A General Learning Objective Introduction to the design Spiral, different phases of Ship design, such as Concept design, preliminary design and various Ship design tools in the industry. **Specific Learning Objectives:** Explain the following: 1.1 Explain the design spiral of the ship 1.2 Different phases of Ship design 1.3 Concept design, preliminary design 1.4 various Ship design tools in the industry	1: 2
B General Learning Objective Introduction and understanding of the Parametric design of the ship based on the various empirical methods applicable. **Specific Learning Objectives:** Explain the following: 2.1 Initial hull form coefficients 2.2 Early estimates of hydrostatic particulars	1: 3

2.3 Parametric estimation of weights and centres of the ship 2.4 Hydrodynamic performance estimation 2.5 Subdivision and Compartments 2.6 Capacities of the ship	
C General Learning Objective Understand the process of developing and transformation of the existing hull form in the software tool. **Specific Learning Objectives:** 3.1 State Methodology for the Geometric Modelling of the Hull Form 3.2 State Generation of the lines and surfaces of the ship 3.3 State Modelling of bulbous bow 3.4 State Fairing of lines 3.5 State Transformation of the existing hull	1: 3
D General Learning Objective Understand the use of various empirical methods for the speed and powering estimates **Specific Learning Objectives:** 4.1 Use of various applicable empirical methods to estimate the resistance and powering estimates of the ship	1: 3
E General Learning Objective Understand and create general arrangement drawing for the ship **Specific Learning Objectives:** 5.1 Arrangement of bulkheads, decks, compartments, tanks, machinery and equipment on board	1: 2
F General Learning Objective Understand Creation of initial weight distribution, estimation of intact and damaged stability of the ship, generation of strength curves **Specific Learning Objectives:** 6.1 Explain Creation of initial weight distribution 6.2 Explain Estimation of intact and damaged stability of the ship 6.3 Explain Generation of strength curves to calculate the maximum bending moment	1: 2
G General Learning Objective Understand and prepare ship deign report **Specific Learning Objectives:** 7.1 Explain Generation of ship design report with detailed information on hull form coefficients, lines plan drawing, hydrostatic curves, general arrangement, report on intact and damaged stability, speed power estimates, and strength curves	1: 2

Course: Blockchain Technology

Instructional Hours:

Lecture/Tutorial	: 15 hours
Self-Learning	: 10 hours
Total	**:** 25 hours
Credits	**:** 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions, tutorials and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

Pre-requisites: Fundamentals of security , encryption , decryption, hashing and fundamentals of programming like linked list.

Recommended Text:

1. Blockchain: Blueprint for a new economy by Melanie Swan.
2. Blockchain Revolution by Don and Alex Tapscott.
3. Cryptoassets by Chris Burniske and Jack Tatar.
4. The Book of Satoshi by Phil Champagne.
5. The Basics of Bitcoins and Blockchains by Antony Lewis.
6. Blockchain Technology Explained: The Ultimate Beginner's Guide by Alan T. Norman.
7. Blockchain Technology for Industry 4.0, Springer.

Table of Topics

Section	Topics	Hours (L: SL)
A1	**Introduction Blockchain technology** **Sub-Topics/SLOs:** Cryptographic Elements in Blockchain, A decentralized society, Blockchain landscape, applications	5:3
B1	**Block chain and Maritime Industry :** **Sub-Topics/SLOs:** Analyse hash cryptography, mining and consensus. Proof-of-Work and Stake-of-Work consensus, block mining, block tampering; block chain architecture	10:7
	Total	**15:10**

Learning objectives	**L: SL**
A. Introduction to BCT:	
Specific Learning Objectives: 1.1 Define Blockchain technology: Why, What, How 1.2 Explain Technological and cryptographic elements 1.3 Define and describe Blockchain Platforms A decentralized society 1.4 Describe the current state of the Blockchain landscape 1.5 Describe Business applications and assessing blockchain	5:3
B. Block chain and Maritime Industry	
Specific Learning Objectives: 2.1 Explain Crypto-anarchism and Cypherpunks 2.2 Explain and analyse hash cryptography, mining and consensus Proof-of-Work and Stake-of-Work consensus, block mining, block tampering 2.3 Explain in detail block chain architecture 2.4 Explain and understand The Limitations, Opportunities and Challenges of Blockchain in marine industry	10:7
Notes for Lessons: a. Introduction: A blockchain is a database that stores encrypted blocks of data then chains them together to form a chronological single-source-of-truth for the data b. Digital assets: are distributed instead of copied or transferred, creating an immutable record of an asset. The asset is decentralized, allowing full real-time access and transparency to the public c. Encryption and block security: Blockchain's inherent security measures and public ledger make it a prime technology for almost every single sector d. Cryptographic Elements in Blockchain: The data in the block. A 32-bit whole number called a nonce. The nonce is randomly generated when a block is created, which then generates a block header hash. The hash is a 256-bit number wedded to the nonce. e. Decentralized society: The asset is decentralized, allowing full real-time access and transparency to the public f. Blockchain landscape: Global blockchain market size will exponentially grow, The banking and financial sector, logistics management, marine sector g. Business applications: crypto currency, The banking and financial sector, logistics management, marine sector, medical sector h. Crypto-anarchism and Cypherpunks: analyse hash cryptography, mining and consensus. Proof-of-Work and Stake-of-Work consensus, block mining, block tampering i. Block chain architecture: Detailed study of BTC architecture j. Future of BCT: The Limitations, Opportunities and Challenges of Blockchain in marine industry.	

MC BASKET 4 SHIPPING BUSINESS

Course: Chartering

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Merchant vessel functions; Ship Operations.

Recommended Text:

1. DRY CARGO CHARTERING: Institute of chartered shipbrokers.
2. TANKER CHARTERING: Institute of chartered shipbrokers.
3. BES' CHARTERING AND SHIPPING TYERMS: Barker & Howard Ltd.
4. SHIBROKING AND CHARTERING PRACTICE: Lars Gorton; LLP.
5. ELEMENTS OF SHIPPING: Alan E Branch; Routledge.

Table of Topics

Section	Topics	Hours (L: SL)
A1	**Introduction to Chartering** **Sub-Topics:** Trade and Chartering	1:1
B1	**Chartering Process** **Sub-Topics:** Process of Chartering	1:1
C1	**Voyage Chartering** **Sub-Topics:** Features of Voyage Charter	3:3
D1	**Time Chartering** **Sub-Topics:** Features of Time Charter	2:2
E1	**Tanker Chartering** **Sub-Topics:** Features of Tanker Charter	3:3
F1	**Freight and Voyage Estimation** **Sub-Topics:** Freight and Voyage Estimation	2:2
	Total	**12: 12**

Learning Objectives	L: SL
A1: Introduction to Chartering	
General Learning Objective: Understand the role of Chartering in Shipping Business **Sub topics & SLOs** 1.0 Liner and Tramp Trade **1.1** Introduction to Chartering	
Specific Learning Objectives: 1.1.1 Explain features of Liner Trade 1.1.2 Explain features of Tramp Trade 1.2.1 Explain Demise & Non- Demise Charter 1.2.2 Explain features of Bareboat Charter 1.2.3 Explain Contract of Affreightment 1.2.4 Explain Slot Charter	1: 1
B1: Chartering Process	
General Learning Objective: Understand process of chartering **Sub-sub topics & SLOs:** 2.0 Chartering Brokers 2.1 Process of Chartering	
Specific Learning Objectives: 2.1.1 Explain the need and responsibility of Chartering Brokers 2.1.2 Explain the need of Ethics in Chartering. 2.1.3 Explain the process of Chartering including Fixtures, Offer, Counter 2.1.4 Explain the essential details of a firm offer for voyage charter and Time Charter 2.1.5 Explain the meaning of Subject in negotiations	1: 1
C1: Voyage Chartering	
General Learning Objective:	

Understand the features of Voyage Chartering **Sub-sub topics & SLOs:** 3.0 Introduction 3.1 Important Clauses	
Specific Learning Objectives: 3.1.1 Explain Voyage Charter and its various types (FIO, GLFD, Gross terms, Net Terms) 3.1.2 Explain how different expenses are distributed between Charterer and Ship-owner 3.3.3 Explain Notice of Readiness 3.1.4 Explain Lay days and cancellation clause 3.1.5 Explain Lay time, Demurrage and Despatch 3.1.6 Explain different types of Lay time 3.1.7 Explain the commencement of lay time, various interruptions and cessation 3.1.8 Explain Statement of Fact 3.1.9 Explain features of Voyage Charter Party Lay Time Interpretation Rules, 1993 3.1.10 Calculate Lay time in Bulk Carrier with Numerical 3.1.11 Explain how Cargo and Ports are described 3.1.12Explain Stowage Factor and Broken Stowage 3.1.13 Overview of FONASBA, AMWELSH	3: 3
D1: Time Chartering	
General Learning Objective: Understand the features of Time Chartering **Sub-sub topics & SLOs:** 1.0 Introduction to Time Charter 4.1 Important Clauses Time Charter	
Specific Learning Objectives: 4.1.1 Explain Time Charter 4.1.2 Explain how different expenses are distributed between Charterer and Ship-owner 4.1.3 Explain Delivery and Redelivery including survey 4.1.4 Explain Hire, how and when it is paid 4.1.5 Explain Trading limits 4.1.6 Explain Duty to Maintain and duties of shipboard personal clause 4.1.7 Explain Off hire and Performance of Off hire 4.1.8 Explain Both to Blame and New Jason Clause 4.1.9 Explain Dangerous cargo and Cargo Exclusion Clause 4.1.10 Overview of ASBATIME and NYPE 93 4.1.11 Explain Inter club New York Produce Exchange Agreement	2: 2
E1: Tanker Chartering	
General Learning Objective: Understand the features of Tanker Chartering **Sub-sub topics & SLOs:** 5.1 Tanker Trade 5.2 Important Organisations 5.3 Features of Tanker Charter	

Specific Learning Objectives: **5.1 Tanker Trade** 5.1.1 Mark on World Map- Important Load Port of Crude Oil and petroleum products 5.1.2 Explain different sizes of Oil Tankers 5.1.3 Explain the Tanker market structure 5.1.4 Explain the factors which affect Freight 5.1.5 Explain World scale freight rate schedule 5.1.6 Explain Average Freight Rate Assessments 5.1.7 Explain World Scale hours Terms and Conditions **5.2 Important Organisations** 5.2.1 Describe INTERTANKO 5.2.2 Describe OCIMF 5.2.3 Describe OPEC 5.2.4 Describe ITOPF **5.3 Features of Tanker Charter** 5.3.1 Explain Interpretation of Tanker Fixtures 5.3.2 Explain Description of Ship for Chartering 5.3.3 Explain Description of Cargo for Chartering 5.3.4 Explain Additional Clauses in Tanker Charter parties: Weather Clause, Cargo Retention clause, War Risk Clause, cleaning of tanks Clause, Inert Gas and Crude Oil Washing Clause and Pumping Clause, ITOPF / TOVALOP Clause, ISPS Clause 5.3.5 Explain Calculation of Lay time in Tanker with Numerical	3: 3
F1: Freight & Voyage Estimation	
General Learning Objective: Understand Freight and Voyage calculations **Sub-sub topics & SLOs:** **6**.1Freight and Voyage Estimation	
Specific Learning Objectives: 6.1.1 Explain Freight 6.1.2 Explain different types of freight 6.1.3 Explain Baltic Freight Index 6.1.4 Explain features of Bill of Lading issued under a charter party 6.1.5 Explain Letter of Indemnity for change of destination and Non-Production of B/L 6.1.6 Explain Voyage Estimation on Bulk Carrier with Numerical 6.1.7 Explain Voyage Estimation on Tankers with Numerical	2: 2

Course: Marine Insurance

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Merchant vessel functions; Ship Operations.

Recommended Text:

1. IC 67 MARINE INSURANCE: Insurance Institute of India.
2. MARINE INSURANCE: Institute of chartered shipbrokers.
3. MARINE Insurance: Reeds.
4. COMMERCIAL MANAGEMENT FOR SHIPMASTERS: Robert L Tallack, The Nautical Institute.
5. LAW OF MARINE INSURANCE: Susan Hodges, Cavendish Publishing Limited.

Table of Topics

Section	Topics	Hours (L: SL)
A1	Introduction to Marine Insurance **Sub-Topics:** Insurance - Need and History.	2:2
B1	Introduction to Principles and Practices of Insurance **Sub-Topics:** Marine Insurance Act**,** Principles of Insurance and Practices.	2:2
C1	Insurance Business **Sub-Topics:** Features of Insurance Business.	2:2
D1	Hull Insurance **Sub-Topics:** features of Hull Insurance along with important clauses of IHC Hull 03	2:2
E1	Cargo Insurance **Sub-Topics:** features of Cargo Insurance along with important clauses of ICC	2:2
F1	**P&I Insurance** **Sub-Topics: features of Protection and Indemnity Insurance**	2:2
	Total	**12:12**

Learning Objectives	**L: SL**
A1: Introduction to Marine Insurance	
General Learning Objective: Understand the role of Marine Insurance in Shipping Industry, History of Marine Insurance **Sub-topics & SLOs** 1.1Introduction to Marine Insurance 1.2 Organisation of Lloyd's of London 1.3 Conduction of Insurance Business	
Specific Learning Objectives: **1.1 Introduction to Marine Insurance** 1.1.1 Explain what is Insurance 1.1.2 Explain the need of Insurance in Shipping Industry 1.1.3 Explain how 'Underwriting' was carried out earlier 1.1.4 Explain Bottomry and Respondentia **1.2 Organisation of Lloyd's of London** 1.2.1 Describe the history of Lloyd's of London 1.2.2 Describe how Lloyd's of London Operate 1.2.3 Explain the role of International Underwriting Association of London (IUA) and International Union of Marine Insurance (IUMI). **1.3 Conduction of Insurance Business** 1.31 Explain Original Slip, Broker's Cover Note, Insurance Policy and Insurance Certificates, Premium and Brokerage	2:2
B1: Introduction to Principles and Practices of Marine Insurance	
General Learning Objective: Understand the features of Marine Insurance Act, Various Principles and Practices of Insurance **Sub-sub topics & SLOs:** 2.1 Introduction to MIA 1963(India) 2.2 Principles of Insurance 2.3 Practices of Insurance	

Specific Learning Objectives: **2.1 Introduction to MIA 1963(India)** 1.1.1 Explain the need of MIA 1963 1.1.2 Define: Marine Insurance, Insurable Property, Marine Adventure, Maritime Perils, Freight and Goods **2.2 Principles of Insurance** 1.2.1 Explain Principle of Utmost Good Faith (Uberrimae Fidei) 1.2.2 Explain Insurable Interest 1.2.3 Explain Proximate Cause 1.2.4 Explain Principle of Indemnity including its corollaries – Subrogation and Contribution. **2.3 Practices of Insurance** 1.3.1 Explain Warranties (Implied and Express) 1.3.2 Explain Statutory Exclusions 1.3.3 Explain Different types of Losses – Total (Actual total loss and Constructive total loss.) and Partial (Particular Average and General Average) 1.3.4 Explain Deductible 1.3.5 Explain Types of Policies: Time, Voyage, Valued, Unvalued, Mixed, Floating	2:2
C1: Insurance Business	
General Learning Objective: Understand the features of Insurance Business **Sub-sub topics & SLOs:** 3.1 Underwriting 3.2 Claims 3.3 Reinsurance 3.4 General Average	
Specific Learning Objectives: **3.1 Underwriting** 3.1.1 Explain Underwriting Procedure: Proposal Form, Declaration, Documents Required, valuation of subject matter 3.1.2 Explain factors considered for initial rating and renewal rating 3.1.3 Explain Physical and Moral hazards in Underwriting **3.2 Claims** 3.2.1 Explain the procedure for claim in Insurance. 3.2.2 Explain the role of Master in preparation of claim documents. 3.2.3 List the documents required in claim settlement 3.2.4 Explain the methods of resolution of disputes between Insurer and Assured **3.3 Reinsurance** 3.3.1 Explain Reinsurance and why is it required 3.3.2 Explain Different types of Reinsurances: Facultative, Different types of Treaties **3.4 General Average** 3.4.1 Explain General Average Act 3.4.2 Explain important features of York Antwerp Rules	2:2
D1: Hull Insurance	

General Learning Objective: Understand the features of Hull Insurance along with important clauses of IHC Hull 03 **Sub-sub topics & SLOs:** 4.1Insurable Interests 4.2 Important Clauses of IHC 03 4.3 Other Important Clauses.	
Specific Learning Objectives: **4.1 Insurable Interests** 4.1.1 Explain the Insurable Interest of Assured in Hull & Machinery, Freight, Disbursements, Builder's & Repairers Liability, Third Party Liability **4.2 Important Clauses of IHC 03** 4.2.1 Explain Perils clause 4.2.2 Explain Pollution Hazard 4.2.3 Explain Collision liability with Sister ship 4.2.4 Explain General Average absorption clause 4.2.5 Explain Sue & Labour 4.2.6 Explain New for Old 4.2.7 Explain Classification & ISM Clause 4.2.8 Explain Return for Layup 4.2.9 Explain Continuation and Termination clauses. 4.210 Explain Institute Warranties 4.2.11 Explain Disbursement Clause **4.3 Other Important Clauses.** 4.3.1 Explain features of Institute Voyage Clause Hull 4.3.2 Explain features of Freight Insurance 4.3.3 Explain features of Builder's Risk Insurance 4.3.4 Explain features of War and Strikes Insurance 4.3.5 Explain features of Container Insurance	2:2
E1: Cargo Insurance	
General Learning Objective: Understand the features of Cargo Insurance along with important clauses of Institute Cargo Clauses. **Sub-sub topics & SLOs:** 5.1 Institute Cargo Clauses A, B and C 5.2 Other Clauses 5.3 Long Term Cargo Insurance	

Specific Learning Objectives: **5.1 Institute Cargo Clauses A, B and C** **W.r.t ICC A, B and C** 5.1.1 Explain Risks covered under ICC A, B and C 5.1.2 Explain various exclusions 5.1.3 Explain Transit Clause 5.1.4 Explain Change of Voyage 5.1.5 Explain Termination of Contract of Carriage clause 5.1.6 Explain Increased Value Clause 5.1.7 Explain Forwarding Charges Clause **5.2 Other Clauses** 5.2.1 Explain features of Institute War clause (Cargo) 5.2.2 Explain features of Institute Strike clause (Cargo) 5.2.3 Explain Incidental Clauses such as Pair & Set Clause, Cutting Clause, Label Clause, Brand & Trade mark Clause, Picking Clause, Replacement Clause and Second-hand Replacement Clause **5.3 Long Term Cargo Insurance** 5.3.1 Explain features of Open Cover 5.3.2 Explain features of Floating Policy 5.3.3 Explain Limit per Bottom; Limit per Location; Classification Clause; Declaration; Certificate of Insurance	2:2
F1: Protection & Indemnity Insurance	
General Learning Objective: Understand the features of Protection and Indemnity Insurance **Sub-sub topics & SLOs:** 6.1 Introduction to P& I	
Specific Learning Objectives: **6.1 Introduction to P& I** 6.1.1 Explain the Concept of Liability and Need of Insuring liability 6.1.2 Explain historical Background of P&I Clubs 6.1.3 Explain Principle of Mutual Insurance, Concept and types of Calls. 6.1.4 Explain How do Club operates 6.1.5 Explain services provided by P&I Club 6.1.6 Explain Role of Club Correspondent 6.1.7 List different Risks covered by Clubs 6.1.8 Explain Freight Demurrage and Defence 6.1.9 Explain features of Trough Transport Clubs 6.1.10 Explain the role of International Group of P&I Clubs	2:2

MC BASKET 5 OCEAN STUDIES

Course: Marine Litter

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Ship Operations.

Recommended Text:

1. http://www.gesamp.org/publications/guidelines-for-the-monitoring-and-assessment-of-plastic-litter-in-the-ocean.
2. https://marinelitternetwork.engr.uga.edu/resources/education/https://shipbreakingplatform.org/resources/library/.
3. https://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/MSFD_identifying_sources_of_marine_litter.pdf.
4. https://www.marlisco.eu/tl_files/marlisco/mixed-images/Final%20Marlisco%20leaflet.pdf.
5. https://www.marlisco.eu/education.en.html.

Table of Topics

Section	Topics	Hours (L: SL)
A	The environmental impact and societal relevance of marine litter problems.	3: 3
B	Technical solutions, including alternatives and recycling	3: 3
C	The governance of marine litter	3: 3
D	Sources, processes, modelling and monitoring of marine litter	3: 3
	Total	**12: 12**

Learning Objectives	Hours (L: SL)
A General Learning Objective Impact of environmental and societal relevance of marine litter problems. **Specific Learning Objectives:** Explain the following: 1.1 Explore and understand the threats of marine debris to our oceans 1.2 Global distribution and composition of marine debris categories 1.3 Debris and global ecosystem impacts 1.4 Social-economic impacts of marine debris	3: 3
B General Learning Objective Technical solutions, including alternatives and recycling **Specific Learning Objectives:** Explain the following: 2.1 Production and use 2.2 Learn the methods to handle, process and recycle the marine litter 2.3 Waste management and end-of-life	3: 3
C General Learning Objective Governance of marine litter **Specific Learning Objectives:** Explain the following: 3.1 Source to sea Frame work for Marine Litter Prevention 3.2 Instruments of Marine Litter at International, Regional and National Levels 3.3 Steps for Circular Economy	3: 3
D General Learning Objective Understand the sources**,** process and monitoring of marine litter **Specific Learning Objectives:** 4.1 Define Sources, Geographical Origin, Pathways and Transport Mechanisms	3: 3

MC BASKET 6 ENERGY AND ENVIRONMENT

Course: Heating, Ventilation and Air conditioning

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions, training in lab and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

This course will include the numerical treatment which will lead to the design of the HVAC system

Course objectives:

(a) Understand the recent vapour compression cycle.
(b) Provide the knowledge of cooling towers used for marine applications.
(c) Understand the design of piping for VCC.
(d) Provide the knowledge of basic concepts of ventilation, infiltration and space distribution techniques.
(e) Understand the techniques to calculate the heat load.

Course Outcomes:

At the end of the course cadets will be able to

(a) Determine the performance parameters of trans-critical & ejector refrigeration systems.
(b) Estimate thermal performance of cooling towers.
(c) Describe refrigerant piping design.
(d) Explain importance of indoor and outdoor design conditions ventilation and air distribution system.
(e) Estimate heat load using CLTD method.
(f) Explain working of types of desiccants, evaporative, thermal storage, radiant cooling, clean room air-conditioning systems.

1. Pre-requisites: Basic knowledge of the thermodynamics, refrigeration and air conditioning.

Recommended Text:

1. ASHRAE Handbook HVAC systems and Equipment.
2. Arora C P, refrigeration and air conditioning, Tata McGraw Hill.
3. Fundamentals of refrigeration, ISHRAE.
4. Dossat Ray J, Principles of the refrigeration, S I Version, Wiley Eastern Ltd, 2000.
5. Shan Wang, Handbook of Refrigeration and Air Conditioning, McGraw Hill Publications.
6. A R Trot and T Welch, Refrigeration and Air conditioning, Tata McGraw hill first print now online.
7. W P Jones, Air conditioning Engineering, Tata McGraw Publishers (Fifth Edition).

Table of Topics

Section	Topics	Hours (L: SL)
A	Advanced Vapour compression cycles for marine plants **Sub-Topics:** Introduction of simple vapour compression cycles, Introduction of trans critical cycles, basic trans critical cycle, performance improvement of trans critical cycles with different methods for marine applications	2: 2
B	Cooling towers for Marine applications **Sub-Topics:** Cooling Tower: types of cooling towers for applications Design of the cooling towers	1.5: 1.5
C	Practical aspects of vapour compression cycle for ship applications **Sub-Topics:** Refrigerant Piping: Copper Tubing, Piping Design for Reciprocating Refrigeration Systems, Size of Copper Tube, Refrigeration Load, and Pressure Drop, Sizing Procedure, Suction Line, Discharge Line (Hot-Gas Line), Liquid Line	1.5: 1.5
D	Ventilation and infiltration in marine cooling **Sub-Topics:** Indoor Design Criteria and Thermal Comfort: Basic parameters, factors affecting thermal comforts, Comfort-Discomfort Diagrams, Indoor Temperature, Relative Humidity, and Air Velocity, Indoor Air Quality: Indoor Air Contaminants, Basic Strategies to Improve Indoor Air Quality Outdoor Design Conditions: Outdoor Air Requirements for Occupants, The Use of Outdoor Weather Data in Design, Outdoor Weather Characteristics and Their Influence Ventilation for cooling: Natural ventilation, mechanical ventilation, Space air distribution	2: 2
E	Heat load calculation for marine air conditioning systems **Sub-Topics:** Cooling load and coil load calculations, cooling load Temperature Difference method (CLTD) or Equivalent Temperature Differential (ETD), detailed calculation procedure using CLTD method	2: 2
F	Advanced Marine Air conditioning systems **Sub-Topics:** Desiccant-Based Air Conditioning Systems, Evaporative-Cooling Air Conditioning Systems, Thermal Storage Air Conditioning Systems, Clean-Room Air Conditioning Systems, Radiant cooling.	2: 2
G	Activity-based learning of refrigeration systems **Sub-Topics:** Activity-based learning of refrigeration systems	1: 1
	Total	**12: 12**

Learning Objectives	Hours (L: SL)
A General Learning Objective Understand the introduction of the modified VCC, history, trans critical refrigeration and its types, ejector refrigeration and its types **Specific Learning Objectives:** 1.1 Know about the history of the refrigeration and air conditioning and developments 1.2 Review the basic vapour compression cycle 1.3 Study the basic trans critical refrigeration cycles and its drawbacks 1.4 Understand the required modifications in the basic trans critical cycle with block diagrams and P-h diagrams for ship applications 1.1.1 Explain Trans critical cycle with heat exchanger 1.1.2 Explain Trans critical cycle with expander 1.1.3 Explain Trans critical cycle with two stage compression (numerical treatment) 1.1.4 Explain Trans critical cycle with ejector system (numerical treatment) 1.1.5 Explain Trans critical cycle with vortex tube 1.1.6 Explain Trans critical cycle with parallel compression economization	2: 2
B General Learning Objective Understand cooling towers used on ships in refrigeration systems **Specific Learning Objectives:** 2.1 Know the working of the different types of cooling towers 2.2 Design of cooling towers in view point of marine applications	1.5: 1.5
C General Learning Objective Understand marine refrigeration and air conditioning pipe sizing **Specific Learning Objectives:** 3.1 Know the procedure to design the marine refrigeration or air conditioning piping for reciprocating refrigeration system 3.2 Solve the numerical based on following parameters: 3.1.1 Size of copper Tube 3.1.2 Refrigeration Load 3.1.3 Pressure Drop 3.1.4 Sizing Procedure 3.1.5 Suction Line 3.1.6 Discharge Line (Hot-Gas Line) 3.1.7 Liquid Line	1.5: 1.5

D General Learning Objective Understand ventilation and infiltration in marine cooling **Sub-Topics/SLOs:** 4.1 Get the knowledge about the indoor design criteria and thermal comfort: 4.1.1 Explain Basic parameters 4.1.2 Explain Factors affecting thermal comforts 4.1.3 Explain Comfort-discomfort diagrams 4.1.4 Explain Indoor temperature 4.1.5 Explain Relative humidity 4.1.6 Explain Air velocity etc. 4.2 Get the knowledge about parameters affecting the indoor air quality 4.2.1 Indoor air contaminants Explain the following: 4.3 Basic strategies to improve indoor air quality 4.4 To get the knowledge of outdoor design conditions 4.5 Outdoor air requirements for occupants, 4.6 The use of outdoor weather data in design, 4.7 Outdoor weather characteristics and their influence 4.8 To discuss the types of ventilation for cooling 4.9 Natural ventilation and 4.10 Mechanical ventilation 4.11 To discuss the space air distribution	2: 2
E General Learning Objective Understand heat load calculation for marine air conditioning systems **Specific Learning Objectives:** 5.1 Discuss the procedure for cooling load and coil load calculations for marine air conditioning systems 5.2 Explain the use of cooling load Temperature Difference method (CLTD) or Equivalent Temperature Differential (ETD) for marine air conditioning systems 5.3 Case study based on CLTD method	2: 2
F General Learning Objective Advanced Marine Air Conditioning Systems **Specific Learning Objectives:** Explain the following: 6.1 The construction and working of the desiccant-Based Air Conditioning Systems 6.2 The construction and working evaporative-cooling air conditioning systems 6.3 The construction and working of thermal storage air conditioning systems 6.4 The construction and working of Clean-Room Air Conditioning Systems 6.5 The construction and working of radiant cooling	2: 2
G General Learning Objective Activity-based learning of refrigeration systems **Specific Learning Objectives:** 7.1 Describe the refrigeration system through activities (practical session)	1: 1

MC BASKET 7 MANAGEMENT

Course: Energy Audit and Management

Instructional hours:

Lecture	: 12 hours
Self-Learning& Preparation	: 12 hours
Total hours	: 24 hours
Credits	:1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Basic English Course, Electrical and Mechanical basics.

Recommended Text:

1. 'Ship Energy Audit' by Seeba Ann Mathew.
2. 'Auditing the Maritime Industry: A case study of offshore support vessel segment' by Bjorn-Morten and AreSydnes.
3. 'General Aspects of Energy Management and Energy Audit' by Bureau of Energy Efficiency.
4. 'Handbook of Energy Audit' by Al Thumann, William J. Younger, Terry Niehus.

Table of Topics

Section	Topics	Hours (L: SL)
A	Energy Scenario on board Ship and Basics of Energy Audit **Sub-Topics:** Energy providing system, Electrical Energy utilizing equipment, pollution and environment, Energy strategy for future	2: 2
B	Energy Management and Audit in general **Sub-Topics:** Energy management approach, energy auditing types and involved terminologies	2: 2
C	Electrical system, generation and distribution and economics involved **Sub-Topics:** Load management, types of loads, power factor improvement, Distribution losses, efficiency of system, AC generators performance, motors and efficiency of motor, Cost of energy	2: 2
D	Air compressor, boiler and heat exchanger **Sub-Topics:** Types of air compressor, compressor and boiler efficiency, efficient compressor operation, Components of air compressor, Capacity assessment, leakage test, performance and efficiency of heat exchanger	1.5: 1.5
E	Refrigeration and air conditioning System **Sub-Topics:** Vapour compression refrigeration cycle, refrigerants, coefficient of performance, Factors affecting refrigeration system and its performance, vapour absorption refrigeration system and performance	1.5: 1.5
F	Energy management – technical and management dimensions on board ship **Sub-Topics:** Ship performance, main and auxiliary engine, Consumers, Fuel management	1.5: 1.5
G	Onboard energy audit scope - **Sub-Topics:** Energy awareness, Primary consumers, Secondary consumers, ship machinery performance	1.5: 1.5
	Total	**12: 12**

Learning Objectives	Hours (L: SL)
A General Learning Objective Understand Energy Scenario on board Ship and Basics of Energy Audit **Specific Learning Objectives:** Explain the following: 1.1 Energy scenario on board ship with power proving system and power utilizing equipment 1.2 List of equipment in generation of electricity- DG sets, emergency generator, transformers 1.3 Electrical protection equipment involved- CB, fuses, isolators, switches	2: 2
B General Learning Objective Understand Energy Management and Audit in general **Specific Learning Objectives:** Describe the following: 2.1 Definition of energy audit. 2.2 Need for energy audit and types of energy audit. 2.3 Energy performance – matching energy uses to requirement 2.4 Instruments and metering for energy audit	2: 2
C General Learning Objective Understand Electrical system, generation and distribution and economics involved **Specific Learning Objectives:** 3.1 Explain survey of instrumentations and equipment 3.2 Define and understand terms -Load management, types of loads, power factor improvement, Distribution losses, efficiency of system 3.3 Define motor audit and efficiency calculations	2: 2

3.4 Define distribution system audit	
D General Learning Objective Understand Air compressor, boiler and heat exchanger **Specific Learning Objectives:** Explain the following: 4.1 Performance testing of boiler and heat exchanger 4.2 Explain a leakage test and capacity assessment 4.3 Boiler efficiency calculations and performance 4.4 Compressed air audit	1.5: 1.5
E General Learning Objective Understand Refrigeration and air conditioning System **Specific Learning Objectives:** 5.1 Define Air conditioning system audit 5.2 Define Temperature and humidity audit 5.3 Define Energy recovery system	1.5: 1.5
F General Learning Objective Understand Energy management – technical and management dimensions on board ship **Specific Learning Objectives:** Explain the following: 6.1 Explain the technical aspects involved in energy management 6.2 Hull condition, propeller condition, cargo capacity 6.3 Review of current fuel on board, identification of specific fuel and CO_2 reduction opportunities 6.4 Maintain Fuel quality and quantity, Fuel sampling	1.5: 1.5
G General Learning Objective Onboard energy audit scope, checklist **Specific Learning Objectives:** 7.1 Explain Check energy awareness 7.2 Explain Performance tests and calculations of SFOC of ME 7.3 Explain Performance test of boiler	1.5: 1.5

Course: Stress Management

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Ship functions/Routines; Ship Operations.

Recommended Text:

1. Susan Cartwright, Cary L. Cooper, Managing Workplace Stress, Sage Publications.
2. Jerrold S. Greenberg, Comprehensive Stress Management, Tata McGraw Hill.
3. Heena T. Bhagtani, Stress Management, Himalaya Publishing House.
4. Documentary 'Stress: Portrait of a Killer'.

Table of Topics

Section	Topics	Hours (L: SL)
A	Introduction to Stress Management **Sub-Topics:** meaning of stress, eustress, distress, Understanding stress as an individual's response to a disturbance.	1: 1
B	Effects of Stress on Bodily Functions **Sub-Topics:** Effects of Stress on Bodily Functions according to A. Melhuish, Stress Costs, Who pays the costs?	2: 2
C	Coping with Stress **Sub-Topics:** Coping Mechanisms: Appraisal focused, Emotional focused and Problem focused.	2: 2
D	Time Management **Sub-Topics:** Explain the classification - The Mananas, The Poor Delegators, The Disorganised, The Mushrooms	2: 2
E	Family Stress **Sub-Topics:** A model of family stress	2: 2
F	Holmes and Rahe Stress Scale **Sub-Topics:** Explain Holmes and Rahe Stress Scale	1.5: 1.5
G	Stress vs Burnout **Sub-Topics:** Distinguish between Stress and Burnout	1.5: 1.5
	Total	**12: 12**

Learning Objectives	Hours (L: SL)
A General Learning Objective Understand Stress Management. **Specific Learning Objectives:** 1.1 Define what is Stress 1.2 Define Behavioural and Physical symptoms of stress 1.3 Define Identify the sources of workplace stress 1.4 List the three stages an individual experience in stressful situations (Hans Selye, 1946)	1: 1
B General Learning Objective Understand Effects of Stress on Bodily Functions **Specific Learning Objectives:** 2.1 Define Stress Psychophysiology 2.2 Define Dynamics of Work Stress 2.3 Explain the Factors intrinsic to the job: Working Conditions, Shift work, Long hours, Travel, New technology, Work overload, Role ambiguity, Role conflict 2.4 Define Relationships at Work: Relationships with Boss, Relationships with Subordinates 2.5 Define Dangers of stress: Tobacco, Alcohol	2: 2
C General Learning Objective Understand Coping with Stress **Specific Learning Objectives:** 3.1 Explain the mechanisms for coping with stress 3.2 Explain Stress Reduction Techniques, Autogenic training, Biofeedback 3.3 Explain Breathing, Meditation and Yoga	2: 2

D General Learning Objective Understand Time Management **Specific Learning Objectives:** 4.1 Explain the classification - The Mananas, The Poor Delegators, The Disorganised, The Mushrooms	2: 2
E General Learning Objective Understand Family stress **Specific Learning Objectives:** 5.1 Explain the Effective Family 5.2 Explain the Changing Family 5.3 Explain Marriage, Cohabitation, Single-Parent Families 5.4 Explain Violence – A family matter 5.5 Explain Financial Stressors	2: 2
F General Learning Objective Understand Holmes and Rahe Stress Scale **Specific Learning Objectives:** 6.1 Define introduction to Somatic Techniques for Stress Management 6.2 Define introduction to Cognitive Techniques for Stress Management	1.5: 1.5
G General Learning Objective Understand Stress vs Burnout **Specific Learning Objectives:** 7.1 Review the current research on Stress	1.5: 1.5

Course: Entrepreneurship

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Basics of Business and Industry.

Recommended Text:

1. Debasish Biswas, Chanchal Dey, Entrepreneurship Development in India, Routledge.

Table of Topics

Section	Topics	Hours (L: SL)
A	Introduction to Entrepreneurship **Sub-Topics:** meaning and concept of entrepreneurship	1: 1
B	MSME Development Act, 2006 **Sub-Topics:** Chapters I to VI.	2: 2
C	National Small Industries Corporation **Sub-Topics:** Bank Credit Facilitation Scheme, Raw Material Assistance, Single Point Registration, Procurement Marketing Support.	2: 2
D	Small Industries Development Bank of India **Sub-Topics:** Role of SIDBI	2: 2
E	Khadi & Village Industries Commission **Sub-Topics:** Role of KVIC	2: 2
F	The industries (Development and Regulation) Act, 1951 The industries (Development and Regulation) Amendment Act, 2016 **Sub-Topics:** Chapter I to Chapter IV	1.5: 1.5
G	The Environment (Protection) Act, 1986 **Sub-Topics/SLOs:** Chapter 1 to Chapter IV	1.5: 1.5
	Total	**12: 12**

Learning Objectives	Hours (L: SL)
A General Learning Objective Understand Entrepreneurship. **Specific Learning Objectives:** 1.1 Define Entrepreneurship 1.2 Define Social entrepreneurship 1.3 Define Health entrepreneurship 1.4 Define Tourism entrepreneurship	1: 1
B General Learning Objective Understand MSME Development Act, 2006 **Specific Learning Objectives:** 2.1 Define micro, small and medium enterprises 2.2 Explain Filing of memorandum 2.3 Explain Measure for protection, development and enhancement of micro, small and medium enterprises	2: 2
C General Learning Objective Understand National Small Industries Corporation **Specific Learning Objectives:** 3.1 Explain Role and responsibility of NSIC, Functions of NSIC 3.2 Explain Organizational Set-up of NSIC	2: 2

D General Learning Objective Understand Small Industries Development Bank of India **Specific Learning Objectives:** Explain the following: 4.1 Features of SIDBI 4.2 Benefits of taking loans under SIDBI 4.3 Products offered by SIDBI 4.4 Types of loan from SIDBI	2: 2
E General Learning Objective Understand Khadi & Village Industries Commission **Specific Learning Objectives:** 5.1 Define Functions of KVIC 5.2 Define Objectives of KVIC 5.3 Define Features of KVIC 5.4 Define Schemes under KVIC	2: 2
F General Learning Objective Understand the industries (Development and Regulation) Act, 1951 **Specific Learning Objectives:** 6.1 Explain Scope of the Act 6.2 Explain Exemption from the Act 6.3 Explain Provisions of the Act	1.5: 1.5
G General Learning Objective Understand the Environment (Protection) Act, 1986 **Specific Learning Objectives:** 7.1 Explain the salient features of The Environment (Protection) Act, 1986	1.5: 1.5

Course: Dry-dock planning and management

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Case study/Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Basic ship construction; Basic Naval Architecture/ship stability; Maintenance & Repair.

Recommended Text:

1. A guide to ship repair estimate by Man hours- by Don Butler.
2. BIMCO Ship REPAIRCON.

Website: www.bimco.org

Table of Topics

Section	Topics	Hours (L: SL)
A	Dry dock requirement and preparation	1: 1
B	Managing and organising the project	1: 1
C	Safety, environmental aspect, security assessment and Risk analysis	2: 2
D	Repair specifications tenders and contracts	3: 3
E	Decision factors for choosing shipyard	1: 1
F	Arrangement for vessel's arrival and actual docking	1: 1
G	Dry docking daily activities and deviation and control	1: 1
H	Completion of docking, Report and final invoicing	2: 2
	Total	**12: 12**

Learning Objectives	Hours (L: SL)
A General Learning Objective Understand class requirement for dry docking and preparation for dry docking. Dry-dock preparation starts from the day of completion of last docking. Input from Class status report, last docking report, defect register, owner requirement, PMS due jobs. **Specific Learning Objectives:** 1.1 Describe the requirement for dry docking as per class survey status 1.2 Describe the preparation of dry-docking as per last docking report, Owner's requirement, defect register etc.	1: 1
B General Learning Objective Understand managing and organising the project in agreement with owners/operators so that vessel is taken off the business during dry docking with minimum losses to owners /operators, work should be competed as per estimated budget and time. **Specific Learning Objectives:** 2.1 Explain why is Dry-docking a Project 2.2 Explain importance of Communication with all stake holder regarding intended time of repair, duration of repair, and estimated budget 2.3 Explain formation of project team	1: 1

C General Learning Objective Understand the responsibility of ship owner regarding Safety, environmental aspect, security assessment and Risk analysis during the docking. Even though the ship will not have all the safety equipment working, arrangement should be discussed and in place for dealing with any issues arising of safety, security, dealing with environmental issues. **Specific Learning Objectives:** 3.1 Explain that the responsibilities regarding safety, security environmental issues lie with Ship Master 3.2 Explain all the arrangement to deal with safety and security should be discussed with shipyard and should be always in readiness 3.3 Explain risk assessment that should be carried out for all the jobs posing hazards and mitigation measures should be in place prior to commencement of works	2: 2
D General Learning Objective Understand the importance of Repair specifications, tenders and contracts. As these provides basic guidelines to accomplish the project effectively. **Specific Learning Objectives:** 4.1 Describe how a Repair specification for Dry-docking job is prepared 4.2 Describe the clauses as per Ship repair contracts 4.3 Describe the responsibilities of each party for dry-docking work	3: 3
E General Learning Objective Understand decision factors for choosing shipyard; what all factors are considered before awarding contract to yard for repairs. Factors like Location and availability, total cost of repair, Total duration of repairs, Workman ship, Vicinity to related industry, Infrastructure of shipyard, Weather during the intended period of repair, Political condition, exchange rates etc. have to evaluated amongst all options and decided. **Specific Learning Objectives** 5.1 Explain importance of Location and availability of shipyard 5.2 Explain that total cost of repairs and duration of repairs one of the main criteria for selection 5.3 Explain that quality of work, Vicinity to related industry and Infrastructure are important factors 5.4 Explain the importance of Political condition, Exchange rate, weather during period of repairs	1: 1
F General Learning Objective Understand arrangement for vessel's arrival, and actual docking. Maintaining correct trim and stability. Following all procedures as per precaution during arrival, during docking, during undocking. **Specific Learning Objectives:** 6.1 Describe the procedure for arrival at the dry-dock 6.2 Describe the preparation for docking 6.3 Describe the stability of the vessel and effect of docking	1: 1
G General Learning Objective Study the importance of daily monitoring of the work progress, attending daily safety meeting, and correctly estimate the completion time. To communicate with stake holder regarding completion time on daily basis. To take measures to maintain the duration of repairs and cost as estimated. **Specific Learning Objectives** 7.1 Explain importance of attending daily meeting with shipyard personnel and senior ship staff 7.2 Explain importance of monitoring daily work and comparing the original schedule 7.3 Explain actions to be taken to correct the deviation	1: 1
H General Learning Objective Understand steps to be taken upon Completion of docking, Report writing, final invoicing and negotiation. **Specific Learning Objectives:** 8.1 Check and confirm each job are completed to satisfaction, any defects should be brought to notice of ship-yard 8.2 Prepare for negotiation of the total cost of repairs 8.3 Report writing, report should include, workman ship, infrastructure, cooperation from shipyard for future reference	2: 2

Course: Risk Management for Shipping

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Ship Operations/Functions.

Recommended Text:

1. Paul Hopkin, Fundamentals of Risk Management, Kogan Page.

Table of Topics

Section	Topics	Hours (L: SL)
A	Introduction to Risk Management **Sub-Topics/SLOs:** meaning and concept of risk, risk management	2: 2
B	Risk Management Standards and Tools **Sub-Topics/SLOs:** Risk Management Standards and Risk Matrix.	2: 2
C	Risk Management in Marine Cargo Insurance **Sub-Topics/SLOs:** Risk Management in relation to Transportation of Cargo	2: 2
D	Marine Insurance Act 1963 **Sub-Topics/SLOs:** Sections 1 to 92	6: 6
	Total	**12: 12**

Learning Objectives	Hours (L: SL)
A Introduction to Risk Management **Specific Learning Objectives:** Explain the following: 1.1 Definitions of Risk 1.2 Types of Risks: Hazard (or pure) risks, control (or uncertainty) risks, opportunity (or speculative) risks 1.3 Definitions of Risk Management 1.4 Principles of Risk Management: Proportionate, Aligned, Comprehensive, Embedded, Dynamic	2: 2
B Risk Management Standards and Tools **Specific Learning Objectives:** 2.1 Describe Risk Management Standards: ISO 31000, British Standard BS31100, Institute of Risk Management, COSO ERM, Turnbull Report, Orange Book, CoCo 2.2 Describe Risk Matrix	2: 2
C Risk Management in Marine Cargo Insurance **Specific Learning Objectives:** Explain the following: 3.1 Risk Management in relation to transportation of cargo 3.2 Components of Risk Management Programme 3.3 Steps involved in Risk Management Programme 3.4 Risk factors – Risk Management of project / heavy-lift cargo 3.5 Risk Management in project cargo	2: 2
D Marine Insurance Act 1963 **Specific Learning Objectives:** 4.1 Sections 1 to 92	6: 6

Course: Introduction to Risk Assessment

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Statistics and Data Analysis using R and Python.

Recommended Text:

1. Haugen, S., Rausand, M. (2020). Risk Assessment: Theory, Methods, and Applications. United Kingdom: Wiley.

Table of Topics

Section	Topics	Hours (L: SL)
A	**Introduction to Risk Assessment** **Sub-Topics/SLOs:** 1. Define Risk analysis, assessment and management 2. Define The study object 3. Define Accident categories 4. Define Risk in our modern society 5. Define Safety legislation 6. Define Risk and decision making	1: 1
B	**Hazards and threats** **Sub-Topics/SLOs:** 1. Explain Hazards and its classifications 2. Explain Threats 3. Explain Energy sources 4. Explain Technical failures 5. Explain Human factors	1: 1
C	**How to Measure and Evaluate Risk** **Sub-Topics/SLOs:** 1. Describe Risk indicators 2. Describe Risk to people 3. Describe Risk matrices 4. Describe Risk acceptance criteria	2: 2
D	**Risk Management** **Sub-Topics/SLOs:** 1. Explain Risk management 2. Explain Bow – Tie analysis 3. Explain Risk Analysis 4. Explain Risk evaluation 5. Explain Risk control and Risk reduction 6. Explain Competence requirements 7. Explain Quality requirements	2: 2
E	**Accident Models** **Sub-Topics/SLOs:** 1. Describe Accident causation 2. Describe Accident models 3. Describe Energy and Barrier models 4. Describe Sequential accident models 5. Describe Epidemiological accident models 6. Describe Event causation and sequencing models 7. Describe Systematic accident models	3: 3
F	**Data for Risk Analysis** **Sub-Topics/SLOs:** 1. Define Types of data 2. Define Accident data 3. Define Component reliability 4. Define Human error data 5. Define Software failure data 6. Define Expert judgement 7. Define Data dossier	3: 3
	Total	**12: 12**

Course: Practical Economics for Marine Engineers

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom discussions and self-learning.

Assessment Methods: Refer to IMU Guidelines prior to the start of the Session for actual allocations.

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Statistics and Data Analysis using R and Python.

Recommended Text:

1. Harry Benford (1991) A Naval Architect's Guide to Practical Economics, Dept. of NAME - UMICH, United State Freely downloadable from https://deepblue.lib.umich.edu/handle/2027.42/93802.

Table of Topics

Section	Topics	Hours (L: SL)
A	**Time value of Money** **Sub-Topics/SLOs:** Explain the following: 1. Engineer's role in society 2. Definition of Engineering Economics 3. Engineering economics as a tool 4. Systems and System analysis 5. Real life complications 6. The human logic and the Financial logic 7. Interest 8. Cash Flow diagrams 9. Six basic relationships 10. Non-uniform cash flows 11. Gradient series 12. Stepped patterns 13. Periodic discrepancies 14. Inflation 15. Non-annual compounding	2: 2
B	**Taxes and Depreciation** **Sub-Topics/SLOs:** Explain the following: 1. Tax shields 2. Depreciation and straight-line depreciation 3. Cash flows before and after tax 4. Fast write off 5. Variable tax rates 6. Dual tax rates 7. Accelerated depreciation 8. Other issues	1.5: 1.5
C	**Leverage** **Sub-Topics/SLOs:** Explain the following: 1. Cash flows before and after tax 2. Differing time periods 3. Accelerated depreciation 4. Residual debt 5. Balloon mortgages	1: 1
D	**Measure of Merit** **Sub-Topics/SLOs:** Explain the following: 1. Measure of merit 2. Net Present Value (NPV) 3. Yield 4. Average Annual Cost (AAC) 5. Required Freight Rate (RFR) 6. Net Present Value Index (NPVI) 7. Average Annual Benefit (AAB) 8. Average Annual Benefit Index (AABI) 9. Capital Recovery Factor After Tax 10. Pay-Back Period (PBP) 11. Life Cycle Cost (LCC) 12. Capital Recovery Factor before tax 13. Economic cost of transport	2: 2
E	**Constructing analysis** **Sub-Topics/SLOs:** Explain the following:	2: 2

	1. Goals 2. Defining system 3. Data collection 4. Selecting the structure 5. Exploiting Lighter Weight Components 6. Charter Parties 7. Time Charters 8. Charter versus buy 9. Analysing differences 10. Planning horizons 11. Residual values 12. Uncertainty	
F	**Building Costs** **Sub-Topics/SLOs:** Explain the following: 1. Introduction 2. Functional capability as a costing basis 3. Technical Characteristics as a costing basis 4. Owner's costs 5. Shipyard bidding 6. Duplicate Cost Savings 7. Estimating Overhead 8. Contingencies 9. Extrinsic factors 10. Unconventional methods 11. Black books	2: 2
G	**Operating Costs** **Sub-Topics/SLOs:** Explain the following: 1. Schedule analysis 2. Application of the Voyage Analysis 3. Voyage Costs 4. Daily Costs 5. Cost Information	1.5: 1.5
	Total	**12: 12**

Course: Risk Assessment Methods and Applications

Instructional hours:

Lecture	: 12 hours
Self-Learning & Preparation	: 12 hours
Total hours	: 24 hours
Credits	: 1

Teaching Methods

The course shall be conducted in a combination of classroom Discussions and self-learning.

Assessment Methods: **Refer to IMU Guidelines prior to the start of the Session for actual allocations.**

Class Assessments (Assignments)	: 40%
Final Presentation and Report	: 60%

Additional Information on Subject:

1. Pre-requisites: Statistics and Data Analysis using R and Python.

Recommended Text:

1. Haugen, S., Rausand, M. (2020). Risk Assessment: Theory, Methods, and Applications. United Kingdom: Wiley.

Table of Topics

Section	Topics	Hours (L: SL)
A	**Risk Assessment Process** **Sub-Topics/SLOs:** 1. Define Plan and prepare 2. Define Reporting **3.** Define Updating	1: 1
B	**Hazard Identification** **Sub-Topics/SLOs:** 1. Define Hazard log 2. Define Checklist Methods 3. Define Preliminary hazard analysis 4. Define Change analysis 5. Define FMECA 6. Define HAZOP 7. Define SWIFT 8. Define Master logic diagram	1.5: 1.5
C	**Causal and Frequency analysis** **Sub-Topics/SLOs:** 1. Explain Cause and effect diagram analysis 2. Explain Fault tree analysis 3. Explain Bayesian Networks 4. Explain Markov methods 5. Explain Petri Nets	2.5: 2.5
D	**Development of accident scenarios** **Sub-Topics/SLOs:** 1. Describe Event Tree Analysis 2. Describe Event Sequence Diagrams 3. Describe Cause – Consequence Analysis 4. Describe Escalation Problems 5. Describe Consequence Models	2: 2
E	**Barriers and Barrier Analysis** **Sub-Topics/SLOs:** 1. Explain Barriers and Barrier Classification 2. Explain Barrier Properties 3. Explain Energy and Barrier models 4. Explain Safety Instrumented Systems 5. Explain Hazard Barrier Matrices 6. Explain Safety Barrier Diagrams 7. Explain Bow-tie Diagrams 8. Explain Energy Flow / Barrier Analysis 9. Explain Layer of Protection Analysis 10. Explain Barrier and Operational Risk Analysis	2.5: 2.5
F	**Human Reliability Analysis** **Sub-Topics/SLOs:** 1. State Task Analysis 2. State Human Error Identifications 3. State HRA Methods	1: 1
G	**Job Safety Analysis** **Sub-Topics/SLOs:** 1. Explain Objectives and Applications 2. Explain Analysis Procedure 3. Explain Resources and Skills Required 4. Explain Advantages and Limitations 5. Explain Applications to Maritime Transport	1.5: 1.5
	Total	**12: 12**

This Syllabus is collated from the combined contribution of many individuals.

Though much efforts have gone into getting this as much correct as possible, there are bound to be errors.

Authors' Names, Publishers' information etc., have been verified as much as possible.

Corrections, inadvertent errors, oversights and scope for improvements may be noted and advised by any and all the users of this work.

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