CURRICULUM & SYLLABUS

FOR

M. TECH
IN
MARINE TECHNOLOGY

INDIAN MARITIME UNIVERSITY

(A Central University, Govt. of India)

2022

FIRST SEMESTER CURRICULUM

Code	Theory	Contacts periods Per week			Total	Credit
		L	T	P		
MMT/T/101	Elementary Course Marine Engineering	3	1	0	4	4
MMT/T/102	Propulsion System, Safety and Environment	3	1	0	4	4
MMT/T/103	Numerical Heat transfer and thermofluid system	3	1	0	4	4
MMT/T/104	Research and Publication Ethics	3	1	0	4	4
MMT/T/105	Ship Structural Design	3	1	0	4	4
MMT/T/106	Optimization Techniques and Applications	1	1	0	2	2
	Practical / Laboratory - I					
MMT/P/101	Design, CNC and 3D Printing Lab	0	0	3	3	3
MMT/P/102	Engineering simulation with Python	0	0	3	3	3
MMT/P/103	CFD Lab	0	0	3	3	3
	Total				31	31

SECOND SEMESTER CURRICULUM

Code	Theory	Contacts periods Per week			Total	Credit
		L	T	P		
MMT/T/201	Dynamics of Marine Vehicles	3	1	0	4	4
MMT/T/202	Internal Combustion Engine	3	1	0	4	4
MMT/T/203	Sustainable Maritime Technology	3	1	0	4	4
MMT/TE/XXX	Elective	3	1	0	4	4
MMT/T/205	Project Management for Marine Engineers	3	1	0	4	4
MMT/T/206	High Voltage and Power Electronic Systems	3	1	0	4	4
	Elective (Any One)					
MMT/TE/201	Cryogenic and LNG Vessels	3	1	0	4	4
MMT/TE/202	Finite Element Method	3	1	0	4	4
	Practical / Laboratory - II					
MMT/P/201	Hydrodynamics Lab	0	0	3	3	3
MMT/P/202	High Voltage Lab	0	0	2	2	2
MMT/P/203	Power Electronic Lab	0	0	2	2	2
Total					35	35

THIRD SEMESTER CURRICULUM

Code	Theory	Contacts periods Per week			Total	Credit
		L	T	P		
MMT/P/301	Project/Internship under Mentor based on Sea Experience or Maritime Industry Experience					25
MMT/P/302	MOOCs or other approved course in Communication skills					3
	Total					28

FOURTH SEMESTER CURRICULUM

Code	Theory	Contacts periods Per week			Total	Credit
		L	T	P		
MMT/P/401	Viva - Voce on Dissertation					5
MMT/P/402	Final Project / Dissertation Under Supervisor					20
	Total					25

Elementary Course in Marine Technology (MMT/T/101)
For 1st Semester

Credit-4 **Full Marks: 100**
Contacts periods per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1.	**Application of marine technology in vessels and offshore activities:** Introduction to types of marine vessels and their functions: Types of LNG Carriers, Types of Gas Carriers, Types of Chemical Tankers, Types of Oil Tankers, Types of Bulk Carriers, Car carriers, Container ships, RO-RO ships, Passenger ships, Reefer ships, Drilling ships, Cable laying and pipeline laying ships, Heavy-Lift ships, Dredgers, Deep Sea mining equipment, Research vessels, Ice breakers, Ice-class ships, Drill ships, Dynamic Positioning Ships, OSVs, Tugs, Fishing vessels,Advanced Marine Vehicles, Types of Offshore Platforms Introduction to Maritime operations: At port cargo loading and discharging, sea voyage, Cargo operations, STS, Bunkering, with various types of cargoes, SPM / SBM operations, various types of port facilities, offshore supplies, towing, surveying, pipeline / cable laying, dredging, ice breaking, drill ships, heavy lift and crane operations and dynamic positioning. Ships propulsion machinery, power generation, cargo and auxiliary machineries, utilities and their functions. Marine Technical Drawings and Interpretation – Systems understanding: Layout, block diagrams, process & instrument drawings – electrical, pneumatic and hydraulic Indian Inland Waterways, Ports and Maritime resources The Maritime legal and administrative establishment in India The IMO, Classification Societies, Industry bodies and other local bodies that frame rules and standards regarding ships and other maritime assets.	10
2.	**Hydrostatics and Stability of Merchant Vessels:** Basic Ship Hydrostatics: Archimedes' Principle, The conditions of equilibrium of a floating body – forces and moments, Definition of stability, Initial Stability, Metacentric Height, Centre of Mass, Small Angles of inclination, The curves of centres of buoyancy, Metacentres for various axes of inclination,Lines drawings and hydrostatics Geometry of ships body – The lines drawings, elements of ship's form – Sheer, Camber, Stern, Midship section, The point of keel, Base plane, Stem; Dimensions of the ship Hydrostatic curves – Areas of waterlines, displacement curves, curve of centres of gravity of waterlines, Bonjean curves, cures of section areas, curves of fullness coefficients, their properties; KB, BM, BML, Position	20

	of B with centre and baseline, MCT1cm, calculation of hydrostatic data. Construction of the lines drawing Stability of ships: Stability theory, stability at finite angles: Calculation of GZ as a function displacement and angle of heel, The Centre of Buoyancy (B) – curve, water plane and the metacentric curve, the curve of arms of statical stability; Dynamic stability: Relations between the arm of statical stability, the dynamic height and the MZ, Approx formula for estimating initial stability, Scribanti's formula for finding GZ for angles of heel up to 10 deg. Applications, stability at relatively great heeling moments, wind pressure, tugs, influence of free surface of liquids carried; Direct calculation of dynamical stability; Prohaska's first and second approximate methods, plotting curve of statical stability; Inclining experiment; Determination of stability curve by experiment; Grounded ships, suspended loads; Longitudinal stability: Shifting of weights onboard, Trim diagrams; Flooding &Damage stability; Grounding, docking and launching; loading conditions and stability criteria; Tank capacity calculations. Use of software for drafting and technical calculations within naval architecture Class drawings, Trim and Stability booklet	
3	**Design of marine systems:** The ship design process – rules-based design, case examples of classification rules.Design based on Data of systematic ship Hull Form Series, General Arrangement Plan, Capacity Plan Risk Based Design / Goal Based Design: Introduction to Risk based approaches in the maritime industry – the need for risk-based design; Origin – probabilistic damage stability, Offshore industry, structural reliability analysis, alternative design and arrangement for fire safety, formal safety assessment, recent regulatory developments; High level introduction to risk based design and approval – linking risk-based design and approval; i) Risk based design and approval – regulatory framework, design framework and tools, qualified engineers; Risk based ship design – methodological approach to risk-based ship design; ii) Risk based design – safety assessment procedure, definition of safety goals, identification of hazards, identification of critical design scenarios, design decision making; Contemporary developments – scope of work, total risk iii) Risk based design Methods and Tools: Introduction; System failure – Introduction, overview of methodology, Modeling phase, Synthesis Phase, Analysis Phase, Optimization Phase, Tool support Industrial Standards and Regulatory frame work: The ISO and its affiliates; Overview of Major national standards developing organizations – ANSI, BSI, DIN, JIS, BIS, ASME, NFPA, CFR, AGA, CGA, API, ASTM, ASM, ISA, IEEE, ASHRAE, SAE, NEMA, NACE, SIGTTO, OCIMF, IGF, IGC, IBC, SOLAS, MARPOL etc.; Economic Benefits of Standardization;	14

4	**New trends in design & manufacturing - Additive Manufacturing:** Additive manufacturing process classification, applications, trends, opportunities and challenges; Basics of Metal additive manufacturing – main processes, process parameters, materials; Material design and considerations for metal additive manufacturing; Standards in additive manufacturing; Cost implications; Non-destructive evaluation for additive manufacturing.	12

Reference Books:

1. Gerritsma, J., Bakker, A. R., Scheltema de Heere, R. F., Gerritsma, J., Bakker, A. R., Scheltema de Heere, R. F. (1969). Buoyancy and Stability of Ships. Netherlands: H. Stam.
2. Risk Based Ship Design – Methods, Tools and Applications by Group of Authors, Edited by ApostolosPapanikolau, ISBN: 978-3-540-89041-6, Springer-Verlag Berlin Heidelberg 2009
3. Papanikolaou, A., Papanikolaou, A. (2014). Ship Design: Methodologies of Preliminary Design. Germany: Springer Netherlands.
4. Rausand, M., Haugen, S. (2020). Risk Assessment: Theory, Methods, and Applications. United States: Wiley.
5. Harrington (Editor) Marine Engineering.(1992).United States:Society of Naval Architects and Marine Engineers.
6. Ship production - 2 nd Edition by Richard Lee Storch, Colin P Hammon, Howard M Bunch & Richard C Moore – Cornell Maritime Press
7. Kletz, T. A., Kletz, T. A. (2018). Hazop&Hazan: Identifying and Assessing Process Industry Hazards, Fouth Edition. United Kingdom: CRC Press.
8. Precision Additive Metal Manufacturing. (2020). United Kingdom: CRC Press.
9. Obehi Ibhadode, O., Sarker, D., Toyserkani, E., Russo, P., Taherkhani, K., Liravi, F. (2021). Metal Additive Manufacturing. United Kingdom: Wiley.

Propulsion System, Safety and Environment (MMT/T/102)
For 1st Semester

Credit-4 **Full Marks: 100**
Contacts periods Per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1	**Overview of ship's machinery - propulsion, power generation, auxiliaries, cargo equipment and steering:** Aspects affecting choice and installation of machinery and equipment, Layout of various kinds of ships propulsion machinery – Slow speed two-stroke diesel directly coupled FPP, Medium Speed Diesels with CPP, Steam Turbine, Gas Turbine, Combined Power Plants, Electric Motor and Propulsion, Azimuth Thrusters, Specific systems and vessel types – Dynamic positioning, integrated control systems, propulsion redundancy, ballast control systems – floating production, storage and offloading units, semi submersibles; ballast control – basic control features; FPSOs, Semisubmersibles and MODUs, self-elevating rigs, Tension leg platforms, offshore renewable energy substation platforms, Layout of various kinds of electric power generation & distribution – Diesel – Electric; HV / MV / LV Distribution, power requirement during ship operations, redundancy, emergency powering, emergency loads, IMO and other international frameworks aimed at decarbonization at design and operation, emission control and pollution prevention relevant to powering. EEDI, EEXI, SEEMP, decarbonization goals, alternate fuels and renewable options, Ships auxiliary machinery, its functionsCargo equipment for ships – bulk carriers, reefer ships, chemical tankers, oil tankers and gas carriers Ships steering, thrusters, stabilizers and mooring equipment, Fire and safety systems onboard ships, Pollution prevention equipment – Annex VI	18
2	**Ships Electrical Equipment:** Aspects affecting electrical design for ships and offshore facilities, safety, environment, Insulation and Temperature ratings: Insulating materials, hot spot temperatures, temperature rise and measurement, ambient air temperatures and measurement, basis of machine ratings, Thermal overloads and motor thermal protection, Ex-classed increased safety certified motors, AC Synchronous generators: Operation principles – speed, generating voltage, sub transient reactance, transient reactance, power factor; The brushless alternator, generator capability diagram, parallel operation of generators, compounding, load-voltage characteristics and regulation; emergency generators, Prime mover selection: Gas turbines, diesel / petrol engines, Steam turbine; Load profiles – projected demand, variability of demand in a day, low load issues, main generation, number of generators, size and location, Governors, Alternators and Excitation systems, Neutral earthing, starting requirements and key services generation, Installation: Switch gear and motor control centres, distribution transformers, motors and generators,	12

	lighting and small power, secure power supply systems – batteries and battery chargers and invertors; communications; cable support systems; Decommissioning and removal / abandonment phases; Electrical system earthing – electrical earths, instrument / communications earths, intrinsically safe earth, equipotential bonding, ships, lightning protection	
3	**Generation and Distribution switchgear and transformers:** Switch gear – general requirements, the mechanism of short circuit current interruption, breaking current, making current; Types of interrupters – HRC Cartridge fuses, ACBs, bulk-oil circuit breakers, VCBs, SF6 circuit breakers; Switchboard construction – MSB 6.6 ~ 13.8 kV, large drive switchboards 3.3 ~ 6.6 kV, utility services and production switchboards, emergency boards, cargo switch boards, living quarters supplies, machinery spaces distribution, transformers, DC Generators: Compound wound generators, adjustment of compounding, parallel operation, DC Switchgear: Switching DC, specification. Electrical Cables: Selection, installation, transits, glands and connectors – transits, glands, connectors; Bus ducting, cables for intrinsically safe circuits, Motors: Voltage levels, Starting, Speed, Pole configuration, Cooling and ingress protection, particular applications, Motor Control: LV Switchgear and motor control centres for offshore use and intelligent motor control centres and its software; Medium-Voltage Starters – DoL and Electronic Starters; Motor control centre software, Power Electronics: Environmental conditions, Uninterruptible and secure power supplies, DC Supplies, AC Supplies, Batteries – Types, charging, ventilation and housing of batteries, sealed cells; Solid State Controllers, DC variable speed drives, variable speed / frequency drive; Process drives and starting requirements: Voltage levels, starting, speed, pole configuration, cooling and ingress protection, special applications, reciprocating pumps and compressors, gas compressors, direct current drilling motors, power swivels, seawater lift pumps, diesel-electric fire pumps, fire pump diesel engine starting requirements, Cathodic protection systems: Subsea power supplies, diver's life support equipment, subsea completion modules, diving chambers for saturation diving, inductive couplers, umbilical and power cables in subsea operations, cathodic protection – types; galvanic anode systems, cathodic protection calculations, Lighting –Lighting calculations, calculation procedure, illuminance at a point, flood lighting, accommodation lighting – normal, accommodation emergency and process area lighting, navigation lighting, Ex-areas lighting, walkways, catwalk and stairways lighting, emergency escape lighting, Transformers: construction, regulation; transformer faults, phase-to-phase faults, core and interturn faults, magnetizing inrush, overcurrent protection, restricted earth fault protection, differential protection, oil and gas-operated devices, parallel transformers and inter-tripping, Motor faults and protection: Motor winding electrical faults - motor mechanical faults, abnormalities in the driven machinery, abnormalities in the supply system, overload protection, stalling protection, phase unbalance protection; Conventional relay types,	18

	static and microprocessor-based relay types, additional protection for synchronous motors, detection of motor faults on large motors with Rogowski coils Busbar protection – Busbar faults, overcurrent and directional overcurrent protection, unrestricted earth fault protection, frame earth protection, differential protection, Feeder protection, conductor sizing, load flow and fault calculation: Fuses, Miniature circuit breakers, overcurrent and earth fault protection, sizing of conductors – load flow, busbar sizing, cable sizing; fault calculations – Main generator fault currents, switchboard fault currents, Calculation of load flow, prospective fault currents and transient disturbances – fault calculation, standard methods of calculation, IEC 61363, IEC 60909 / IEEE141/ANSI37, Digital methods of fault calculation, digital simulation of system disturbances, transient simulations and harmonic analysis, short circuit analysis software, unbalanced short circuit analysis for multiple and single-phase systems, Protection and discrimination: Relay setting of typical MV platform scheme, overcurrent protection, data requirements – system, base values, operating conditions; Over current relay setting – Relay F, Relay T and Relay G; coordination, earth fault relay setting; CT Saturation – Relay Z and Relay F, Power Management system: Generator controls, start and stop buttons, AVR and Governor Raise / Lower switches, synchronizing equipment, instrumentation – metering, synchronizing indicators, alarm annunciator, load sharing systems, power management systems and its design, Harmonics – Overheating of motors, overheating of transformers and increased associated losses, resonance effects, UPS, switch mode power supplies, percentage distortion definition, current or voltage total harmonic distortion	
4	**Environmental Protection:** Weather and sea protection: Different materials – stainless steels, Grey cast iron, hot dipped galvanized steel, polycarbonate, manganese bronze and gunmetal, welded and cast structural steel, glass fiber reinforced plastic, enclosure ingress protection; structural considerations – weight control, shock and vibration, location of engine intakes and exhausts, mechanical protection, noise control, prime movers, motors; Hazardous Area installation – Hazardous area applications, temperature consideration – ignition temperature, flashpoint temperature, Explosion proof Ex 'D' equipment; Explosion proof equipment groups, increased safety Ex 'E' equipment, terminals, enclosure, Ex 'NA' Non-sparking, Non-sparking: Ex 'N', Pressurised: Ex 'p', Intrinsic Safety – Ex'I' A and Ex 'I' B, Level of protection 'IA', 'IB', 'IC'; simple apparatus and components, loop calculations for galvanic barriers, selection of equipment, avoidance of ignition by non-electrical equipment, avoidance of ignition by radio and radar transmissions, hazard source schedules, defining boundaries, ventilation and logic and area classification, selection of motors for hazardous area, Mixing – hazardous area certified equipment – various global and national standards, equipment for use in polar regions, intrinsically safe barriers – galvanic	8

	and optical isolation, Statutory requirements and safety practice: Various national and international regulations and duties of electrical competent person, duty holder, Independent competent person, Guidance on developing written schemes of examination and test, developing the scheme activity list, combined operations, multiples ICPS/interface with other ICPs, Reporting activities, retention of verification records; Preparation and use of performance standards; Safety integrity level assessment for electrical engineers – safety function, safety instrumented function, safety instrumented system, safety integrity level assessment process, determining safety integrity levels – process, determining safety integrity levels – instrumentation, safeguards	

Reference Books:

1. Macangus-Gerrard, G. (2017). Offshore Electrical Engineering Manual. Netherlands: Elsevier Science.
2. Islam, M. N., Engineers, I. O. E. A. E. (2004). Handbook to IEEE Standard 45: A Guide to Electrical Installations on Shipboard. United States: Standards Information Network, IEEE Press.
3. Islam, M. M. (2018). Shipboard Power Systems Design and Verification Fundamentals. Germany: Wiley.
4. Harrington (Editor) Marine Engineering. (1992). UnitedStates: Society of Naval Architects and Marine Engineers.
5. Cowley, J. (2002). The Running and Maintenance of Marine Machinery. United Kingdom: IMarEST.
6. Piper, J. F. (1943). Marine Electrical Installation. United States: Cornell maritime Press.
7. Hall, D. T. (1999). Practical Marine Electrical Knowledge. United Kingdom: Witherby.

Numerical Heat transfer and thermofluid system (MMT/T/103)

For 1st Semester

Credit-3 **Full Marks: 100**

Contacts periods Per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1.	**Review of Introductory Topics**: Governing equations of marine fluid flow and heat transfer, Mass conservation in three dimensions, Rates of change following a fluid particle and for a fluid element, Momentum equation in three dimensions, Energy equation in three dimensions, Equations of state, Navier–Stokes equations for a Newtonian fluid, Conservative form of the governing equations of fluid flow, Differential and integral forms of the general transport equations, Classification of physical behaviors, The role of characteristics in hyperbolic equations, Classification method for simple PDEs	10
2.	**Discretisation methods:**Taylor series formulation, variational formulation, method of weighted residuals, control volume formulation, four basic rules	8
3	**The finite volume method for conduction-diffusion problems:** Basic equations for steady 1-D conduction, grid spacing, interface conductivity,nonlinearity, source term linearization, boundary conditions, solution of linear algebraic equations, unsteady one dimensional conduction, two and three dimensional situations, over relaxation and under relaxation, some geometric considerations	8
4	**The finite volume method for convection-diffusion problems:** Basic equations for steady 1-D convection and diffusion, upwind scheme, exact solution, exponential scheme, hybrid scheme, power law scheme, generalized formulation, consequences of various schemes, discretisation equation for two dimensions, discretisation equation for three dimensions	8
5	**The finite volume method for unsteady flows:** One-dimensional unsteady heat conduction, Explicit scheme, Crank–Nicolson scheme, The fully implicit scheme, Illustrative examples,Implicit method for two- and three-dimensional problems, Discretisation of transient convection–diffusion equation, Worked example of transient convection–diffusion using QUICK Differencing,	8
6	**Solution algorithms for pressure---velocity coupling in steady flows:** Some related difficulties,representation of pressure gradient term,	6

	representation of continuity equation, a remedy by staggered grid,corresponding momentum equations, pressure and velocity corrections,pressure correction equation, SIMPLE algorithm, IMPLER algorithm.	
7	**Solution of discretised equations:** The Tri diagonal matrix Algorithm (TDMA),Application of the TDMA to two-dimensional problems, Application of the TDMA to three-dimensional problems, Examples, Gauss–Seidel iteration method,Relaxation methods, Multigrid techniques, An outline of a multigrid procedure, An illustrative example, Grid generation for the multigrid methodIMPLER algorithm.	8

Reference Books:

1. An Introduction to Computational Fluid Dynamics: The Finite Volume Method by H. K. Versteeg and W. Malalasekera
2. Numerical Heat transfer and Fluid Flow by Suhas V. Patankar
3. Computational Fluid Dynamics: The Basics with Applications by John D. Anderson, Jr.
4. Computational Fluid Mechanics and Heat Transfer by Dale A. Anderson, John C. Tannehill, Richard H. Pletcher
5. Computational Fluid Dynamics: Principles and Applications by J. Blazek
6. Computational Fluid Dynamics for Engineers by TuncerCebeci, Jian P. Shao, FassiKafyeke, Eric Laurendea

Research and Publication Ethics (MMT/T/104)

For 1st Semester

Credit - 4 **Full Marks: 100**

Contacts periods per week: 3-1-0 (L-T-P) **Course Type: Department Sub-Core**

Sl No.	Topic	No. of lecture periods
1.	**Philosophy and Ethics:** Introduction to Philosophy : definition, nature and Scope, Concept, Branches, Ethics: definition, moral philosophy, nature of moral judgments and reaction	10
2.	**Scientific Conduct:** Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), Redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data.	12
3	**Publication Ethics:** Publication ethics: definition, introduction and importance, Best practices /Standards setting initiatives and guidelines: COPE. WAME, etc., Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types, Violation of publication ethics, authorship and contributor ship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals	12
4	**Practice open Access Publishing:** Group Discussions**:** Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad**.** Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.	10
5	**Research Report.** Report writing , Intellectual property reporting, Structure of Thesis, References writing, Testing plagiarism, IPR Filing, Ethical issues in research	12

Reference Books:

1. Oladokun Sulaiman Olanrewaju , Abdul Hamid Saharuddin , AbSaman Ab Kader , Wan MohdNorsani, 'Marine Technology and Sustainable Development: Green Innovations (Advances in Environmental Engineering and Green Technologies) '2012.
2. PetarGeorgiev, Carlos GuedesSoares., Sustainable Development and Innovations in Marine Technologies, Taylor and Frances.

Ship Structural Design (MMT/T/105)
For 1st Semester

Credit-3 **Full Marks: 100**
Contacts periods Per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1.	**Basic Relationship:** Load, shear force and Bending Moment, application of Beam Theory, Characteristic of Shear force and Bending Moment Curves, Estimation of Weight Distribution, Calculation of Still water Bending Moment, Correction for Changes in Weight,	12
2.	**Approximate Design Value of Wave Loads:**Horizontal Bending Moment, Torsional Moment, Vertical Shear Force	8
3	**Hull Girder Bending Stress:** Constraint on Hull Grinder in Rule-Based Design, Section Modulus Requirement to prevent Hull Girder Fatigue Failure, Allowable Area For Section Modulus, Combines Vertical and horizontal Bending The Composite Beam Technique, Changes to Section Modulus. Derivative of Hull Grider Stress	8
4	**Calculation of Hull Girder Shear Stress:** Shear stress in open Section, Shear stress in Multicell Section, Example of Shear Flow Calculation for a Multicell Section, Shear Flow in Section Containing Different Elastic Moduli	8
5	**Matrix Stiffness analysis:** FrameAnalysis, Nodal Displacement, Stiffness Matrix of a Structure, Stiffness Matrix of a Spring (or Bar) Element, Assembling the Structure Stiffness Matrix, Solution Procedure and Numerical Example, Rigid-Joint Frame analysis, Flexure-Only Beam Element, General Method for Deriving an Element Stiffness Matrix, Ordinary Beam Element, Distribution of Loads, Example. General Beam Element, Effect of Shear Deflection, Torsional and Axial Stiffness	12
6	**Plate Bending:** Small Deflection Theory, Long Plates (Cylindrical Bending), Derivation of the Plate Bending Equation, Boundary Conditions, Solution of Special Cases, Combine Bending and Membrane Stress-Elastic Range, Large Deflection Plate Theory, Membrane Tension (Edges Restrained Against Pull-in), Application of Elasto-plastic Theory to Laterally Loaded Plates.	8

Reference Books:

1. Owen Hughes. Ship Structure Design, A Rationally –Based, Computer-Aided, Optimization Approach, John Wiley & Sons, New York, 1983. ISBN 0-471-03241-7
2. S. Timoshenko and S. Woinowsky, Theory of Plates and Shell, 2nd ed., McGraw-Hill, 1959
3. L.G. Jaeger, Elementary Theory of Elastic Plastic, Pergamon, 1964.
4. Finite Element Analysis Theory and Application with ANSYS (4th edition), by SaeedMoaveni, Pearson, 2015.
5. An introduction to the Finite Element Method (3rd Edition), by J.N. Reddy, Tata McGraw-Hill, 2005.

Optimization Techniques & applications (MMT/T/106)

For 1st Semester

Credit-2 **Full Marks: 100**

Contacts periods per week: 2-0-0 (L-T-P) **Course Type: Department Sub-Core**

Sl. No.	Topics	No. of lecture periods
1	**Roots of High-Degree Equations:** Introduction of Simple Iteration Method, Bisection Method, interpretation-convergence analysis, problems, Regula Falsi Method, Newton's Method-interpretation, convergence analysis, problems, Secant Method-convergence analysis, problems.	4
2	**Interpolation & Curve Fitting:** Polynomial Interpolation, Interpolating polynomial: Lagrange Form, Interpolating Polynomial: Newton Form, Calculating Coefficients using Finite Difference, Linear Regression, Introduction to Curve Fitting Function, Method of Least Squares, linear least square, examples.	8
3	**Numerical Integration**: Trapezoidal Rule, Simpson's 1/3 Rule, Simpson's 3/8Rule, Application of Double in finding the area of a region, the volume under a surface, Application of Triple integrals in finding volume and mass when the volume of the region has variable density.	6
4	**System of Linear equations :**Gaussian Elimination Method, row reduction algorithm for solving linear equations systems, Tridiagonal and Banded System, Tridiagonal system, strictly diagonal dominance, summary, problems, Matrix Factorization, solving linear system using LU factorization, numerical example, Eigen Values and Eigen Vectors, Properties of eigen values, eigen vectors, numerical example	6
5	**Ordinary Differential Equation & Partial Differential Equation:** Taylor Series Method, Initial value problem, solving differential equation and integration, vector field, Taylor series method, Runge Kutta Method of order 4, Method of first order system', Taylor series method, vector notation, system of ordinary differential equations. Higher Order Equations and Systems, system of higher order differential equations, summary, problems, Reduction of a partial differential equation (PDE) to a system of ordinary differential equation(ODEs).	6

Reference Books:

1. Numerical Mathematics and Computing by Ward Cheney and David Kincaid
2. Numerical Methods for Engineers by Steven C Chapra and Raymond P Canale

Dynamics of Marine Vehicles (MMT/T/201)
For 2nd Semester

Credit-4 **Full Marks: 100**
Contacts periods per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl. No.	Topics	No. of lecture periods
1	**Basic equations that govern flow motion:** Basic concepts and principles, motions of fluid elements: Rotation and irrotational flow, continuity principle, inertia forces, applied forces, momentum equation and equations of Navier Stokes, Turbulence: mean and fluctuating components of motion, turbulence mean and fluctuating components of motion, turbulence effects	2
2	**Simple Harmonic Motion:** Equations of SHM, Phase difference, Vector representation, addition of SHMs, graphical solutions,	2
3	**Sinusoidal Water Waves:** Description, velocity, length and period of waves, addition of wave trains, standing wave, depth effects, pressure in a wave, energy in a wave, group velocity, ship in waves, wave slope	2
4	**Uncoupled heaving, pitching and rolling motions:** Definitions, heaving, free undamped heaving motion, free damped heaving motion, forced heaving motion, inertial force, damping force, determination of damping, restoring force, exciting force, ship model correlation, accelerated rotational motion, radius of gyration for different angular motion – rolling, pitching and yawing, effects of removal of weight and addition of weight, Pitching, determination of coefficients of pitching motion, damping coefficient for pitching, restoring moment coefficient, pitching motion in calm water, pitching periods, exciting moment for pitching motion, pitching in waves, Rolling, determination of coefficients for rolling motion, damping moment coefficient, restoring moment coefficient, rolling in calm water, exciting moment for rolling, rolling in regular seaway, ratio of response amplitude to wave amplitude, motions in shallow water	8
5	**Irregular seaway:** Classification of seas, definitions of sea conditions, irregularity of the seaway and the histogram, wave spectrum, prediction of an irregular seaway, standard wave spectrum – ITTC, most probable largest wave amplitude	4
6	**Motion in an irregular seaway:** Response in an irregular seaway, prediction in an irregular seaway, extreme value of motion amplitude, extreme values as a function of time, parametric rolling	4
7	**Dynamic effects:** Definitions, vertical motion, vertical velocity, vertical acceleration, phase difference between wave motion and bow motion, relative bow velocity in head seas and irregular seaway, deck wetness and slamming, deck wetness, slamming,	4

	interval between slam impacts, vertical and rolling effects, seasickness, stability in waves	
8	**Coupled heaving and pitching motions:** Basic approach, force equation, applied force equation, motion equation, strip theory	4
9	**Non-linear rolling motion, uncoupled:** linear damping, nonlinear restoring moment with constant coefficients, nonlinear damping: linear restoring moment, linear damping, linear restoring moment	4
10	**Powering in a seaway**: Added resistance in regular waves, experiments, added resistance in irregular seaway, propeller open water tests in waves, self-propulsion factors, thrust and torque in irregular waves, prediction of added power, Torque-RPM method, Thrust method, effect of rolling, power increase due to wind and waves, speed reduction	6
11	**Loads due to motion:** Forces of component weights, forces due to heaving, forces due to rolling, forces due to pitching	4
13	**Motion stabilization:** Roll stabilization – bilge keels, passive stabilizers, gyroscopic stabilizer, tank stabilizers, active roll stabilizers – roll tanks, fin stabilization, rudder stabilization, pitch stabilization, fixed fins, active anti-pitching fins, effectiveness of motion stabilizers	6
14	**Model tests, full scale trials and scale effects:** model preparation, load determination, centre of gravity, radius of gyration, bifilar suspension, facilities and instrumentation, resistance tests in a seaway – ITTC Standards for seakeeping experiments, full scale tests, measurement of sea waves, seakeeping prediction, trails, scale effect	6

Reference Books:

1. Bhattacharyya, R. (1978). Dynamics of Marine Vehicles. United Kingdom: Wiley.
2. Experimental Methods in Marine Hydrodynamics.Faculty of Engineering Science and Technology, NTNU, Trondheim Norwegian, University of Science and Technology - https://home.hvl.no/ansatte/gste/ftp/MarinLab_files/Litteratur/NTNU_Eksprimentelle_metoder_kompendium.pdf
3. Lewis, E. V. (1988). Principles of Naval Architecture: Motions in waves and controllability. United States: Society of Naval Architects and Marine Engineers.
4. J.M.J. Journée and W.W. Massie (2001), Offshore Hydromechanics, Delft University of Technology - https://ocw.tudelft.nl/wp-content/uploads/OffshoreHydromechanics_Journee_Massie.pdf

Internal Combustion Engine (MMT/T/202)
For 2nd Semester

Credit-3 **Full Marks: 100**
Contacts periods Per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1	Introduction: Design and operating principles of diesel engines, including four and two stroke, naturally aspirated and turbocharged. Diesel engine environmental pollutants and their mitigation, Performance analysis of IC Engine, Measurement of Indicated Power and Brake Power, Performance Parameter, Morse Test, Heat Balance Sheet	10
2	Application of the first law of thermodynamics to a combustion system, Enthalpy of formation, Some important relationships and properties of gaseous mixtures, Stoichiometry, Equivalence ratio	8
3	Adiabatic flame temperature, Equilibrium and dissociation, Mechanisms of combustion and chemical kinetics, Overall reactions and intermediate reactions, Reaction rate, Detailed mechanisms, Reduced mechanisms	8
4	Governing equations for combusting flows, The simple chemical reacting system (SCRS), Modelling of a laminar diffusion flame – an example, CFD calculation of turbulent non-premixed combustion SCRS model for turbulent combustion, Probability density function approach, Beta pdf	8
5	The chemical equilibrium model, Eddy break-up model of combustion Eddy dissipation concept, Laminar flamelet model Generation of laminar flamelet libraries, Statistics of the non-equilibrium parameter	6
6	Pollutant formation in combustion, Modelling of thermal NO formation in combustion, Flamelet-based NO modelling An example to illustrate laminar flamelet modelling and NO modelling of a turbulent flame, Other models for non-premixed combustion, Modelling of premixed combustion, Summary	8
7	Concept of duel fuel system and combustion process, Duel fuel IC engine, Engine operation and performance with respect to load, Analysis of performance, Additional safety requirements in duel fuel engine.	8

Reference Books:

1. Cohen, H. and Rogers, G.F.C. and Saravanamuttoo, H.I.H. Gas Turbine Theory. Pearson Education, 2001.ISBN 9788177589023.

2. R.W. Haywood. Analysis of Engineering Cycles: Power, Refrigerating and Gas Liquefaction Plant. Thermodynamics and Fluid Mechanics for Mechanical Engineers. Elsevier Science, 2012. ISBN 9780080984131.
3. Y. Shi, H.W. Ge, and R.D. Reitz.Computational Optimization of Internal Combustion Engines.SpringerLink :Bücher. Springer London, 2011.ISBN 9780857296191.
4. J.B. Heywood. Internal Combustion Engine Fundamentals.Automotive technology series.McGraw-Hill, 1988.ISBN 9780071004992.
5. An Introduction to Computational Fluid Dynamics: The Finite Volume Method by H. K. Versteeg and W. Malalasekera.

Sustainable Maritime Technology (MMT/T/203)
For 1st Semester

Credit-4 **Full Marks: 100**
Contacts periods per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl. No.	Topics	No. of lecture periods
1	**Sustainable Maritime Transport**: Concept, key trends in maritime transport, challenges to sustainable maritime transport	2
2	**Green ship technologies**: Design of energy efficient ships, hull optimization, vessel operational profile, area of operation, principal dimensions, constraints, hull optimization: improving elements of resistance, fore body optimization, aft body optimization, appendage resistance, maneuvering and course-keeping considerations	4
3	**Propulsion arrangement and propeller selection**: Single screw vessels, twin screw open shaft, Azimuthing propulsion and pod propulsion	2
4	**Ship machinery-propeller interaction:** Introduction, propulsion machinery, ship-propeller interaction – influence of condition of the ship, influence of number of propeller blades, influence of propeller diameter, propeller area ratio, pitch ratio P/D, service condition, wake and thrust deduction, ship-propeller interaction at extreme propeller loadings; Ship-Machinery-Propeller interaction – introduction, specification of speed, power, and rate of revolution, choice of n, P_B, Choice of propeller, Transformation of the power curve, ship trials, acceleration and retardation.	8
5	**Energy saving devices:** overview, evaluation and analysis of energy saving devices, wake equalizing duct, flow guide fins, pre-swirl devices, rudder position, rudder bulb, twisted rudder, Novel technologies: air lubrication, renewable energy	4
6	**Machinery technology:** Main and auxiliary ICE – propulsion and power generation arrangements, propulsion engines, power generation engines, engine design trends, fuel consumption characteristics, air pollution, ICE efficiency improvements – de-rating, slow steaming, electronic engine control and common rail, engine instrumentation, monitoring and control, energy efficiency optimization, exhaust emission abatement equipment, waste heat recovery, shaft generator, power management systems, HVAC, variable speed motors, hybrid systems and equipment	6
7	**Ballast water management**: requirements as per IMO convention, USCG requirement, Ballast water management systems, technology used – filtration, UV biocidal, electrolysis, mechanical means, short sea shipping and biofouling	4
8	**EEDI / EEXI / SEEMP regulations under MARPOL Annex VI:** Overview, regulations, EEDI: calculations, technical file, survey and verification, sea trials, verification, IEE Certificate; EEXI – overview,	8

	calculations, difference in EEDI and EEXI, EPL and calculations, EEXI Technical file and verification; SEEMP – 1, 2 and 3, Operational Energy Efficiency parameters EEOI, CII ratings, Operators measures to cope with regulation – new sailing speeds in the service, altering sailing frequency, fleet reconfiguration and vessel swaps	
9	**Sustainable vessel design:** production, operation and maintenance, maritime supply chain – operational and technological knowledge, key enabling technologies for sustainable shipping	4
10	**Sustainable ship recycling:** Introduction, business of shipbreaking, International and national laws, alternative to beaching, ship recycling contract, decontamination of hazardous materials, Indian ship recycling industry, promoting safety in the recycling, transparency and flag state responsibilities, polluter pays principle and creation of ship recycling fund, responsibility of IMO, the ship recycling convention, IMO guidelines, Basel convention, Hong Kong international convention for the safe and environmentally sound recycling of ships.	4
11	**Alternative fuels:** NG and LNG, LPG, Hydrogen, Methanol, Ammonia, Biofuels, Fuel Cells and IMO strategy on reduction of GHG emissions from ships	6
12	**CO2 reduction by shipping routing and scheduling:** Tramp ship and scheduling, operational characteristics of tramp shipping, basic linear model and non-linear model with speed optimization, modeling the emission reduction schemes	4

Reference Books:

5. Sustainable Shipping: A Cross-Disciplinary View. (2019). Germany: Springer International Publishing.
6. Hagen, J. E. (2021). Sustainable Power, Autonomous Ships, and Cleaner Energy for Future Shipping. United States: Artech House.
7. Harvald, S. A. (1983). Resistance and Propulsion of Ships. United Kingdom: Wiley.
8. Puthucherril, T. G. (2010). From Shipbreaking to Sustainable Ship Recycling: Evolution of a Legal Regime. Netherlands: MartinusNijhoff Publishers.
9. Regulating speed: a short-term measure to reduce maritime GHG emissions – CE Delft Publication - https://www.cleanshipping.org/download/Slow-steaming-CE-Delft-final.pdf

Cryogenic and LNG Vessels (MMT/E/201)
For 1st Semester

Credit-4 **Full Marks: 100**
Contacts periods Per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1	**Introduction to transport of liquefied gases:** Liquefied gases, Liquefied gas production, Types of gas carriers, The ship-shore interface, jetty and terminals	4
2	**Production of low temperatures:** Thermodynamic consideration, systems involving only pressure-volume effects– solids and liquids, gases, two-phase systems, Reversible heat engine cycles – the Carnot cycle, Stirling cycle, Ericsson cycle, Siemens/Claude cycle, Irreversible refrigeration cycles, vapor compression cycles, Joule-Thomson (Linde and Hampson) cycles, Nonreversible adiabatic (Cailletet type), thermos-electric cooling LNG reliquefaction cycle – Indirect cycle, Direct cycle, thermodynamics of 2 and 3 stage reliquefaction cycles, Cascade cycle, Mixed Refrigerant (MR), Nitrogen expander (Turbine based) process,Comparison of performance of actual refrigeration systems with ideal cycles, gas liquefaction, T-s charts for various gases, comparison of cycles for N2 liquefaction, liquefaction of natural gas, liquefaction of hydrogen, helium liquefaction	8
3	**Cryogenic Properties of solids and liquids:** Lattice specific heat, law of Dulong and Petit, Einstein theory, Debye theory, Specific heat of liquids, Thermal conductivity of gases, Lattice thermal, conductivity of a solid, Electrons in Solids, Thermal conductivity by electrons, Electrical conductivity of metals, Electrical conductivity of semiconductors, Wiedemann-Franz rule, Electrical and thermal conductivity of liquids, Liquid Hydrogen, Thermal expansion, Elastic constants, Mechanical properties, Absolute temperature and Hotness	8
4	**Physical behavior of Natural gas systems: Physical and Thermal properties, Phase behavior analyses:** Pure substances – Vapor pressure, The phase Rule, nomenclature and basic concepts, criterion for equilibrium, pure solid or pure liquid phase in equilibrium with vapor, the virial equation of state, solubility in liquid phase, Behavior of mixtures – binary, ternary and complex, Phase behavior of Natural gas systems, Vaporization by gas pressure, Molecular theory of gases and liquids – use of moles, equation of state – the gas law, compressibility of natural gases, Natural gases – Effects of Nitrogen, Carbon dioxide, and hydrogen sulfide, choice of methods of obtaining compressibility factors (Z), Handling of two-phase systems, Properties of natural gases and volatile hydrocarbon liquids – Diffusion coefficients, Density of Natural gas, Density of liquids, Dense phase, Surface Tension, Viscosity of gases and pure substances, Thermal conductivity of gases, Thermodynamic properties – Heat	16

	capacity, effect of pressure on enthalpy and specific heat, Entropy-Enthalpy diagrams, vaporization equilibrium constants, convergence pressures, calculation of Vapor-Liquid Equilibria, Heating value, limits of flammability, Sampling and Analyses – Sampling, Analyses of Gases and Liquid hydrocarbons, Chromatographic analyses, Molecular weights and Liquid Densities, Gas gravity, analyses for H2S and CO2, Liquid analyses	
5	**Instrumentation:** Temperature – Scales, Sensors – Gas thermometry, Resistance thermometry, Thermoelectric thermometry, vapor pressure thermometry, magnetic-thermometry, special type thermometers, Temperature sensor – evaluation, calibration and installation, error analysis Pressure, Level and overflow control, Gas detection, Process system example – P&ID drawings, Safety and Pressure relief devices	8
6	**Liquefied Gas Carrier and terminals:** Gas carrier Types: The IGC Code, Factors affecting gas carrier design, Types – Fully pressurized (FP), Semi-refrigerated (SR), Fully refrigerated (FR), Liquefied ethylene/ethane carriers (LECs), LNG Carriers, Regasification Vessels (RVs), Gas carrier layout, Cargo containment systems: Materials of construction and insulation; Cryogenic insulation technology – high vacuum, multiple layers, powder, rigid foam, supports and piping, The ship cargo equipment, Cargo handling operations Cargo measurement and calculations	6
7	**Safety with cryogenic fluids:** Cryogenic fluids, hazards and safety considerations, Physiological hazards – frostbite, respiratory ailments, miscellaneous, Physical hazards – Phase changes – closed systems, heat transfer, flash vaporization; Low temperature effects, miscellaneous – embrittlement, Chemical hazards – Ignition, Deflagration – Methane, hydrogen, ethylene, carbon monoxide; Detonation – gas phase reactions, condensed phase reactions, blast waves, scaling laws, blast effects; Fire, Safety in handling, storage and operations: Operational procedures, personnel protection, Ship safety systems – Hazardous zones, Hazardous area classification, IEC definitions,Zone determination, Ventilation, fire and safety systems, Survival capability, Surveys and Certification, Terminal safety	6

Reference Books:

1. Vance, R. W. (1963). Cryogenic Technology. United Kingdom: J. Wiley.
2. Katz, D. L. V., Lee, R. L. (1990). Natural Gas Engineering: Production and Storage. United Kingdom: McGraw-Hill.
3. Katz, D. L. V. (1959). Handbook of Natural Gas Engineering. United Kingdom: McGraw-Hill.
4. McGuire, G. (2016). Liquefied Gas Handling Principles on Ships and in Terminals: (LGHP4). United Kingdom: Witherby.
5. IGC Code: International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (2016 Edition). (2016). United Kingdom: IMO.
6. Zabetakis, M. G. (2013). Safety with Cryogenic Fluids. United States: Springer US

Finite Element Method (MMT/E/202)
For 2nd Semester

Credit-3 **Full Marks: 100**
Contacts periods Per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1	Introduction: Basic concepts of the Finite Element Method, Versatility of FEM and its use in different applications, Review of matrix theory and numerical solution of linear algebraic equations.	6
2	FE solution of assemblage of linear springs arranged in 1D, Element equations, Assembly rule and imposition of BC, Solution and calculation of support reactions, Problems	8
3	Extension of FE analysis of discrete systems from 1D to 2D, Analysis of Plane truss, Element equations, Assembly rule and imposition of BC, Solution for displacements, member forces and support reactions. Special case of inclined roller supports, Problems on plane truss.	8
4	Approximate solution of boundary value problems involving ODE by the weighted residual method, Weighted integral statement. Point collocation, Least-square, Rayleigh-Ritz and Galerkin procedure, Weak form: primary variables, secondary variables, essential BC, natural BC, Advantages of weak form over strong form, Examples	6
5	Solution of boundary value scalar field problem (such as heat transfer with surface convection and heat generation) depicted by ODE in 1-D. Deriving Shape functions of a 1-D linear and quadratic element, Natural coordinates, Weak form over a typical element, Element equation, Assembly and solution for PV and SV.	8
6	Review of Euler-Bernoulii beam equations. FE formulation of 1D beam problem governed by Euler-Bernoulli equation: Weak form, Galerkin procedure etc, Derivation of element equations, Assembly, Examples with different cases of supports, e.g., fixed, simple and distributed supports, Introduction to Frame elements.	10
7	FE formulation of 2D scalar field problem, Weak form, Galerkin procedure, 3-node, 6-node triangular elements,Isoparametric formulation, Conforming and non-conforming elements while introducing 4-node and 8-node quadrilateral elements, Coordinate transformation, Jacobian, Parent and child elements, Stress analysis problems: Plane stress and plane strain type in 2D,Review of equilibrium equation, stress-strain and strain-displacement relation, Variational formulation of stress analysis and heart transfer problems and derivation of their functional.	10

Reference Books:

1. Finite Element Analysis Theory and Application with ANSYS (4th edition), by SaeedMoaveni, Pearson, 2015
2. A First Course in the Finite Element Method (5th Edition), by Daryl L. Logan, Cengage Learning, 2012
3. An introduction to the Finite Element Method (3rd Edition), by J.N. Reddy, Tata McGraw-Hill, 2005.
3. Fundamentals of Finite Element Analysis, by David V. Hutton, Tata McGraw-Hill Publishing Co. Ltd., 2005.
4. Introduction to Finite Elements in Engineering, by T.R. Chandrupatla and A.D. Belegundu, Prentice-Hall of India Pvt. Ltd., 1991.

Project Management for Marine Engineers (MMT/T/205)
For 1st Semester

Credit-4 **Full Marks: 100**
Contacts periods per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1	**Phases of a project:** Project Principles: Definition of a project, how projects are successful, importance of project management – Managing the unknown, Climate change and sustainability goals, Managing the change, Managing resources and completion; Project process model – block diagram with Gantt chart. Examples of some major maritime projects, Examples of Lessons from disasters Project Initiation: Need for a project – opportunity, problem, threat, why initiate the project; Involvement in the project initiation – the initiator, management support, roles, end user / customer and stakeholders; What is a project; Time and money – minimal initial cost, economic duration, emergency, resale and recycling, life cycle costs; Shipping market economics – Shipping market cycles, supply demand and freight rates, decisions facing shipping markets, owners, freight markets; Project Planning Project strategy and organization: How to execute the project? Preliminary project execution strategy, pre-qualification of vendors and contractors, Work Based Structure (WBS), producing detailed execution strategy, Organization for a project, finding team, roles and responsibilities, Climate and environmental impact minimization Technical specification: Requirement of technical specification, Specification in maritime industry – Industry standards, IMO rules and regulations, classification rules, risk based & goal-based standards and yard specification Engineering definition: Collection of Engineering data, who and how to produce engineering definition, information required for engineering definition, approval of projects – examples. Detail design: Design concepts – rules based, risk based and goal based; design strategy, people involved in detailed design, items required in detailed design; The design cycle – basic, functional, transition, work instruction; Information flow; GT shipbuilding impact on design engineering; Design stages – basic design, functional design; system diagrammatic and key plans; material list by system; Transition design – pallet definition, composite drafts, composite arrangements; work instruction design - fitting work instruction drawings; material lists for fitting, manufacturing work instruction drawings, material	20

	lists for manufacturing; mold loft interface; Design and Engineering for production – General principles, standardization, logic of design, zone orientation, design development by zones, product orientation, hull structural design to facilitate outfitting, overlapping design stages, format standardization for purchase order specifications, design changes, sources, preventives, counter-measures, CAD / CAM – CAD outputs, CAD / CAM potential; Models; Locating, installation and commissioning of machinery & systems, The project manager's role. Procurement: Enquiry, Tender assessment, placing order, interim actions, transportation and off-loading, closing orders Construction, installation and commissioning: Safety in construction, repairs and installation, Management of contractors, Management of contracts; Commissioning strategy, Commissioning team, Commissioning programme, hand over from construction, repair or installation; pre-commissioning and commissioning. Project closure: Close out, project review and report	
2	**Project management tools and techniques:** Statutory frameworks – rules, regulations, industry standards: Country specific, international and industry specific rules and regulations – structure, applicability, penalties, approving authorities and agencies; employer's duties; relationships between parties – the planning supervisor, principal contractor, designer and constructor or fabrication or installer; Control of substances hazardous to health, injury at work – compensation; environmental considerations Quality assurance: Principles of quality – quality, quality systems, quality standards and legislation, the cost of quality, creating a quality culture, maintaining a quality culture – training, coaching, auditing; The quality cycle; Modern concepts of quality. Hazard studies: Hazard assessment, Hazard studies – Safety, Health, Environment, Reliability and Quality, Hazard identification, use of guidewords, work breakdown, completeness of the engineering information; Six-stage hazard study process in a project life cycle, Hazard studies under ISO standards, computer control and human error; Incident reporting – reporting near misses, encouraging incident reporting. Risk analysis and management: Project risks – systematic risk analysis and risk management, qualitative risk analysis, quantitative risk analysis, risk management; when to apply risk management – Start of project, Risk in funding decisions, the importance of time; Risk during project implementation – Risk in contracts, institutional risk, joint ventures, project size and design flexibility, design freezing; Qualitative techniques for project risk analysis – sensitivity analysis, probability analysis, risk management Cost estimation: Stages of a project – The conception stage, Definition stage, Execution stage; Estimating techniques – Capacity methods, structural methods, methods based on specific data, calculation methods; Requirements of successful estimation – estimation accuracy, structure of	20

	an estimating system, methods of estimation, estimating engineering costs, contingency, work breakdown structure with examples, estimating check list, estimating consistency, Cost elements, pricing, materials, labor, engineering, equipment, parts and tools, economic costs, activity based cost management; Manufacturing and operating costs; Computer based techniques in estimations; examples of structural approach to cost estimation Project planning: The purpose of planning – why, objectives, benefits, strategy; Planning the plan; Sources of data for planning; Planning techniques – activities, bar charts, linked bar charting; Network analysis techniques; Precedence diagramming; Activity on arrow networking; Computer software packages and case studies; Work breakdown structure (WBS) – example, specification for a work package, case studies; Resource levelling – resource scheduling techniques; Use of S-curves Project monitoring and control: The principals of control – 80/20 rule, the rolling wave concept; Techniques for the control of time – bar charts, effective monitoring, network analysis, s-curves; Techniques for control of cost – traditional cost control using accruals, the master control plan, monitoring actual expenditure, anticipated final costs, graphical representation, use of definitive/control estimates; Project monitoring using earned value analysis; Cost and schedule analysis, variance analysis, estimation of AFC and work package duration, trend analysis; Managing change Contracts for purchase of goods and services: Contract definition, scope of a contract, parties to a contract, words used in contracts; Standard maritime contracts – overview of various BIMCO standard contracts with emphasis on buildcon / repaircon; Planning a contract – objectives, number of contracts; Choice of types of contract, comprehensive contract – turnkey/EPC/Engineer-Procure-Install-Construct, all-in, package deal, design_build contracts, stage by stage contracts, parallel contracts, traditional contract responsibilities; Subcontracts; Risks – risk allocation, liquidated damages terms in contracts; Types of payments - fixed price payment, lump sum payment, firm or fixed price payment, down payment or payment for preliminaries, milestone and planned progress payment systems, unit rates basis of payment, contract price adjustment for escalation (CPA), cost-reimbursable and day works payment / Time and materials, Target-incentive contracts, convertible terms of payment, retention money, indicative prices; Alternatives in contract strategy – Management contracting, construction management, concession contracts, Needs of project management, Partnering and alliances; Contract documents and international practices Project organization: Organizations – structure, Economic allocation of resources; Project teams – Client project team, contractor's project team; Project co-ordination and control - project managers, the project managers roles in management structure, matrix systems, matrix management or internal contracts	

	Project information**:** Project definition; Contract commitments; Project documentation – Project authorizing documents, engineering briefing documents, procedural documents, project control documents, deliverable documents; Project information centre – configuration control	
3	**Skills and knowledge:** Personal skills and organization: The project manager's position in the organization; Managing people – teams, people and motivation, managing within the organization, managing suppliers, managing the clients, negotiations. Information management: Meetings – types, chairing meetings, agenda and minutes; Correspondence – writing letters, managing correspondence; Reports; Telephones; Project administration – project records, project administration systems. Basics of maritime economics, accountancy and shipping: Accountancy – The structure of accounts, the balance sheet, profit and loss account, impact of the project on the accounts; Investment appraisal and project financing – investment appraisal – Payback, discounted payback, accounting rate of return, NPV and internal rate of return; Life cycle costing; Project finance – getting paid and paying for things; maritime business – currency exchange, movement of goods, shipping terms, shipping restrictions, letters of credit; Bank guarantees and retentions – form of words, costs. Value Engineering: Design to cost; Value engineering – value for money, value engineering in project execution, value engineering – composition of the team, value engineering – organization of the session. Different projects**:** Fast-track projects; Brown field projects; Shutdown projects; Redfield projects; Ship building, Ship conversion, Ship refit, Ship repairs, Ship-breaking and recycling, maritime software projects; EPIC projects; Validated projects; Joint ventures, consortia and alliance projects; Research and development projects	16

Reference Books:

1. Project Management for the Process Industries. (1999). United Kingdom: Institution of Chemical Engineers.
2. Stopford, M., Branch, A., Stopford, M., Branch, A. (2013). Maritime Economics. (n.p.): Taylor & Francis.
3. Rad, P. F., Rad, P. F. (2001). Project Estimating and Cost Management. United States: Management Concepts Press.
4. Butler, D., Butler, D. (2012). A Guide to Ship Repair Estimates in Man-hours. Netherlands: Elsevier Science.
5. Harrington (Editor) Marine Engineering.(1992).United States:Society of Naval Architects and Marine Engineers.
6. Ship production - 2 nd Edition by Richard Lee Storch, Colin P Hammon, Howard M Bunch & Richard C Moore – Cornell Maritime Press
7. Risk Based Ship Design – Methods, Tools and Applications by Group of Authors, Edited by Apostolos Papanikolau, ISBN: 978-3-540-89041-6, Springer-Verlag Berlin Heidelberg 2009

8. Kletz, T., Kletz, T. (2007). Learning from Accidents. United Kingdom: CRC Press.
9. Kletz, T. A., Kletz, T. A. (2018). Hazop & Hazan: Identifying and Assessing Process Industry Hazards, Fouth Edition. United Kingdom: CRC Press.
10. Rausand, M., Haugen, S. (2020). Risk Assessment: Theory, Methods, and Applications. United States: Wiley.

High Voltage and Power Electronic Systems (MMT/T/206)
For 2nd Semester

Credit-4 **Full Marks: 100**

Contacts periods Per week: 3-1-0 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1.	**High Voltage System:** Basic requirements and type of protection, Earthling, interference with control system, Breakdown in non-uniform fields-Vacuum insulation and vacuum breakdown. Breakdown Phenomenon in Liquid and Solid insulation, Conventional Diagnostic Techniques, Chemical Techniques, Moisture Analysis, Dissolved Gas Analysis, Measurement of Degree of Polymerization, Furan in Oil Analysis Basic Theory of Time Domain Dielectric Response Measurement	10
2.	**Fundamentals of Power Electronics systems:** An introduction to modern electrical drives, Ideal switch, diode static characteristics, thermal dissipation, heat sink design, diac, triac.	10
3	**Single Phase & Three Phase Converters:** Single phase converters – Half controlled and fully controlled converters, single phase dual converters – power factor Improvements Techniques–, PWM – single phase sinusoidal PWM – single phase series converters, three phase converters – Half controlled and fully controlled converters – twelve pulse converters – Applications – Design of converters.	12
4	**Harmonics Analysis:** Harmonics sources – definitions & standards – impacts - calculation and simulation –harmonic power flow mitigation and control techniques – filtering – passive and active Analysis of constant and variable speed electrical drive, V/f control,	12
5	**Simulation Tools and Materials:** Basics of MATLAB to analyze electrical machine and power electronic system behavior, State of the art in electrical machines and power electronic systems and advanced materials and topologies influencing future designs.	12

Reference Books:

1. High Voltage Engineering – by M.S.Naidu and V.Kamarajuu, Tata Mc Graw Hill Book Co., New Delhi,2nd edition, 1995.
2. Shipboard Propulsion, Power Electronics, and Ocean Energy. (2012). Patel, M.R., CRC Press, 1st Edition, Washington State University, Pullman, USA.
3. Electrical Circuit Theory and Technology. (2010). Bird, J., Elsevier, 4th Edition, the Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, UK.
4. Shipboard electrical power systems. (2011). Patel, M.R., CRC Press, 1st Edition, U.S. Merchant Marine Academy in Kings Point, New York, USA.

High Voltage Laboratory (MMT/P/202)
For 2nd Semester

Credit-3 **Full Marks: 100**

Contacts periods Per week: 0-0-3 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1.	AC, DC And Impulse Breakdown Test of Insulation	
2.	Capacitance and Tanδ Measurement of Insulator.	
3	Measurement of Insulation Resistance of Cable	
4	100 kva Motorized Fully Automatic Insulating Oil Testing Machine	
5	Dielectric Characteristics of Solid Insulating Material Using Impedance Analyzer	
6	Study Of Impulse Voltage Generator	
7	To Study High Voltage, Withstand Test on Cables as Per IS.	
8	Generation and Measurement of Ac Voltage Through Oscilloscope.	
9	Disruptive Discharge Voltage Tests with Direct Current	

Power Electronics Laboratory (MMT/P/203)
For 2nd Semester

Credit-3 **Full Marks: 100**

Contacts periods Per week: 0-0-3 (L-T-P) **Course Type: Department Core**

Sl No.	Topic	No. of lecture periods
1.	Characteristics of power diode, BJT, SCR, IGBT & Power MOSFET.	
2.	Single phase fully controlled bridge converter with R & RL Loads.	
3	Three phase Fully controlled bridge converter with R Load.	
4	Four quadrant operation of chopper with R load.	
5	PWM control of Boost converter with R and RL loads.	
6	Single phase Inverter with current controlled PWM technique using MATLAB / SIMULINK.	
7	Single phase Fully controlled PWM rectifier with R & RL loads using PSCAD.	
8	Micro controller based PWM pulse generation.	
9	Determination of speed and output voltage of 3-phase AC voltage controller fed induction motor drive.	
10	Output voltage characteristics of flying capacitors multi-level inverter fed induction motor drive.	
11	To Study Speed Torque Characteristics Of 1. AC Servomotor 2. B. DC Servomotor