Bachelor of Technology
in
Naval Architecture & Ocean Engineering

CURRICULUM AND COURSE CONTENTS
(Applicable from 2023 batch)

INDIAN INSTITUTE OF TECHNOLOGY MADRAS
CHENNAI 600 036

B.TECH - NAVAL ARCHITECTURE & OCEAN ENGINEERING

Course Category Codes:

S : Basic Science; E : Basic Engineering; H : Humanities; P : Professional; F : Free Elective

Semester and Category-wise Credit Distribution – B.Tech (NA&OE)

category	S1	Win	S2	Sum	S3	S4	S5	S6	Sum	S7	S8	Total	CTF
S	20		37		**9**	9+**9**						84	**84**
E	32	3		3	10							48	**45**
H			**9**		**9**						**9**	27	**27**
P	6		10		32	41	49	20	6	**9**+9	**18**	200	
Total	**58**	**3**	**56**	**3**	**60**	**59**	**49**	**20**	**6**	**9**	**27**	**359**	
Free Electives (**F**) **(suggested)**							**9**	**36**		**27**	**9**	72	**72-96**
Overall	**58**	**3**	**56**	**3**	**60**	**59**	**58**	**56**	**6**	**36**	**36**	**431**	**432**
EL & HS			**9**		**18**	**9**	**27**	**36**		**36**	**36**	**171**	**172**
Honors*								**9**		**9**	**9**	**27**	**27**

*** OE courses of 5000 & above**

SEMESTER I

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
MA1101	Functions of Several Variables	3	1	0	0	6	10	S
PH1010	Physics I	3	1	0	0	6	10	S
AM1100	Engineering Mechanics	3	1	0	0	6	10	E
CS1100	Introduction to Programming	3	0	0	3	6	12	E
ME1100	Thermodynamics	3	1	0	0	6	10	E
OE1101	Introduction to Naval Architecture & Ocean Engineering	2	0	0	0	4	6	P
	Total	**17**	**4**	**0**	**3**	**34**	**58**	
	NCC/NSS	0	0	0	0	2	0	
	LIFE SKILLS	0	0	0	0	3	0	

WINTER

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
WS1010	Workshop I	0	0	0	3	0	3	E

SEMESTER II

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
MA1102	Series and Matrices	3	1	0	0	6	10	S
PH1020	Physics II	3	1	0	0	6	10	S
PH1030	Physics Lab	0	0	0	3	1	4	S
CY1001	Chemistry I	3	1	0	0	6	10	S
CY1002	Chemistry Lab	0	0	0	3	0	3	S
HSxxxx	Humanities Elective – I	3	0	0	0	6	9	H
OE1012	Ship Hydrostatics and Stability	3	1	0	0	6	10	P
	Total	**15**	**4**	**0**	**6**	**31**	**56**	
	NCC/NSS	0	0	0	0	3	0	

SUMMER

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
WS1010	Workshop I	0	0	0	3	0	3	E

SEMESTER III

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
MA	Mathematics Elective-I	3	0	0	0	6	9	S
EE1100	Basic Electrical Engg.	3	1	0	0	6	10	E
HSxxxx	Humanities Elective – II	3	0	0	0	6	9	H
OE2044	Ship Hydrodynamics	3	1	0	0	6	10	P
AM2200	Strength of Materials	3	1	0	0	6	10	P
OE2013	Ship Drawing and Calculations	1	3	0	3	3	10	P
OE2023	Marine Instrumentation Lab	0	0	0	2	0	2	P
	Total	**16**	**6**	**0**	**5**	**33**	**60**	
	Ecology & Environment	2	0	0	0	0	0	

SEMESTER IV

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
MA	Mathematics Elective – II	3	0	0	0	6	9	S
BT1010	Life Sciences	3	0	0	0	6	9	S
OE2014	Marine Engineering	3	1	0	0	6	10	P
OE2024	Analysis of Structures	3	1	0	0	6	10	P
OE2034	Ship Resistance and Propulsion	3	1	0	1	6	11	P
OE2054	Ocean Wave Hydrodynamics	3	0	0	1	6	10	P
	Total	**18**	**4**	**0**	**1**	**36**	**59**	

SEMESTER V

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OE3015	Ship Structural Analysis	3	1	0	0	6	10	P
OE3035	Motion of Ships & Floating Systems	3	1	0	1	6	11	P
OE3016	Ship Design	3	1	0	0	6	10	P
OE3045	Vibration of Marine Structures	3	0	0	0	6	9	P
OE3190	Design of Ocean Structures	3	0	0	0	6	9	P
	Free Elective – I	3	0	0	0	6	9	F
	Total	**18**	**2**	**0**	**2**	**36**	**59**	

SEMESTER VI

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OE3036	Maneuvering & Control of Marine Vehicles	3	1	0	0	6	10	P
OE3046	Ship Structural Design	3	1	0	0	6	10	P
	Free Elective – II	3	0	0	0	6	9	P
	Free Elective – III	3	0	0	0	6	9	F
	Free Elective – IV	3	0	0	0	6	9	F
	Free Elective – V	3	0	0	0	6	9	F
OExxxx	**Honours Elective – I**	**3**	**0**	**0**	**0**	**6**	**9**	**HE**
	Total	**15+3**	**2**	**0**	**0**	**36**	**56+9**	

SUMMER

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OE3026	Shipyard Training (Summer)	0	0	0	0	6	6	P

SEMESTER VII

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OExxxx	Professional Elective - I	3	1	0	0	6	9	P
OE4051	*Project or Professional Elec – I	3	0	0	0	6	9	P
	Free Elective – VI	3	0	0	0	6	9	F
	Free Elective – VII	3	0	0	0	6	9	F
	Honours Elective – II	**3**	**0**	**0**	**0**	**6**	**9**	
	Total	**15+3**	**1**	**0**	**0**	**30+6**	**36+9**	
	Professional Ethics	2	0	0	0	0	0	

SEMESTER VIII

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
HSxxxx	Humanities Elective – III	3	0	0	0	6	9	H
OE4052	*Project or Professional Elective – II	3	0	0	0	6	9	P
	*Project or Professional Elective – IV	3	0	0	0	6	9	P
	Free Elective – VIII	3	0	0	0	6	9	F
	Honours Elective – III	**3**	**0**	**0**	**0**	**6**	**9**	
	Total	**12**	**0**	**0**	**0**	**24**	**36+9**	

Students are required to take 72 FREE elective credits during semesters V-VIII from any department including Ocean Engineering. Electives can be taken in semesters V-VIII, subject to maximum of 60 credits per semester or as suggested.

* **Project**: An optional B.Tech project can be taken in lieu of 27 elective credits as mentioned in Sem VII and Sem VIII. These 27 elective credits have to be against ocean engineering elective courses. If the student starts a project in VII Sem and cannot successfully continue then he has to substitute the same with departmental elective credits of 9 credits in the semester VIII.

BTech (Honours): (Total credit requirement: 431 + 27 = **458)**

- ***Eligibility***: minimum CGPA of 8.5 at the end of 6th Sem without U or W grade in any course. They need to maintain these conditions until graduation.
- ***BTech Project is not mandatory***. Three Professional Elective courses (OE 5000 and above level courses) can be taken in place of the project.
- ***Extra credit requirement***: BTech extra up to 9 credits in VII semester + 18 credits in VIII sem over and above the regular BTech requirement. These 27 credits (three) elective courses should be at OE 5000 level or higher.

LIST OF ELECTIVES

No	Title	L	T	Ext	Lab	Home	Cr
	ELECTIVE (A) – Mathematics						
MA2010	Complex Variables	3	0	0	0	6	9
MA2030	Differential Equations	3	0	0	0	6	9
MA2040	Probability, Stochastic Process &Statistics	3	0	0	0	6	9
MA2060	Discrete Mathematics	3	0	0	0	6	9
MA2130	Basic Graph Theory	3	0	0	0	6	9
ELECTIVE (E) – Professional for NA&OE (BTech&DD)							
ME3350	Design of Machine Elements	3	0	0	0	6	9
MM3012	Joining and NDT Lab	3	0	0	0	6	9
MM3060	Metal Joining Technology	3	0	0	0	6	9
MM5320	Corrosion Engineering	3	0	0	0	6	9
MM5750	Welding Application Technology	3	0	0	0	6	9
OE4300	Ocean Energy	3	0	0	0	6	9
OE4400	Drilling vessels and Support Crafts	3	0	0	0	6	9
OE4600	Advance ship Hydrodynamics	3	0	0	0	6	9
OE4xxx	Shipbuilding Material & Production Processes	3	0	0	0	6	9
OE5011	Marine Robotics	3	0	0	0	6	9
OE5080	Marine Instrumentation	3	0	0	0	6	9
OE5170	Ocean Acoustics	3	0	0	0	6	9
OE5230	Foundation of Offshore Structures	3	0	0	0	6	9
OE5310	Guidance and control of Marine Vehicles	3	0	0	0	6	9
OE5320	Nonlinear Problems in Ocean Engineering	3	0	0	0	6	9
OE5330	Advanced Marine Structures	3	0	0	0	6	9
OE5xxx	Advanced Structural Analysis Of Marine Vehicles	3	0	0	0	6	9
OE5xxx	Design Of Fishing Vessels	3	0	0	0	6	9
OE4xxx	Design Of Ship Outfit Systems	3	0	0	0	6	9
OE5xxx	Design Of Submarine And Submersible	3	0	0	0	6	9
OE5xxx	Marine Corrosion, Prevention And Control	3	0	0	0	6	9
OE4xxx	Ship Electrical And Electronic Systems	3	0	0	0	6	9
OE4xxx	Ship Positioning Systems	3	0	0	0	6	9
OE5xxx	Design Of High Speed Vessels	3	0	0	0	6	9
OE5xxx	Warship Design	3	0	0	0	6	9
OE4xxx	Analysis And Design Tools In Marine Hydrodynamics	3	0	0	0	6	9
OE4xxx	Laboratory Modelling In Marine Hydrodynamics	3	0	0	0	6	9
OE5xxx	Design, Construction and Operation of LNG Carriers and Terminals	3	0	0	0	6	9
OE5450	Numerical Techniques in Ocean Hydrodynamics	3	0	0	0	6	9
OE5500	FEM Applied to Ocean Engineering	3	0	0	0	6	9
OE5600	Advanced Wave Dynamics	3	0	0	0	6	9
OE5800	Coastal Engineering	3	0	0	0	6	9
OE6005	Reliability of Offshore Structures	3	0	0	0	6	9
OE6020	Mesh-free Methods Applied to Hydrodynamics	3	0	0	0	6	9
OE6200	Design of Offshore Structures	3	0	0	0	6	9
OE6300	Plated Structures and Shells	3	0	0	0	6	9
OE6930	Modeling of Offshore and Coastal Processes	3	0	0	0	6	9
OE6980	Computer Aided Surface Development of Marine	3	0	0	0	6	9
OE6990	Advanced Marine Vehicles	3	0	0	0	6	9
PE6060	HSE Management in Petroleum and Offshore Engineering	3	0	0	0	6	9

CURRICULUM – B.TECH - NAVAL ARCHITECTURE & OCEAN ENGINEERING

SEMESTER 1

MA 1101: FUNCTIONS OF SEVERAL VARIABLES

Course Content:

Limits, continuity and differentiability of functions of several variables. Taylor's theorem and applications to unconstrained and constrained optimization. Vector calculus: Gradient, Divergence, Curl, Line integral, conservative fields, Green's theorem, surface area of solids of revolution, surface area, surface integral, Triple integrals and Gauss Divergence theorem, Stokes' theorem.

Text Books:

1. **G.B. Thomas Jr., M.D. Weir and J.R. Hass,** Thomas Calculus, Pearson Education, 2009.

Reference Books:

1. **E. Kreyszig**, Advanced Engineering Mathematics, 10th Ed., John Willey & Sons, 2010.
2. **N. Piskunov,** Differential and Integral Calculus Vol. 1-2, Mir Publishers, 1974.
3. **G. Strang,Calculus**, Wellesley-Cambridge Press, 2010.
4. **J.E. Marsden, A.J. Tromba, A. Weinstein**, Basic Multivariable Calculus, Springer Verlag, 1993.

Prerequisite:

PH1010: PHYSICS I

Course Content:

Use of vectors in practical mechanics. Unit vectors in spherical and cylindrical polar coordinates. Conservative vector fields and their potential functions -gravitational and electrostatic examples. Gradient of a scalar field. Equipotentials, states of equilibrium. Work and energy, conservation of energy. Motion in a central force and conservation of angular momentum. Physics concepts in vector fields, Continuity equations and conservation principles for matter, energy and electrical charge. Flux, divergence of a vector. Gauss' theorem, physical applications in gravitation and electrostatics. Irrotational versus rotational vector fields. Physical significance of circulation, curl of a vector field. Stokes' theorem, physical applications. Oscillatory motion, Wave motion in one dimension. Wave equation and travelling wave solutions. Wave velocity, group velocity and dispersion. Shallow water waves. Wave equation in three dimensions, spherical waves.

Text Books

Reference Books:

1. **Kittel C., Knight W.O. and Ruderman M.A.**, Mechanics - Berkeley Physics Course, Vol. 1, Tata McGraw-Hill
2. **Purcell E.M. Electricity and Magnetism** - Berkeley Physics Course, Vol.2, Tata McGraw-Hill
3. **Crawford F.S. - Waves and Oscillations**, Berkeley Physics Course, Vol. 3, McGraw-Hill
4. **Feyman R.P., Leighton R.B. and Sands M. (Narosa)** The Feyman Lectures on Physics, Vol. 1
5. **Feyman R.P., Leighton R.B. and Sands M. (Narosa)** The Feyman Lectures on Physics, Vol. 26. Davis D. (Academic) - Classical Mechanics

Prerequisite:

AM 1100: ENGINEERING MECHANICS

Course Content:

Equilibrium of rigid bodies, free body diagram, Analysis of beams and trusses, Equilibrium of continuous systems -derivation of relation between load, shear force and bending moment. Energy conservation in rigid bodies -potential energy and elastic energy. Virtual work in multibody assemblies. Lumped mass models in Dynamics -Particle motion in cylindrical c0ordinates, engineering applications of central force motion. Kinetics of rigid bodies -translation and rotation motion of a rigid body, relative motion with translating and rotating axes and Coriolis acceleration. Kinematics of rigid bodies -3-D properties of sections, angular momentum of rigid bodies and energy relations for rigid bodies. Mechanical vibrations of single degree of freedom systems -free vibration of rigid bodies, general equations of motion and response to forced sinusoidal loading.

Text Books:

Reference Books:

1. **Beer F.P. and Johnston E.R.,** Vector Mechanics for Engineers - Volume I - Statics, Volume II - Dynamics, McGraw Hill, New York.
2. **Merlam J.L and Kraige L.G.,** Engineering Mechanics, Volume I - statics, Volume 11-dynamics, John Wiley & Sons, New York.
3. **Shames L.H.,** Engineering Mechanics, Prentice HaII, New Delhi

Prerequisite:

NULL

CS1100: INTRODUCTION TO PROGRAMMING

Course Content:

Module 1 : (Introduction to Computing) - 6 lectures Fundamentals of Computing, Historical perspective, Early computers. Computing machine. Problems, Pseudo-code and flowcharts. Memory, Variables, Values, Instructions, Programs. Module 2 : (Introduction to C) 10 lectures The language of C : Phases of developing a running computer program in C. Data concepts in C :Constants, Variables, Expressions, Operators, and operator precedence in C. Statements : Declarations, Input-Output Statements, Compound statements, Selection Statements. Conditions, Logical operators, Precedences. Repetitive statements, While construct, Do-while Construct, For construct. Data types, size and values. Char, Unsigned and Signed data types. Number systems and representations. Constants, Overflow. Arrays. Strings. Multidimensional arrays and matrices. Module 3 : (Modular Programming and Example Problems) : 10 lecture Functions :The prototype declaration, Function definition. Function call : Passing arguments to a function, by value, by reference. Scope of variable names. Recursive function calls, Tail recursion. Analysing recursion, Tree of recursion, linear recursion. Sorting problem : Selection Sort, Insertion Sort, Comparison between sorting algorithms. Sorting in multidimensional arrays. Sorting in strings. Search problem : Linear search and binary search. Comparison between search procedures. Recursive and Iterative formulations. Module 4 : (More Data Types in C) 14 lectures Pointers : Pointer variables. Declaring and dereferencing pointer variables. Pointer Arithmetic. Examples. Accessing arrays through pointers. Pointer types, Pointers and strings. String operations in C. Structures in C : Motivation, examples, declaration, and use. Operations on structures. Passing structures as function arguments. type defining structures. Self-referential structures. Dynamic Data Structures. Linked Lists. Examples. File input-output in C. Streams. Input, output and error streams. Opening, closing and reading from files. Programming for command line arguments. Numerical errors due to data representations and machine precision. Approximation and error analysis. Illustration through examples.

Text Books:

Reference Books:

Prerequisite:

ME1100: THERMODYNAMICS

Course Content:

Fundamentals - System & Control volume; Property, State & Process; Exact & Inexact differentials; Work - Thermodynamic definition of work; examples; Displacement work; Path dependence of displacement work and illustrations for simple processes; Other forms of work - electrical, spring and shaft Temperature - Definition of thermal equilibrium and 0th (Zero) law; Temperature scales; Various Thermometers Heat - Definition; examples of heat/work interaction in systems First Law - Cyclic & Non-cyclic processes; Concept of total energy E ; Demonstration that E is a property; Various modes of energy; Pure substance Ideal Gases and ideal gas mixtures Properties of two phase systems - Const. temperature and Const. pressure heating of water; Definitions of saturated states; P-v-T surface; Use of steam tables and R134a tables; Saturation tables; Superheated tables; Identification of states & determination of properties First Law for Flow Processes - Derivation of general energy equation for a control volume; Steady state steady flow processes including throttling; Examples of steady flow devices; Unsteady processes Second law - Definitions of direct and reverse heat engines; Definitions of thermal efficiency and COP; Kelvin-Planck and Clausius statements; Definition of reversible process; Internal and external irreversibility; Carnot cycle; Absolute temperature scale Entropy - Clausius inequality; Definition of entropy S ; Demonstration that entropy S is a property; Evaluation of ΔS for solids, liquids, ideal gases and ideal gas mixtures undergoing various processes; Determination of s from steam tables; Principle of increase of entropy; Illustration of processes in T-s coordinates; Definition of Isentropic efficiency for compressors, turbines and nozzles Thermodynamic cycles - Basic Rankine cycle; Basic Brayton cycle; Basic vapor compression cycle

Text Books:

1. **Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner and Margaret B. Bailey, Wiley, 7th edition,** Fundamentals of Engineering Thermodynamics,

Reference Books:

Nil

Prerequisite:

Nil

OE1101: INTRODUCTION TO NAVAL ARCHITECTURE & OCEAN ENGINEERING

Course Content:

Physical Oceanography: Physical properties of seawater, Different types of ocean waves and their importance, tides, ocean currents, ocean circulation, ocean basin oscillations, Tsunamis, storm surge, Air-sea interaction. Marine Vehicles: Oceangoing, ship types, types of small crafts, high speed crafts, vehicles for Inland water transport, special ship types, e.g. warships, icebreakers, types of propulsion systems, marine safety regulation, underwater vehicles and submersibles. Introduction to Ship general arrangement, Ship terms and terminologies; Outfits – deck, accommodation, cargo, machinery, etc., Life saving appliances, Fire fighting appliances, Communication and navigation systems, Mooring and anchoring systems, Different piping systems, Ship board electrical systems.Offshore Structures for oil and gas: Fixed offshore platforms (jackets, gravity platforms, articulated towers); superstructure & foundation, floating platforms (semi-submersibles, jack-ups, TLPS, FPSOs, pipe laying barges); Mooring, station keeping, berthing systems for floating platforms; towing launching & installation of platforms, Nearshore structures.

Text Books:

1. Practical: Visit to a ship - identification and familiarisation of various spaces and parts of ship, Make sketches of general arrangement of different ships types.

Reference Books:

1. **Thomas Lamp:** Ship Design and Control Vol I & II, SNAME.

Prerequisite:

GN1101: LIFE SKILLS 1

Course Content:

The contents of the program are aimed at creating a confident ,mature individual. The curriculum is built around one single topic which is the Ability to Get Along. Under this topic are sub topics, like Cross cultural skills, Personal grooming, Dining etiquette, falling in love with oneself and body language.

Text Books:

Carnegie, Dale. How to win friends and influence people. Simon and Schuster, 2010. Pease, Allan. Body language: how to read other thoughts by their gestures. Sheldon Press, 1981. Hofstede, Geert, Gert Jan Hofstede, and Michael Minkov. Cultures and organizations: Software of the mind. Vol. 2. London: McGraw-Hill, 1991.

Reference Books:

1. **Morris, Desmond. Manwatching:** A field guide to human behaviour. Ed. G. Desebrock. New York, NY: HN Abrams, 1977.

Prerequisite:

WINTER

WS1301: WORKSHOP-I-WS1301

Course Content:

Text Books:

Reference Books:

Prerequisite:

NULL

SEMESTER II

MA1102: SERIES AND MATRICES

Course Content:

Series: Sequences of real numbers, Series, ratio and root test, improper integral, integral test, alternating series, absolute and conditional convergence, power series, radius and interval of convergence of power series, term by term differentiation and integration of power series, Taylor's formula, Taylor series, periodic functions and Fourier series, convergence of Fourier series, functions of any period, even and odd functions, half-range expansions. Matrices: Matrix operations, special types of matrices, matrices as linear transformations, linear independence, basis and dimension, rank of a matrix, nullity of a matrix, elementary operations, inverse of a matrix, orthogonalization, determinant, existence-uniqueness of solutions of a linear system, Gaussian elimination, Gauss-Jordan elimination, Eigenvalues, eigenvectors, eigenvalues of special types of matrices, similarity of matrices, basis of eigenvectors, diagonalization.

Text Books:

1. **G.B. Thomas Jr., M.D. Weir and J.R. Hass**, Thomas Calculus, Pearson Education, 2009.
2. **E. Kreyszig**, Advanced Engineering Mathematics, 10th Ed., John Willey & Sons, 2010.

Reference Books:

1. **J. Hefferon**, Linear Algebra, http://joshua.smcvt.edu/linearalgebra, 2014.
2. **S. Lang**, Introduction to Linear Algebra, 2nd Ed., Springer-Verlag, 1986.
3. **M.T. Nair**, Calculus of One Variable, Ane Books, 2014.
4. **N. Piskunov**, Differential and Integral Calculus Vol. 1-2, Mir Publishers, 1974.
5. **G. Strang**, Linear Algebra and its Applications, Cengage Learning, 4th Ed., 2006.

Prerequisite:

PH1020: PHYSICS II

Course Content:

Unit 1: Electrostatics and magnetostatics Maxwell's equation-I, work and energy in electrostatics, displacement and polarization, boundary conditions. Maxwell's equation-II, Ampere's law, magnetic vector potential, magnetism in matter. Unit 2: Electrodynamics and electromagnetic radiation Lorentz force, Faraday's law and Lenz's law, electromagnetic induction. Displacement current, Maxwell's equations III and IV, energy stored in an electromagnetic field, electromagnetic waves in vacuum and in matter, Snell's law. Unit 3: Introduction to quantum mechanics The quantum nature of radiation, interference experiment with radiation and particle beams. Postulates of quantum mechanics, Schrodinger wave equation. Applications to simple physical systems such as free particle, particle in a box and barrier penetration, spin, two-state systems.

Text Books:

1. Introduction to Electrodynamics **David J. Griffiths**, Pearson Education India Learning Private Limited; 4 Edition, 2015
2. Intro to Quantum Mechanics **David J. Griffiths**, Pearson Education India Learning Private Limited, 2015
3. Fundamentals of Physics II - Electromagnetism, Optics, and Quantum Mechanics: 2 (The Open Yale Courses) **R. Shankar** Yale University Press; 1 edition, 2016

Reference Books:

1. The Feynman Lectures on Physics Vol 2, **Richard P. Feynman and R. B. Leighton** Narosa Publishing House, 2008
2. The Feynman Lectures on Physics Vol 3, **Richard P. Feynman and R. B. Leighton** Narosa Book Distributors, 2008
3. Quantum Physics **H C Verma**, TBS, 2nd edition, 2012

Prerequisite:

None

PH1030: PHYSICS LABORATORY I

Course Content:

Experiments in Mechanics Properties Materials, Heat, Electromagnetism and Optics.

Text Books:--

Reference Books:

1. **Smith E. V.** -Manual of Experiments in Applied Physic$, London,'" Butterworth, 1970.
2. **Workshop B.L., and Flint H.P.** -Advanced Practical Physics for Students, Methuen and Co. Ltd. London.
3. **Jerrad H.G. and Mc Neil D.B.** -Theoretical and Experimental Physics.
4. **Fretter W.B.** -Introduction to Experimental Physics, Blackiee
5. **M. Nelkon and J.rlJl. Ogborn** -Advanced Level Practical Physics, English Language Book Society, 1955.

Prerequisite:

CY1001: CHEMISTRY I: STRUCTURE, BONDING & REACTIVITY

Course Content:

Chemical Thermodynamics Second Law of Thermodynamics – Entropy change accompanying various processes (isothermal expansion, phase transition, heating, entropy of mixing of perfect gases); Absolute entropy and the Third Law of Thermodynamics; Statistical entropy; Spontaneity of a chemical reaction and Gibbs energy; Standard Gibbs energies of formation and reactions; Thermodynamic functions (A, G, U & H) and four fundamental equations, Maxwell relationships; variation of G with T and P, Gibbs-Helmholtz equation, Chemical potential; G versus extent of reaction ( ), Equilibrium constant through chemical potential (gas equilibria), relation between Kp & Kc; Phase equilibria, Gibbs phase rule, phase diagrams of water and carbon dioxide (supercritical H2O & CO2), Clausius-Clapeyron equation; Liquid-solid phase diagrams – two-component eutectic systems and cooling curves. Chemical Kinetics Parallel, opposing and consecutive reactions; Mechanism of complex chemical reactions; Analysing mechanisms using the steady-state approximation, Chain reactions (hydrogen-bromine reaction); Unimolecular reactions (Lindemann-Hinshelwood approach); Transition State Theory for bimolecular reactions (thermodynamic approach); Enzyme catalysis (Michaelis-Menten Mechanism). Chemisorption and Langmuir Isotherm. Basic Concepts of Quantum Chemistry Uncertainty principle; Motion of a quantum mechanical particle in one dimension; The Schrödinger wave equation for the hydrogen atom; physical meaning of a wave function, radial wave functions and probability densities, quantum numbers, wave functions and orbital shapes. Transition metal chemistry Bonding in transition metal complexes; coordination compounds; crystal field theory, octahedral, tetrahedral and square planar complexes; CFSE; Jahn-Teller theorem; Spectral, electronic and magnetic properties of coordination complexes.. Organometallic chemistry Synthesis structure and reactivity of metal carbonyls; 16 and 18 electron rules; Variety of ligands and hapticity; Type of reactions: Oxidative addition, Reductive elimination, Migratory insertion; Homogeneous catalysis, Hydrogenation, Hydroformylation, Monsanto process, Wacker process. Aromaticity Aromatic, non-aromatic and anti-aromatic compounds. Aromatic nucleophilic substitution reactions. Pericyclic reactions Definition, classifications, electrocyclic reaction of butadiene and hexatriene, photochemical [2+2] and thermal [4+2] cycloadditions, Sigmatropic rearrangements – limited to Cope and Claisen rearrangements, FMO approach – Woodward Hoffmann rules and basic stereochemistry aspects of the above reactions.

Text Books:

1. Atkin's Physical Chemistry by **PW Atkins and J de Paula**, 8th and 9th Eds., Oxford University Press.
2. Organic Chemistry by **J Clayden, N Greeves and S Warren**, 2nd Edition 2012, Oxford University Press.
3. Shriver and Atkin's Inorganic Chemistry by **P Atkins, T Overton J Rourke, M Weller and F Armstrong,** 4th Edition 2009, Oxford University Press.

Reference Books:

Nil

Prerequisite:

NIL

CY1002: CHEMISTRY LAB I

Course Content:

Determination of reaction rate constant and acid strength, Preparation of gold nanoparticles, Estimation of copper, iron and nickel ions, Preparation of dibenzalproposanone, Bromination of stilbene, qualitative analysis of organic compounds

Text Books:

Nil

Reference Books:

1. Laboratory Manual for Undergraduates, Department of Chemistry, IIT Madras (CY 1002)

Prerequisite:

COT

HSXXX: HUMANITIES ELECTIVE – NO COURSE NO.

OE1012: SHIP HYDROSTATICS AND STABILITY

Course Content:

Lines plan and hull form coefficients – Hull forms of different types of ships and boats – Numerical techniques for ship calculations- Bonjean calculation and curves, Hydrostatic particulars – definition and derivations. Weight estimation – lightship, deadweight, centre of gravity, CoG, CoB, Metacentre, Conditions of equilibrium Transverse stability at small angles – angles of heel, trim, list, loll, effects of weight shift, fee surface, wind, waves, grounding; Inclining experiment; Stability at large angles – cross curves of stability, dynamical stability; Ship longitudinal stability; Submarine stability; Stability of modern vehicles. Floodable length, and subdivision; Damaged stability – deterministic and probabilistic approaches and IMO criteria. Capacity and tonnage calculations; Trim and stability booklet Practicals: Lines plan drawing and fairing; Calculation and drawing of ship bonjean and hydrostatic data; Stability calculation and GZ curve; Floodable length calculation and drawing;

Text Books:

1. **Rawson, K.J and Tupper, E.C**. Basic Ship Theory, B&H, 2001
2. **Robert B. Zubaly** , Applied Naval Architecture, Cornell Maritime Press Inc.,2010.
3. **E. C. Tupper**, “Introduction to Naval Architecture”, Butterworth-Heinemann, 2013.

Reference Books:

1. **Lewis,E.U,** Principles of Naval Architecture,Vol.1, SNAME, New Jersey, U.S.A, 2010.Thomas Lamp: Ship Design and Control Vol I & II, SNAME.

Prerequisite:

SUMMER

WS1302: WORKSHOP-II

Course Content:

Text Books:

Reference Books:

Prerequisite:

NULL

SEMESTER III

MAXXX: MATHEMATICS ELECTIVE I

NO COURSE NUMBER

EE1100: BASIC ELECTRICAL ENGINEERING

Course Content:

1. Properties of resistance, Ohms law, KVL, KCL, mesh and nodal analysis, Network theorems: Superposition, Thevenin, Norton and maximum power transfer. 2. Properties of inductance and capacitance, DC transients: Series RL, RC, RLC and parallel RLC. 3. Single phase AC, voltage and current phasors, impedance, network theorems application to AC, frequency response of ac circuits, resonance, filters, active power, reactive power, apparent power, power factor. 4. Balanced Three phase AC, three phase power, star and delta connection. 5. Single phase transformer: Principle of operation, equivalent circuit, OC and SC test, voltage regulation, efficiency. 6. Three phase Induction motor: Construction, rotating magnetic field, principle of operation, slip, torque, equivalent circuit, efficiency. 7. DC machines: Principle of operation, excitation, equivalent circuit, emf, speed and torque characteristics. 8. Diodes and applications: Diode characteristics, voltage and current relationship, diode circuits-rectifiers, peak and envelop detectors, solar cell. 9. Operational amplifiers: Description of amplifiers as a black box and definition of gain, effect of feedback on gain, Operational amplifier circuits: Non-inverting, inverting, summing, differential, integrators, differentiators, buffers.

Text Books:

1. Electrical Engineering Fundamentals, **Vincent Del Toro**, Prentice Hall, 2006.

Reference Books:

1. Electrical Circuit Theory and Technology**, John Bird**, Elsevier, 2011.
2. Essentials of Electrical and Computer Engineering, **Kerns & Irwin**, Pearson, 2004.
3. Electrical Engineering Concepts and Applications, **Carlson and Gisser**, Addison Wesley, 1990.

Prerequisite:

HUMANITIES ELECTIVE -II – HSXXX – NO COURSE NUMBER

OE2044: SHIP HYDRODYNAMICS

Course Content:

Continuity, Euler, Laplace, Navier-Stokes (N-S) and Bernoulli equations; Divergence and Stokes theorems; Potential flow and stream function; Elementary potential flows: parallel flow / source and sink (2D & 3D) sink / vortex / doublet, flow over circular cylinder with and without circulation.Role of compressibility; Vector and tensor forms of fluid dynamic equations; Common dimensional groups (Froude / Reynolds / Cavitation / Euler / Weber / Strouhal numbers); Stokes law of viscosity for shear and normal stresses; Circulation and Stokes theorem (2D & 3D); Helmholtz's vorticity theorems; Vortex line and tube; Vorticity transport equation, convection and diffusion of vorticity; Boundary conditions - rigid and oscillating body or surface, free surface etc., Superposition of elementary flows, Rankine half and closed bodies etc., method of images, source or vortex near wall; Kutta-Joukowski theorem and lift; D'Alembert's paradox; Unsteady flow past circular cylinder and sphere: added mass; Munk moment; Cavitation; Lifting surfaces; Foil section characterizations; Flow around a foil: generation of lift, Kutta condition; Linearised lifting surface theory of thin 2D hydrofoil, thickness and camber problems and their solutions, lift and moment coefficients.N-S equations to Prandtl boundary layer (BL) equations by order of magnitude analysis; Dynamic similarity and boundary conditions; Laminar flow, BL thickness, displacement and momentum thicknesses; BL separation, bluff and streamlined bodies; Vortex shedding by cylinders, Karman vortex street, role of Strouhal no.; Vortex induced vibration; Skin friction, BL along a flat plate at zero incidence, its solution; Blasius formula; Plane Couette flow and Poiseuille flow; Impulsively started plate; Momentum integral equation of BL; Characteristics of turbulent flow; Drag crisis in circular cylinder and sphere; Friction due to turbulent BL over flat plate, power law, roughness effect;

Text Books:

1. **J.N.Newman**, Marine Hydrodynamics, MIT Press, 1977
2. **O.M.Faltinsen**, Hydrodynamics of High Speed marine Vehicles, Cambridge Press, 2005
3. **V.Betram**, Practical Ship Hydrodynamics, B&H, 2000

ReferenceBooks:

1. Principles of Naval Architecture, **E. V. Lewis (Ed.),** SNAME Publications, 1989

Prerequisite:

AM2200: STRENGTH OF MATERIALS

Course Content:

The course content is as follows: 1. Definiation of stress and strain in 1D, 2D and 3D 2. Transformation of stress and strain in 2D, Mohr's Circle 3. Constitutive relations, understanding of plane stress and plane strain phenomenon 4. Stress, strain, deformation of determinate and indeterminate axial members 5. Stress, strain, rotation of determinate and indeterminate torsional members 6. Bending stress and strain in beams 7. Composite beams, equivalent theory 8. Shear stresses in beams 9. Unsymmetric beams 10. Deflections in beams, Compatability conditions for indeternminate beams 11. Stability in columns 12. Introduction to strain energy and determination of deflection 13. Introduction to failure theories

TextBooks:

1. Mechanics of Materials, 8th Edition **| Russell C. Hibbeler |** Pearson Education
2. Elements Of Strength Of Materials **| SP Timoshenko |**

ReferenceBooks:

1. An Introduction to Mechanics of Solids, 3rd Edition **| SH Crandall, NC Dahl, TJ Lardner, MS Sivakumar | Mc Graw Hill**
2. Lecture notes

Prerequisite:

NA

OE2013:SHIP DRAWING AND CALCULATIONS

Course Content:

Introduction to Engineering drawing and graphics. Construction of plane curves. Coordinate system-projection of lines and planes. Projection of right regular solids. Section and intersection of solids and development of surfaces; Systems of projections-principles, conventions and applications of orthographic and isometric projections. Dimensioning principles and conventional representations. Drawing and faring of lines plan from supplied offset data; Calculations for launching, subdivision, damage stability, trim and stability booklet, sounding tables.

Text Books:

1. **Rawson, K.J and Tupper, E.C**. Basic Ship Theory, B&H, 2001
2. **E. C. Tupper**, Introduction to Naval Architecture, Butterworth-Heinemann, 2013.
3. **N. D. Bhat,** Engineering drawing, Charotar publishing house Pvt. Ltd, 2019

Reference Books:

1. **Lewis,E.U**, Principles of Naval Architecture,Vol.1, SNAME, New Jersey, U.S.A, 2010.
2. **Thomas Lamp**: Ship Design and Control Vol I & II, SNAME.

Prerequisite:

OE2023: ARINE INSTRUMENTATION LAB

Course Content::

Basics of instrumentation systems; Working principles of different transducers and their calibration : Strain gauges, Potentiometers, LVDT, Velocity probes, Inclinometers, Accelerometers, Pressure transducers, Wave probes, Load cells. Introduction to signal conditioning and data acquisition, and sources of errors in instrumentation systems

Text Books:

1. Instrumentation lab manual

Reference Books:

1. **Beckwith,T.G., Marangoni, R.D. and Lienhard, J.H.**, Mechanical Measurements, Addison Wesley, USA, 1993.
2. **Collacot, R.A.,** Structural Integrity Monitoring, Chapman and Hall, London, 1985.

Prerequisite:

ID1200: ECOLOGY AND ENVIRONMENT

Course Content:

The course is divided into different modules that are taught by different teachers: This a two credit course – with two instruction classes every week for 14 weeks. The modules and the current set of teachers are as follows: 1. Introduction to Sustainability: Dr. B.S. Murty (Civil Engg.) • Introduction • Definition of Sustainability • Sustainability Goals, • Climate Change • Case Studies (Eg: Dams, Chemicals, e-waste, IOT, Landfill siting etc) 2. Ecology : Dr. Susy Varughese (Chemical Engg.) • Ecology – definitions of Ecological Systems • Biodiversity and Examples • Historical Impact of Economy on Ecology • Restoration / Ecological Engineering 3. Energy: Dr. Srinivas Jayanti (Chemical Engg.) • Energy Demand / Resources • Pollution from Energy generation • Energy and Climate Change (Global Warming) • Energy and Sustainability • Long Range and Short Range Solutions, (Global vs. India) 4. Water Quality and Waste Management: Dr. Ligy Philip (Civil Engg.) • Water Quality and Treatment • Waste Management and Treatment • Case Studies 5. Water Management and Resources: Dr. B. S. Murty (Civil Engg.) • Urban Drainage • Water Resource Management • Impact of Climate Change 6. Sustainability – Economics/Ethics : Dr. Sudhir Chella Rajan (Humanities and Social Sciences) • Sustainability and Economics • Sustainability and Ethics • Urban Planning Sprawl and Sanitation • Transportation • Energy and Smart Grid • Water , Waste and Governance 7. Environmental Management and Life Cycle Assessment: Dr. R. Ravi Krishna (Chemical Engg.) • Risk Assessment - Definition • Pollutant Pathways / Safety/ Exposure • Liability • Life Cycle Assessment and Environmental Management • Case Study Wrap up – Emphasis on Climate Change and Adaptation Course Structure: • Online Recorded Video Lectures • Live sessions for interaction / Q&A • Assignments and Poster • Two Exams – Online on Moodle

Text Books:-

Reference Books:-

Prerequisite:

SEMESTER IV

MAXXX: MATHEMATICS ELECTIVE – II

NO COURSE NUMBER

BT1010: LIFE SCIENCES

Course Content:

Students will be exposed to basic biology concepts and their applications: What is life and how did it originate on earth? ; What is evolution?; The fundamental molecules of life (Biomolecules), cellular metabolism, energy aspects; DNA replication; Cell replication and its quantification; How are proteins made in the cell? – Transcription and translation; Mendelian genetics as a useful tool; The coordinated function of cells in a biological system – Human organ systems; Applications of life sciences in healthcare and industrial biotechnology.

Text Books:

1. **Campbell, N. A., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., and Reece, J. B,** Biology: A Global Approach, Global edition, 11th edition, Pearsons, 2017.
2. **David S.** Goodsell, The Machinery of Life, 2nd Edition, 2009, Springer

Reference Books:

1. **Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter,** Molecular Biology of the Cell, 5th Edition, 2007, Garland Science
2. **Karp, G,** Cell and Molecular Biology: Concepts and Experiments, 7th edition, Wiley, 2013.
3. **Paul Davidovits**, Physics in Biology and Medicine, 3rd Edition, 2007, Academic Press
4. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 3rd Edition, 2006, Cambridge University Press
5. **Suraishkumar G. K.,** Biology for Engineers, Oxford University Press, 2019.

Prerequisite:

NULL

OE2014: MARINE ENGINEERING

Course Content:

Introduction to marine machinery -Types of marine power systems-Engine room layout -Marine diesel engines and their cycles, Fuels Super charging, Ignition and combustion problems-Fuel oil, lubricating oil-Compressed air cooling water systems. Turbines, pumps, their types and characteristics, cavitation etc. Marine boilers, Composite boilers-Exhaust gas and heat exchangers-Economizers, Super heaters. Auxiliary machineries-Choice of power systems for ships. Fire fighting, Navigational aids, Steering gear, shafting, stern tubes and transmission system

Text Books:

1. **Harrington,R.L.** Marine Engineering, SNAME,New York (1992)
2. **Taylor,D.A.,**Introduction to Marine Engineering,Butterworths,London(1983)
3. **Woodward, J.B.,**Low Speed Marine Diesel,Ocean Engineering,A Wiley series(1981)

Reference Books:

1. Any standard text books on thermodynamics and IC engines

Prerequisite:

OE2024: ANALYSIS OF STRUCTURES

Course Content:

Work and energy theorems, Reciprocal theorem, Analysis of indeterminate frames and trusses, Unit load and conjugate beam methods, introduction to Influence lines diagram, Strain energy of beams, bars and torsion members, Matrix formulation of displacement method for frame, truss, bar and torsion members, Beam on elastic foundation and its stiffness matrix, 3D beam element, Transformation, assembly of stiffness matrices.Beam Column theory, Geometric stiffness matrix, Buckling of bars and frames, Introduction to finite element method with application to buckling; 2D and 3D theory of elasticity, Equilibrium and compatibility equations in cartesian and polar coordinates, Strain-displacement relations, Plane stress and plane strain, Use of stress function in 2D problems. Application of matrix methods to problems of marine structures.

Text Books:.

1. **L S Srinath**, “Advanced Mechanics of Solid”, Tata McGraw Hill. New Delhi, 2003
2. **F Guarracino and A Walker**, “Energy Methods in Structural Mechanics”, Thomas Telford Publishing, London, 1999.
3. **Madhulit Mukhopadhyay, Abdul Hamid Sheikh,** “Matrix and Finite Element Analysis of Structure”, Ane Books Pvt Ltd, New Delhi., 2009.

Reference Books:

1. **R D Cook, D S Malkus and M E Plesha**, “Concepts and applications of Finite Element Analysis”, John Wiley & Sons, 1988
2. **D Menon**, “Structural analysis”, Narosa, New Delhi, 2010.
3. **D Menon**, “Advanced Structural analysis”, Narosa, New Delhi, 2010

Prerequisite:

OE2034: SHIP RESISTANCE AND PROPULSION

Course Content:

Components of resistance; Form factor; Wave making resistance - ship wave systems,interference effects, theoretical calculation of wave making resistance, wave breaking resistance, bulbous bows and their effects.Dimensional analysis - laws of comparison – geometrical, dynamical and kinematical similarity,Newton’s, Froude’s and Reynold’s laws, model-ship correlation; Model testing – tank testing facilities, testing, prediction of resistance from model tests, extrapolation (ITTC 78), Froude's Concept, laminar influence and tank wall effect, comparison of resistance prediction with results of full scale trials. Air and wind resistance, resistance of appendages, added resistance in waves; Resistance in restricted waterways – resistance in shallow water, resistance in canals; Determination of resistance from series test results; Resistance of planing crafts, multi-hull vessels, hovercrafts,hydrofoils, SES. Introduction to different propulsion systems in ships; Screw propeller-screw propeller geometry,sections, propeller drawing; Propeller theories - momentum theory, blade element theory,circulation theory.Interaction between hull and propeller- wake and wake fraction; thrust deduction factor,propulsive efficiency in open water and behind conditions, hull efficiency, quasi propulsive coefficient; Powering; Cavitation - types, cavitation number, effects of cavitation, prevention of cavitation, design for minimum cavitation, cavitation tests. Propeller design - propeller series, open water diagrams, design charts; Propeller design and performance study using design charts; Engine selection; Propeller model tests - test facilities,laws of comparison, open water test, self propulsion test; Strength of propellers Practicals: 1. Resistance calculation using Guldhammer - Harvald series 2. Shallow water resistance calculation 3. Propeller design using series chart 4. Propeller drawing Experiments: 1. Model test for ship resistance determination 2. Flow-line test for identifying bilge keel position 3. Propeller model open water test in towing tank 4. Model test for wake fraction determination 5. Self propulsion model test for thrust deduction fraction determination

Text Books:

1. **John Letcher, Randolph Paulling**: Principles of Naval Architecture series-Ship Resistance and flow, SNAME, U.S.A., 2009.
2. **Antony F Molland, Stephen R turnock**, Ship resistance and propulsion-practical estimation of propulsive power,2011.

Reference Books:

1. **Harvald S.A.**; “Resistance and Propulsion of Ships”, John Wiley & Sons., 1983. 137
2. **John Carlton**, Marine Propellers and propulsion, 2007. Baker George Stephen, Ship form, Resistance and screw propulsion, Hard press publishing, 2013.
3. **D. W. Taylor** ; Resistance of Ships and Screw Propulsion, Unikum, 2012.
4. **J P GHOSE and R P GOKARN**. Basic Ship Propulsion, KW Publishers Pvt Ltd. 2015.

Prerequisite:

OE2054: OCEAN WAVE HYDRODYNAMICS

Course Content:

Review of Basic Fluid Mechanics: Conservation of mass and momentum, Euler Equations, Bernoulli's equation, velocity potential, stream function. Ocean Environment, Waves: Classification of water waves – Two-dimensional wave equation and wave characteristics – wave theories – Small amplitude waves – Finite amplitude waves – Stokian, Solitary and Cnoidal wave theories – Water particle kinematics – wave energy, power. Wave deformation – Reflection, Refraction, Diffraction, Breaking of waves – Spectral description of Ocean Waves – Design wave. Wave-Currents Interactions, Radiation Stress. Forces: Wave forces – Morison equation – Wave loads on vertical, inclined and horizontal cylinders. Diffraction theory – wave slamming and slapping. Lab : Measurement of wave properties such as L, H, T, C and Cg. Wave Reflection, pressure measurements, force estimations, mass transport velocity, random waves, wave paddle transfer function

Text Books:

1. **Dean, R.G. and Dalrymple, R.A**., Water wave mechanics for Engineers and Scientists, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1994

ReferenceBooks:

1. **Sarpkaya, T. and Isaacson, M**., Mechanics of Wave Forces on Offshore Structures, Van Nostrand Reinhold Co., New York, 1981
2. **Weigel, R.L**.Oceanographical Engineering, Prentice Hall Inc, 1982
3. **Sorenson, R.M.,** Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978.

Prerequisite:

SEMESTER V

OE3015: SHIP STRUCTURAL ANALYSIS

Course Content:

Loads acting on ships; Longitudinal strength-shear force and bending moment-still water and wave loads-deflections unsymmetrical bending-bending stresses and design of mid-ship section, Shear flow analysis of multi-cell sections-Torsional analysis-Warping torsion-Determination of shear and normal stresses-shear lag and effective breadth. Bending of plates-stiffened, plates-orthotropic, plates-large deflection theories and applications. Buckling and ultimate strengths of columns, plates and stiffened panels-concept of effective width-ultimate strength of the hull girder. Finite elements for simple plated structures-use of computer packages for the analysis of ship structures. Review of SDOF systems, Sources of ship vibrations – propeller excited, wave-induced and machinery – Calculation procedure for torsional vibration of propulsion systems – empirical methods. Hull girder vibration. Practicals: 1. Longitudinal strength calculation for ships 2. Transverse strength calculation for ships

Text Books:

1. **Hughes, O.E,** Ship Structural Analysis and Design, SNAME , 2010
2. **Mansour, A. and Liu, D**. Strength of Ships and Ocean Structures, PNA series, SNAME 2008

Reference Books:

1. **Jensen, J.J**, Load and Global Responses of Ships, Elsevier, 2001
2. **Bai, Y**. Marine Structural Design, Elsevier, 2003

Prerequisite:

OE3035: MOTION OF SHIPS & FLOATING SYSTEMS

Course Content:

Ship motions – coordinate systems, 6 dof, uncoupled and coupled equation of motion; hydrodynamic coefficients; encounter frequency; motion damping effects, magnification and tuning factors. Ship responses in regular waves. Ship in seaway and dynamic effects – Linear superposition, response amplitudes operator, motions in irregular waves, local and relative motions, green water effects, slamming, parametric rolling, broaching, added resistance, powering in waves; motion sickness. Linear wave induced motions on floating structures- Responses in regular and irregular seas, Wave induced motions and loads on a tension leg platform and spar. Heave and pitch motion of a semi-submersible, discussion of natural period, damping and excitation. Ship and floating system motion control – Control of roll - bilge keel, free surface tanks, U-tanks, moving weight;, fin stabilisers, gyro, active-tank;, rudder stabilization; Control of pitch. Practical : 1. Estimation of hydrodynamic coefficients and RAOs using strip theory. Experiments: 2. Roll and heave damping coefficient estimation using free oscillation tests 3. Ship and floating body motion response in regular waves

Text Books:

1. **Lewis,E.U**, Principles of Naval Architecture, SNAME, New Jersey, U.S.A, 2010.
2. **Lewandowski, E.M.** The Dynamics of Marine Crafts – Seakeeping & Maneuvering, World Scientific, 2004

Reference Books:

1. **Faltinsen, M.O.** Sea Loads on Ships and Offshore Structures, Cambridge Ocean Technology Series, 1999
2. **Bhattacharyya..R**; ‘Dynamics of Marine vehicles’, 1978, Wiley Inter Science, New York
3. **Faltinsen, M.O**. Hydrodynamics of High Speed Marine Vehicles, Cambridge Press, 2005

Prerequisite:

OE3016: SHIP DESIGN

Course Content:

Marine transportation and trade routes, ship categorization - dead-weight carrier, capacity carrier, linear dimension ship; Service ships and offshore support vessels; Advanced marine vehicles; Ship design requirements. Ship design methods – design using basic type ships, design using coefficients, design using iteration methods; design spiral; Ship parameters – displacement, displacement coefficient, displacement equation, volume equation, solution of the cubic equation; Ship dimensions, hull form, form coefficients; Mass estimation - lightship mass – steel mass, outfit mass, engine plant mass; dead weight. Design of hull form – conventional method of lines, distortion of existing forms; stem and stern contours, bulbous bow.; General arrangement - Subdivision of the ship's hull and erections, arrangement of spaces, arrangement of tanks, superstructure and deckhouses, arrangement of engine plants, cargo handling capacity, hold capacity and stowage factor. Effect of form on Ship's performance: Freeboard and load line regulation; Stability – stability booklet, IMO Regulations, Checks on stability, trim; Watertight integrity; damage stability, Behaviour of ships in sea, resistance, powering, propulsion Cargo handling equipment, cargo hatches; Anchoring and mooring systems; Accommodation requirements, layout and design. Access equipment –hatches, manholes, doors, other closing & opening devices, load line rules, gang ways and ladders; LSA and FFA; Steering gear systems, navigational systems. Tender specification; Economic considerations in ship design and building; Operational Economics; Introduction to ship design softwares. Practicals: 1. Computer-Aided ship design - owner's requirement of ship (given), design of main dimensions, design of form, weight estimation, hydrostatics, checks on stability, trim, capacity, general arrangement, etc. 2. Practicals on softwares dealing with basic ship calculations and ship design.

Text Books:

1. **D.G.M.Watson**, "Practical Ship Design", Elsevier 2002
2. Thomas Lamb, "Ship Design and Construction", SNAME 2003
3. ApostolosPapanikolaou, Ship Design: Methodologies of preliminary design, SNAME,2014.

Reference Books:

1. **Schneekluth, H**; Ship Design for Efficiency and Economy, Butterworths, 1987
2. **Taggart**; Ship Design and Construction, SNAME, 1980.
3. **IndraNath Bose**, Energy Efficiency and Ships, SNAME, 2012.
4. **Antony F Molland**, A Guide to ship design, construction and operation, SNAME, 2008

Prerequisite:

OE3045: VIBRATION OF MARINE STRUCTURES

Course Content:

Equations of motion, D'Alembert's principle. Analysis of single degree of freedom systems (free and forced), Dynamic amplification factor and resonance, Viscous and structural damping, Impulse response system, Time & Frequency domain methods, Duhamel integral, Vibration isolation, Concept of Lagrange • Discrete MDOF systems, Modes of vibration, Normal modes, Natural frequencies, modal Participation factor, orthogonality applications, forced vibration using eigen functions expansions, vibration absorbers, Shear building models • Continuous systems: Vibration of cables, rods and beams – Sources of vibration – propeller excited, wave-induced and machinery, Hull girder vibration. • Dynamic effects of earthquake, wind and moving loads, vehicular impacts. Random vibrations, Calculation procedure for torsional vibration of propulsion systems – empirical methods. • Approximate methods, Rayleigh's quotient, Rayleigh Ritz and Galerkin methods.

Text Books:

1. **L Meirovitch** 1997, Principles of techniques of vibration, Prentice Hall, NJ
2. **A K Chopra** 2007, Dynamics of structures, Pearson Education India.
3. **R W Clough and J Penzien** 2015, Dynamics of Structures, CBS Publishing; 2nd edition.
4. **S. S. Rao** 2019, Vibration of Continuous Systems, Wiley-Blackwell.
5. **E. V Lewis** 1990, Principles of Naval Architecture, SNAME

Reference Books:

1. **L Fryba** 2012, Vibration of solids and structures under moving loads, Springer
2. **R. D. Blevins** 2006, Flow-Induced Vibration, Krieger Publishing Company
3. **M.Y.H. Bangash** 2009, Shock, Impact and Explosion: Structural Analysis and Design, Springer.
4. **J. P. Den Hartog** 1985 Mechanical Vibrations, Dover
5. **L. Meirovitch** 2007, Methods of Analytical Dynamics, Dover.
6. **L D Lutes and S Sarkani**, “Random Vibrations”, Elsevier Butterworth, Burlington, USA, 2004

Prerequisite:

OE3190: DESIGN OF OCEAN STRUCTURES

Course Content:

Coastal Structures:Design principles of breakwater, seawall, groynes, berthing structures, quay walls and open sea jetty, breasting and mooring dolphins; Dry Docks, Slipways; Code Provisions : IS 4651, IS 2911 and BS 6349 Offshore Structures:Concepts and design principles of jacket and topside structures,Tension Leg Platforms, Spar Structures, Jackups and FPSO's; Concepts and design of foundation for offshore structures; Code Provisions : API RP 2A and API RP2T.

Text Books:

1. Coastal Hydrualics by **A.M.M. Wood and C.A. Fleming**, Macmillan Press Limited, 1981.
2. Coastal Engineering by **K. Horikawa**, University of TokyoPress, 1978
3. Design and Construction of Port and Marine Structures by **A. D. Quinn**, McGraw-Hill Book Company
4. Port Design : Guidelines and recommendations by **C. A. Thoresen**, Tapir Publications
5. Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels by **J. W. Gaythwaite**, VanNostrand;

Reference Books:

1. Handbook of Offshore Engineering by **S.K. Chakrabarti**, Elseviers, 2005

Prerequisite:

Core Course

FREE ELECTIVE – I

SEMESTER VI

OE3036: MANOEUVRING AND CONTROL OF MARINE VEHICLES

Course Content:

Controllability fundamentals of ships and submarines–Introduction- Kinematics of rotating frame, Nonlinear 6-DoF and 3-DoF rigid body equation of motion, nonlinear and linear hydrodynamic derivatives, linear equations of motion for ship, longitudinal and lateral models for submarines, stability indices; Stability and control in the horizontal and vertical planes; Munk moment Definitive manoeuvres – turning tests, overshoot and zigzag tests, spiral and pullout tests, accelerating, stopping and backing tests. Control surface hydrodynamics – rudder geometry, aspect ratio, influence of fixed structures; Control surface design - specification of requirements and constraints on rudder design, types of rudder, rudder stock; Influence of ship features on controls fixed stability. Experimental determination of hydrodynamic derivatives - straight line test, rotating arm technique, planar motion mechanism; Numerical methods used in ship manoeuvring problems, ship manoeuvring simulators; IMO Rules and Recommendations. Ship manoeuvring sea trials. Control fundamentals-introduction-(Linear and nonlinear control, PID) , Linear system representation, first and second order Nomoto Equation, State-space modelling, Converting State-space model to transfer function, PD & PID controllers, Tuning, PID controller with acceleration feedback Practicals : 1. Calculation of free stream characteristics of rudder. 2. Rudder design – dimensions, form, structure and system Experiments: 1. Straight line test in towing tank 2. PMM tests in the towing tank 3. Free running models tests in the basin

Text Books:

1. **Lewis,E.U,** Principles of Naval Architecture, SNAME, New Jersey, U.S.A, 2010.
2. **Fossen, T.I,** Guidance and Control of Marine Vehicles, John Wiley & Sons, 1999
3. **Molland,A.F and Turnock, S.R.,** Marine Rudders and Control Surfaces, Elsevier, 2007
4. **Lewandowski, E.M**. The Dynamics of Marine Crafts – Seakeeping & Maneuvering, World Scientific, 2004

Reference Books:

1. **Abkowitz,M.A**.; Lectures on Ship Hydrodynamics – Steering and Manoeuvrability, Danish Technical Press, Copenhagen, Denmark, 1964
2. Lecture notes – Maneuvering and control of marine vehicles**, Michael S. Triantafyllou, Franz S. Hover** , Department of Ocean Engineering Massachusetts Institute of Technology Cambridge, Massachusetts USA
3. **Khac Duc Do and Jie Pan**, Control of Ships and Underwater Vehicles , Springer, 2009
4. **Faltinsen, M.O**. Hydrodynamics of High Speed Marine Vehicles, Cambridge University Press, 2009
5. **Newman J.N**; ‘Marine Hydrodynamics’, MIT Press, USA, 1977

Prerequisite:

OE3046: SHIP STRUCTURAL DESIGN

Course Content:

Review on Shipbuilding materials, joining techniques, structural design steps, basic approach and use of classification rules. Ship framing systems; Structural systems and components at bottom, side, deck, bulkheads, fore-end, aft-end, engine room and their design using classification rules. Design of superstructures, accommodation area, forecastle, hatch covers, chain locker, rudder, cargo handling systems, nozzle, etc. Practicals: 1. Structural design and drawing of mid-ship section, fore-peak, aft-peak, engine room, bulkhead, rudder 2. Shell expansion drawing

TextBooks:

1. **Taggart;** Ship Design and Construction, SNAME, 1980.
2. **Eyres D.J.;** Ship Construction, William Heinemann Ltd, London, 2011.
3. **Okumoto,Y.** Design of Ship Hull Structures- A practical guide for Engineers, Springer – Verlag, 2009.

ReferenceBooks:

1. **Jensen, J.J**, Load and Global Responses of Ships, Elsevier, 2001
2. **Bai, Y**. Marine Structural Design, Elsevier, 2003
3. **Paik, J.K and Thayamballi, A.K.**, Ultimate Limit State Design of Steel-Plated Structures, John Wiley, 2003

Prerequisite:

FREE ELECTIVE – II

FREE ELECTIVE – III

FREE ELECTIVE – IV

FRE ELECTIVE – V

HONOURS ELECTIVE – I -

OEXXX – NO COURSE NUMBER

SUMMER

OE3026: SHIPYARD TRAINING

Course Content:

As per industry requirements in concurrence with one faculty advisor

Text Books:

As per manuals from instructor

Reference Books:

As per manuals from instructor

Prerequisite:

SEMESTER VII

OEXXXX – PROFESSIONAL ELECTIVE – I

NO COURSE NUMBER

OE4051: NAVAL ARCHITECTURE AND OCEAN ENGINEERING BTECH PROJECT - PHASE I

Course Content:

Students should be able to find out the appropriate numerical/analytical/ experimental tools required and learn them. The pilot problem as well as the hands-on experience in the tools (analytical, numerical and experimental) should be finalized so as to obtain results from the proposed research

Text Books:

1. As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Reference Books:

1. As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Prerequisite:

FREE ELECTIVE – VI

FREE ELECTIVE – VII

HONOURS ELECTIVE – II

SEMESTER VIII

HUMANITIES ELECTIVE – III

OE4052: NAVAL ARCHITECTURE AND OCEAN ENGINEERING BTECH PROJECT - PHASE II

Course Content:

Experiments and /or simulations and / or computations related to the project. Analysis of outcomes and presentation of the results from the proposed research. Present any theoretical proofs of any new methods / findings (if applicable).

Text Books:

1. As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Reference Books:

1. As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Prerequisite:

FREE ELECTIVE – VIII

HONOURS ELECTIVE – III

LIST OF ELECTIVES

ELECTIVE A: MATHEMATICS

MA2010: COMPLEX VARIABLES

Course Content:

Analytic functions: Limits and continuity, differentiability and analyticity, analytic branches of inverse of functions, branches of logarithm, Cauchy-Riemann equations, harmonic conjugates. Complex integral: Cauchy's theorem and integral formula, series of complex functions and the Weierstrass M-test, Taylor series, identity theorem, isolation of zeros of an analytic function, statements of open mapping, inverse function, Liouville's theorem, fundamental theorem of Algebra. Residue Calculus: Singularities and their classification, Laurent series, residue theorem and argument principle, computing real integrals using residues. Bilinear transformation: Bilinear transformation, conformal mapping, elementary properties of the mapping of exponential, sine and cosine functions. Complex integrals: Line integral, Cauchy's integral theorem and integral formula, Taylor and laurent series, Residue theorem and applications, Bilinear transformations. Transforms: Fourier transformations Fourier transforms (exp, sin, cos), Laplace transforms inversion integrals, Convolutions, Applications.

Text Books:

1. **E. Kreyszig**, Advanced Engineering Mathematics, 10th Ed., John Willey & Sons, 2010.

Reference Books:

1. **R.V Churchill & J.W. Brown:** Complex Variables and Applications, Mc-Graw Hill, 1990.
2. **S. Ponnusamy and H. Silverman**, Complex Variables with Applications, Birkhauser, 2006.

Prerequisite:

NULL

MA2030: DIFFERENTIAL EQUATIONS

NO DATA

MA2040: PROBABILITY, STATISTICS AND STOCHASTIC PROCESS

Course Content:

Probability: Probability models and axioms, conditioning and Bayes' rule, independence discrete random variables; probability mass functions; expectations, examples, multiple discrete random variables: joint PMFs, expectations, conditioning, independence, continuous random variables, probability density functions, expectations, examples, multiple continuous random variables, continuous Bayes rule, derived distributions; convolution; covariance and correlation, iterated expectations, sum of a random number of random variables. Stochastic processes: Bernoulli process, Poisson process, Markov chains. Weak law of large umbers, central limit theorem. Statistics: Bayesian statistical inference, point estimators, parameter estimators, test of hypotheses, tests of significance.

TextBooks:

1. **D. Bertsekas and J. Tsitsiklis**, Introduction to Probability, 2nd ed, Athena Scientific, 2008.

ReferenceBooks:

1. **K.L. Chung**, Elementary Probability Theory with Stochastic Process, Springer Verlag, 1974.
2. **A. Drake**, Fundamentals of Applied Probability Theory. McGraw-Hill, 1967.
3. **O. Ibe**, Fundamentals of Applied Probability and Random Processes, Academic Press, 2005.
4. **S. Ross**, A First Course in Probability. 8th ed. Prentice Hall, 2009.

Prerequisite:

NULL

MA2060: DISCRETE MATHEMATICS

Course Content:

Sets and cardinality. Propositional logic, predicates and quantification, Methods of proof. Modular Arithmetic: Divisibility, modular arithmetic, prime numbers, induction proofs. Introduction to graphs: Graphs, paths, connectivity. Combinatorics: Counting, Binomial theorem and Bijective counting.. pigeonhole principle, inclusion-exclusion principle, generating functions and recurrences. Discrete Probability: Probabilistic counting (after introducing Probability, independence, random variables, expectation).

Text Books:

1. **Kenneth .H. Rosen**, Discrete Mathematics and its Applications, 7th Ed., McGraw Hill, 2012.
2. A walk through combinatorics - **Miklos Bona**, 4th edition. World scientific.

Reference Books:

1. Elements of Discrete Mathematics - **C L Liu, D Mohapatra**. 4th edition. Mcgraw Hill. 2017.

Prerequisite:

MA2130: BASIC GRAPH THEORY

Course Content:

Fundamentals:Graphs, subgraphs, isomorphism, representation of graphs, degrees and graphic sequences, walks, trails, Paths, Cycles, connectivity, bipartite graphs Trees: Characterisations of trees, minimum -spanning -trees, number of trees, cayley's formula connectivity: cut-seats, characterization of blocks. Search algorithms: DS,BFS, shortest peth algorithms, identification of cut-vertices and cut-edges. Eulerian and Hamilton graph; Characterizations, Necessary / sufficient conditions, Fleury's algorithms. Converings, independent sets:Basic relations, Matchings in bipartite graphs, Tutte's perfect matching theorem and consequences. Colorings, Edge-colorings of bipartite graphs, Gupta Vizing's theorem (without Proof), greedy algorithm for vertex-colorings, Brook's theorem, clique-number and vertex shromatic number. Planar graphs: Euler's formua V-E+F=2 and its consequences, Kuratowski's Characterization(without proof), DMP planarity algorithm. Direct graphs: Basics, various connectivities and tournaments.

Text Books:

1. **J.A.Bondy and U.S.R.Murthy**; Graph theory with applications, Macmillan (1976)

Reference Books:

1. **D.B.West**; Introduction to graph theory, P.H.I.(1999).

Prerequisite:

NULL

ELECTIVE (E) – PROFESSIONAL FOR NA & OE (B.TECH & DD)

ME3350: DESIGN OF MACHINE ELEMENTS

NO DATA

MM3012: JOINING & NDT LAB

Course Content:

Demonstration of joint preparation for welding. Demonstration of manual metal arc welding, gas tungsten arc welding, plasma arc welding, gas metal arc welding and resistance spot welding with regard to equipment details, operational parameters and execution of the process. Demonstration of Liquid penetration testing, Magnetic particle testing, Ultrasonic testing and Radiographic testing and familiarization with corresponding equipment.

Text Books:

NA

Reference Books:

NA

Prerequisite:

MM3060: METAL JOINING TECHNOLOGY

NO DATA

MM5320: CORROSION ENGINEERING

Course Content:

Corrosion principles: Electrochemical aspects, environmental effects, metallurgical aspects, economics of corrosion Thermodynamical aspects: Electrified interface (metal-electrolyte interface), potential difference, EMF series, Nernst Equation and Pourbaix diagram Kinetic aspect: Corrosion rate, Current density, Exchange current density, Mixed potential theory, Polarization, relation between corrosion rate and overpotential, Passivation Forms of corrosion characteristics, mechanisms, prevention, and testing. Corrosion testing: DC and AC methods of testing, polarization measurements- Corrosion rate assessment by Tafel's extrapolation method, Linear polarization resistance (LPR).

Text Books:

1. Corrosion Engineering, **Mars. G. Fontana**. Published by Tata McGraw Hill Education Pvt. Ltd., 2005.
2. Electrochemical Techniques in Corrosion Science and Engineering. **R.G. Kelly, J.R. Scully, D.W. Shoesmith, R.G. Buchheit**. Published by Marcel Dekker Inc., 2002

Reference Books:

1. Corrosion: Metal / Environment Reactions, Volume 1, **L.L. Shreir, R.A. Jarman, G.T. Burstein, Butterworth-Heinemann**, 1994.
2. Principles and Prevention of Corrosion, **Denny A. Jones**, Prentice Hall, 1995.
3. Corrosion and Surface Chemistry of Metals, **Dieter Landolt**, EPFL Press, 2007.
4. Corrosion of Stainless Steels, **A. John Sedriks, Wiley**-Interscience, 1996.

Prerequisite:

NIL

MM5750: WELDING APPLICATION TECHNOLOGY

Course Content:

Testing of Weldments: destructive and non-destructive. Fatigue behaviour of welded structures. Brittle fracture: metallurgical considerations. Notch toughness, transition temperature and their dependence on various factors. Fracture mechanics approach: plane strain toughness and crack opening displacement criteria, J-integral and R-curve method, application of above concepts in toughness characterization of weldments. Economics of welding: Cost evaluation and selection of process, comparison with other fabrication techniques. Training of welding personnel, safety precautions. Quality control in welding, standards and codes. Application of welding technology in a few industries. Pressure vessel fabrication, chemical industry, nuclear reactors, ship and offshore structures, aviation, automotive and railroad industries.

Text Books:

1. Advanced welding processes – Technologies and Process Control by **John Norrish**, ISBN: 978-1-84569-130-1., Woodhead Publishing, reprint by Elsevier, 2006.
2. Welding Engineering and Technology by **R.S. Parmar**, Khanna Publishers., ISBN: 81-7409-028-2, 2010

Reference Books:

1. International Institute of Welding – Codes and Standards (iwelding.sharepoint.com)
2. **Li, Leijun. et. al**. eds.. ASM Handbook: Welding Fundamentals and Processes, vol. 6A. Materials Park, OH: ASM International, 2011.

Prerequisite:

NIL

OE4300: OCEAN ENERGY

Course Content:

Importance of generation of Ocean Energy, Various forms of ocean energy, Generation of waves ; Wave theories Systems generating power from oceans Offshore Wind – Wind as an offshore resource, wind loads and aerodynamics. Wave load and hydrodynamics, Design loads for wind turbines- wind and wave spectra, Support structures – fixed and floating. Offshore Waves -- Major forms of ocean wave energy devices, Physics behind conversion – interaction between oscillation and waves, Hydrodynamics of devices, Wave energy resource- wave spectra analysis and design loads, Tides, Currents and Thermal gradients - Energy From Tides, Currents and Offshore Thermal Energy Conversion (OTEC), Tide and Current Generation, OTEC System Concepts – Open and Closed System. Special reference to Indian scenarios in each case

Text Books:

1. Energy Harvesting Solar, Wind, and Ocean Energy Conversion Systems: Authors: **Alroza Khaligh Omar G. Onar.**
2. Offshore Wind Power. Authors: **J Twidell and G Gaudiosi**
3. Wind Energy Explained: Theory, Design and Application. Authors: **JF Manwell, JG McGowan and AL Rogers**
4. Ocean Wave Energy: Current Status and Future Perspectives. Author: **Joao Cruz.**
5. Ocean Energy: Tide and Tidal Power. Authors**: R. H. Charlier and Charles W. Finkl**
6. Renewable Energy From the Ocean: A Guide to OTEC (Johns Hopkins University Applied Laboratory Series in Science and Engineering) 1994 Authors: **William H. Avery and Chih Wu**

Reference Books:

1. Wind Energy Handbook. Authors: **T Burton, N Jenkins, D Sharpe and E Bossanyi**.
2. Ocean Waves and Oscillating Systems: Linear Interactions Including Wave-Energy Extraction. Author: **Johannes Falnes**

Prerequisite:

OE4400: DRILLING VESSELS AND SUPPORT CRAFTS – NO DATA

OE4600: ADVANCED SHIP HYDRODYNAMICS

Course Content:

i. Introduction. Review of basic hydrodynamics, wave mechanics and complexities of practical Ship Hydrodynamics problems. ii. Navier-Stokes Equation: Formulation and derivation of ship hydrodynamics in real fluids. Some exact solutions including of impulsively started plate. Boundary-Layer theory. Blasius solution. Friction lines of ships. iii. Computational Fluid Dynamics: Introduction to boundary-integral and finite-difference methods applied for ship hydrodynamics problems. Application of vortex-lattice and panel methods for lifting surface hydrodynamics. iv. Approximate Methods: Slender body theory; Strip theory for determining ship motion in waves. Michell's thin ship theory to determine wave resistance.

Text Books:

1. **Faltinsen, M.O**. Hydrodynamics of High Speed Marine Vehicles, Cambridge Press, 2005
2. **Newman J.N**; 'Marine Hydrodynamics', MIT Press, USA, 1977

Reference Books:

1. **Newman J.N**; 'Theory of Ship Motions', Advances in Applied Mechanics, Vol., 1980.

Prerequisite:

OE4XXX: SHIPBUILDING MATERIAL & PRODUCTION PROCESSES – NO COURSE NUMBER

OE5011: MARINE ROBOTICS

Course Content:

Introduction to marine robotics and robotic configurations; autonomous underwater gliders (AUGs), autonomous underwater vehicles (AUVs), and remotely operated underwater vehicles. Actuation and sensing systems; communication; manipulation; interaction; guidance, navigation and control; and mission control systems. Algorithms for simultaneous localization and mapping (SLAM), fault detection/tolerance systems; multiple coordinated vehicles; and networked vehicles. Signature detection, analysis and optimization; sensor networks for radar, sonar and navigation; design of propulsion systems; and trajectory measurements and simulations. Design and analysis of thrusters for AUGs/AUVs, motion prediction and control systems, and co-operative adaptive sampling techniques. Design of variable buoyancy systems for UVs. Design of DCDM based controllers for UVs. Remote sensing and environmental monitoring with AUGs/AUVs, underwater vehicle-manipulator systems, bio-mimetic underwater robotics, and bio-inspired robotic systems. Case studies from India, Republic of Korea, Japan and USA.

Text Books:

1. **T. Fossen** (1994), “Guidance and Control of Ocean Vehicles”, Chichester New York, USA.
2. **J. N. Newman** (1997), “Marine Hydrodynamics”, MIT Press, USA.
3. **T. Fossen** (2002), “Marine Control Systems: Guidance, Navigation and Control of Ships, Rigs and Underwater Vehicles”, Marine Cybernetics, Trondheim, Norway

Reference Books:

1. **K. D. Do and J. Pan** (2009), "Control of Ships and Underwater Vehicles: Design for Underactuated and Nonlinear Marine Systems", Advances in Industrial Control, 1st edition, Springer, Germany.
2. **G. Griffiths** (2002), "Technology and Applications of Autonomous Underwater Vehicles", Ocean Science and Technology, Vol. 2, CRC Press, USA.
3. **R. Sutton and G. Roberts** (2006), "Advances in Unmanned Marine Vehicles", IEE Control Series, Institution of Engineering and Technology, USA.

Prerequisite:

Consent of teacher

OE5080: MARINE INSTRUMENTATION

Course Content:

Dynamic response of measuring instruments (with examples), acoustic instruments and transducers, CTD construction and operation, expendable ocean instruments, current profilers, strain gauges, acoustic positioning systems, sampling, spectral analysis, basic filtering, measuring system response using spectral analysis (magnitude and phase response), optical instruments.

Text Books:

1. "Mechanical Measurements," by **Thomas G. Beckwith, Roy D. Marangoni, and John H.Lienhard V**, 6th Edition, 2009
2. "Encyclopedia of OceanSciences" 2nd Edition Six Volumes set, 2009 ISBN9780122274305 published by Academic Press

Reference Books:

1. "Mechanical Measurements," by **Thomas G. Beckwith, Roy D. Marangoni, and John H.Lienhard V**, 6th Edition, 2009
2. "Encyclopedia of OceanSciences" 2nd Edition Six Volumes set, 2009 ISBN9780122274305 published by Academic Press

Prerequisite:

NIL

OE5170: OCEAN ACOUSTICS

Course Content:

Introduction. Physical properties of seawater. Effects of density, salinity and temperature on sound speed. Underwater sound channels (USC). Surface and bottom effects. Ambient noise. Sound Propagation: Wave equation;Helmholtz equation; Lighthill's acoustic analogy; Point source and plane wave solutions; Refraction of sound waves; Snell's Law; Caustics and shadow zones; Ray theory. Reflection and Transmission: Changes at an interface between two immiscible liquids. Transmission of sound from air to water and vice versa; Reflection from ocean bottom; Propagation of sound in shallow water. Sound propagation in Underwater Sound Channel (USC): Ray theory for USC; Munk's model; Acoustic field as sum of normal modes; Analysis based on a parabolic equation, Scattering of Sound: Scattering at rough boundary surfaces; Method of small perturbation (MSP); Scattering of sound by surface waves and internal waves. Sound Radiation: Generation of sound by marine vehicles and offshore platforms. Acoustics Applications: Remote sensing; Underwater communication; Sonar principle and use; Acoustic tomography; Geophysical seismic exploration.

Text Books:

1. **Kinsler, Frey, Coppens and Sanders**, "Fundamentals of Acoustics", 4th edition, 1999.

Reference Books:

1. **L. M. Brekhovskikh and Yu. P. Lysanov**, "Fundamentals of Ocean Acoustics," Springer Series on Wave Phenomena (Edited by L.B. Felsen), Springer-Verlag, 1982. 2. Class and lecture notes

Prerequisite:

NIL

OE5230: FOUNDATION OF OFFSHORE STRUCTURES

Course Content:

Basic Soil Mechanics: Basic soil properties, correlation between engineering parameters, geotechnical investigation, bore log.Pile foundation: Jacket main piles, skirt piles, driven piles, drilled and grouted piles, steel and concrete piles, axial capacity, point bearing and skin friction, factor of safety, lateral load on piles, p-y, t-z and q-z curves, pile group effect, scour around piles, seabed subsidence and design of piles against seabed movement, negative skin friction, cyclic degradation, main pile to jacket connections, skirt pile to jacket connections, API RP 2A provisions.Pile Installation: Minimum pile wall thickness, pile handling stresses, static and dynamic stresses, pile stickup, stresses during stickup, wave and current loads, hammer selection, pile driving stresses, wave equation analysis, pile driving fatigue, API RP 2A guidelines.Pile Testing: Working load test, ultimate load test, pile monitoring during driving, pile integrity testing, high strain dynamic testing, rebound method.Special Foundations: Mud-mats : bearing capacity, sliding stability, overturning stability, short term and long term settlements, factor of safety; Bucket foundation; Suction anchors; Gravity foundation.Design exercises on axial capacity of piles, lateral capacity and load deflection of laterally load piles estimation of mudmat bearing capacity; group effect etc.

Text Books:

1. Pile Design and Construction by **M. J. Tomlinson, E & FN Spon,** 1994.

Reference Books:

1. Handbook of Offshore Engineering by **S.K. Chakrabarti**, Elseviers, 2005.
2. Foundation analysis and design by **J. E. Bowles**, McGraw-Hill, 19884.
3. Construction of Marine and Offshore Structures by **Ben C. Gerwick**, CRC Press, 1999.

Prerequisite:

OE5310: GUIDANCE & CONTROL OF MARINE VEHICLES

Course Content:

Controllability, elements of ship motion control system, ship motions, coordinate transformation, basic equations of motion, hydrodynamic forces during a maneuver, force derivatives, model tests, linearised equations of motion, types of stability, ship maneuvering mathematical models – linear, nonlinear coupled and uncoupled, standard maneuvering tests, free-running model tests, IMO maneuvering criteria, numerical and experimental determination of hydrodynamic derivatives, ship motion control. Control surface and devices, rudder design, automatic control of ships – open and closed loop systems, dynamic positioning of ships, roll and pitch stabilization, control of high-speed vessels, Remotely operated vehicles, autonomous underwater vehicles, equations of motion of underwater vehicles, stability and control of underwater vehicles.

Text Books:

1. **T.I.Fossen**, "Guidance and Control of Marine Vehicles", John Wiley & Sons, 1994.
2. **E,V.Lewis**, "Principles of Naval Architecture", Vol.3, SNAME, 1989
3. **Lewis,E.U**, Principles of Naval Architecture, SNAME, New Jersey, U.S.A, 2010.
4. **E.M.Lewandowski**, "The Dynamics of Marine Crafts – Manoeuvring and Seakeeping", World Scientific, 2004

Reference Books:

1. **A.F.Molland and S.R.Turnock**, "Marine Rudders and Control Surfaces", Elsevier, 2007
2. **O.M.Faltinsen**, "Hydrodynamics of High Speed Marine Vehicles", Cambridge University Press, 2005.
3. **T.Perez**, "Ship Motion Control", Springer, 2005
4. **T.I.Fossen**, "Handbook on Marine Craft Hydrodynamics and Motion Control", Wiley, 2011

Prerequisite:

B.Tech/DD /M.Tech/MS/PhD in Naval Architecture & O

OE5320: NONLINEAR PROBLEMS IN OCEAN ENGINEERING

Course Content:

Nonlinearity – definition and sources; examples of offshore systems involving nonlinear analysis Degrees of freedom, Generalized coordinates, Behaviour of Dynamical systems about Equilibrium points, System with non-linearity, Conservative and Non-conservative systems – Nonlinear Stiffness and damping.- Duffing, van-der-Pol equation Analytical solutions – Perturbation solution Forced oscillations – Sub and super harmonic motions; Chaotic motions. Systems with periodic coefficients- Mathieu's equations, Floquet's theory, Stability; Moorings, Nonlinear wave theories and wave loading; Responses of structures excited by Second-Order Effects; Nonlinear wave loading on large floating systems, Random response and statistical analysis.

Text Books:

1. Nonlinear Methods in Offshore Engineering by **SK. Chakrabarti**
2. Stochastic Dynamics of Marine Structures by **Arvid Naess, Torgeir Moan**
3. Nonlinear Dynamics and Chaos by **SH. Strogatz**
4. Nonlinear Oscillations by **Ali H. Nayfeh and DT Mook**

Reference Books:

1. Nonlinear Dynamics and Chaos by **J. M. T. Thompson and H. B. Stewart**
2. Hydrodynamics of Offshore Structures by **SK Chakrabarti**
3. Wave Forces on Offshore Structures by **T Sarpkaya**
4. Fluid Structure Interaction in Offshore Engineering by **S. K. Chakrabarti**
5. An Introduction to Random Vibrations, Spectral & Wavelet Analysis by **D. E. Newland**
6. Ocean Waves: The Stochastic Approach by **Michel K. Ochi**
7. Random Data: Analysis and Measurement Procedures by **Julius S. Bendat and Allan G. Piersol**

Prerequisite:

OE5330: ADVANCED MARINE STRUCTURES

Course Content:

Ultimate load design, Principles; Factors affecting strength, Ultimate behavior of bars and beams; Plastic capacity of sections, Plastic capacity of beams and frames, Plastic capacity of plates, Influence of membrane forces, Application to ships and offshore structures, Collision problems, Fundamentals of impact analysis, Impact capacities of steel jackets, local and global; Capacities of tubular joints, Column, flexural and torsional buckling, Design. Structural response to underwater explosion, Design issues Fluid Structure interaction, Framed offshore structures, Elements of flow-induced vibration, Vibration of underwater structures; Sound radiation and scattering by structures Design of stiffened structures, Reliability design and simulation concepts, FOSM and AFOSM methods, Partial safety factors and code calibration Fatigue and Fracture: Fatigue failure, cumulative fatigue damage models, Fracture mechanics approach to fatigue failure, Fatigue analysis and design of marine structures.

Text Books:

1. Construction of Marine and Offshore Structures, by **Ben C. Gerwick Jr**
2. Offshore Structures: Design, Construction and Maintenance by **Mohamed A. El-Reedy**
3. Stochastic Dynamics of Marine Structures by **Arvid Naess, Torgeir Moan**
4. Fatigue and Fracture Mechanics of Offshore Structures by **Linus Etube**
5. Fluid Structure Interaction in Offshore Engineering by **S. K. Chakrabarti**

Reference Books:

1. Matrix Analysis of Framed Structures by **William Weaver and James M. Gere**
2. Numerical Models in Fluid-Structure Interaction by **S. K. Chakrabarti**
3. Fatigue Handbook: Offshore Steel Structures by **A. Almar-Naess**
4. Advanced Marine Structures by **S Chandrasekaran**

Prerequisite:

Consent of teacher

OE5XXX - ADVANCED STRUCTURAL ANALYSIS OF MARINE VEHICLES

NO COURSE NUMBER

OE5XXX - DESIGN OF FISHING VESSELS

NO COURSE NUMBER

OE4XXX - DESIGN OF SHIP OUTFIT SYSTEMS

NO COURSE NUMBER

OE5XXX - DESIGN OF SUBMARINE AND SUBMERSIBLE

NO COURSE NUMBER

OE5XXX - MARINE CORROSION, PREVENTION AND CONTROL

NO COURSE NUMBER

OE4XXX - SHIP ELECTRICAL AND ELECTRONIC SYSTEMS

NO COURSE NUMBER

OE4XXX - SHIP POSITIONING SYSTEMS

NO COURSE NUMBER

OE5XXX - DESIGN OF HIGH SPEED VESSELS

NO COURSE NUMBER

OE5XXX - WARSHIP DESIGN

NO COURSE NUMBER

OE4XXX - ANALYSIS AND DESIGN TOOLS IN MARINE HYDRODYNAMICS

NO COURSE NUMBER

OE4XXX - LABORATORY MODELING IN MARINE HYDRODYNAMICS

NO COURSE NUMBER

OE5XXX - DESIGN, CONSTRUCTION AND OPERATION OF LNG CARRIERS AND TERMINALS

NO COURSE NUMBER

OE5450: NUMERICAL TECHNIQUES IN OCEAN HYDRODYNAMICS

Course Content:

Revisit Fluid Dynamics fundamentals. Numerical solution of Diffusion, Advection and Burgers' equations . Requirements of numerical solutions - Lax theorem; linear stability analysis. Introduction to CFD concepts: Pressure elimination, Pressure correction and Split algorithms; modeling of turbulence; introduction to LES, DES and DNS. Computations in solution of PDEs, Pressure elimination and Pressure correction. Introduction to computations using unstructured meshes. Introduction to Numerical Marine Hydrodynamics: Partial differential equations of inviscid hydrodynamics; Code development and computations of hydrodynamics of wave-structure interaction for fixed and floating bodies using BIEM, BEM and FEM techniques; Application of Fast methods; Time domain computation - non-linear velocity potential and acceleration potential approaches. Free surface computation in viscous models - VOF and Levelset. Computation of the motions of ships in waves. Forward speed problem and computation. Integral boundary layer equations and numerical solutions. Introduction to Parallel Machines and High Performance Computing.

Text Books:

1. **Anderson, D**. Computational Fluid Dynamics, McGraw Hill International Editions, 1995.

Reference Books:

1. **Tannehill, C., Anderson, D and Pletcher, R.** Computational Fluid Mechanics and Heat Transfer, 1997.
2. **Newman, JN.** Marine Hydrodynamics, MIT Press, Cambridge, MA, 1977.
3. Journal and thesis publications and prescribed by teacher.

Prerequisite:

Nil

OE5500: FEM APPLIED TO OCEAN ENGINEERING

Course Content:

Introduction – Different approaches to finite element formulation – Different types of element and interpolation functions, Lagrange & Hermitian Polynomials, natural co-ordinates – Derivation of element property matrices – Assembly – solution of finite element equations – Structural and geotechnical problems – Nonlinear analysis. Application to fluid mechanics problems, Fluid-structure interaction – Diffraction of waves, 2D formulation using mild – slope equation – use of infinite elements – Added mass and damping matrices for floating bodies, 2D formulation – Harbour resonance, Liquid sloshing – Vibrations of underwater structures Introduction to Boundary element techniques.

Text Books:

1. **J.N. Reddy**. 1984. An Introduction to the finite element method. McGraw Hill. (third edition, 2005)
2. **O.C. Zienkiewicz, R.W. Lewis and K.G. Stagg (eds.)** 1978. Numerical methods in Offshore Engineering. Wiley

Reference Books:

1. **R.D. Cook**. 1981. Concepts and applications of finite element analysis. Wiley
2. **O.C. Zienkiewicz.** 1977. The Finite Element Method. McGraw Hill. (vol.I, II, III)
3. **K.J. Bathe**. 1981. FE procedures in Engineering Analysis.

Prerequisite:

OE5600: ADVANCED WAVE DYNAMICS

Course Content:

Introduction to wave generation, SMB and CEM approaches of wave estimation. Elements of probability theory and random processes - Sea as a stationary random process – Description of random sea waves – Statistical and Spectral analysis - Short term and Long term wave statistics – Directional Spectra – Design wave spectrum – Extreme value prediction. Non-stationary waves: Wavelet transforms and principal component analysis; Univariate and multivariate spectral analysis of signals; Hilbert transform; Bi-spectral analysis of nonlinear waves. Laboratory wave simulation, measurement & analysis: Wave groups, Breaking waves, Stokes 2nd order & Shallow water waves such as Cnoidal and Solitary waves. Multi-Directional waves – simulation and analysis using Fourier Method, MLM & MEM – single point measurement and array of gauges.

Text Books:

1. **Y.Goda**, Random Seas and Design of Maritime Structures, World Scientific Publishing Company, 2010. ISBN 10: 9814282405.

Reference Books:

1. **Chakrabarti S K**: Offshore Structure & Modeling, World Scientific, 1994.
2. **Ochi M K.:** Ocean Waves - The Stochastic Approach- Cambridge University Press, 1998.

Prerequisite:

Consent of teacher

OE5800: COASTAL ENGINEERING

Course Content:

Waves in shallow waters – Shoaling, refraction, diffraction and breaking– Interaction currents and waves- near shore currents-wave run-up and overtopping- coastal sediment characteristics- Initiation of sediment motion under waves- Radiation stress-wave set-up and wave set- down- mechanics of coastal sediment transport - Limits for littoral drift – Suspended and Bed Load – alongshore sediment transport rate – Distribution of alongshore currents and Sediment transport rates in Surf zone. Physical modeling in Coastal Engineering. Onshore offshore sediment transport – Stability of tidal inlets- Coastal features – Beach Features – Beach cycles – Beach Stability – Beach profiles -Coastal erosion, Planning and methods of coast protection works - Design of shore defense structures – Non-breaking and breaking wave forces on coastal structures -Breakwaters- Classification, Design and application in coastal protection and harbor planning- Case studies on coastal erosion and protection- Generation, propagation and effect of tsunami.

Text Books:

1. **Horikawa,K.,** Coastal Engineering, University of Tokyo press, 1978
2. **Sorenson, R.M.**, Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978
3. **Kamphius,J.W.** Introduction to coastal Engineering and Management, Advances on Ocean Engineering-Volume 16, World Scientific,2002.

Reference Books:

1. **Reeve,D., Chadwick, A. and Fleming,** C. Coastal Engineering-Processes, theory and design practice, Spon Press, Taylor & Francis Group, London & Paris,2004
2. **Silvester,R. and Hsu,J.R.C**. Coastal Stabilisation, Advances on Ocean Engineering-Volume 14, World Scientific, 1997.
3. Coastal Engineering Manual, U.S.Army Corps of Engineers, Washington, DC 20314-1000,, Vol. 1 to 3, July 2003.
4. **Wood,M.**, Coastal Hydraulics: Mcmillan, Civil Engineering Hydraulics, London, 1969 Decisions.” CIFE Technical Report (177), Stanford University, Stanford.

Prerequisite:

Consent of teacher

OE6005: RELIABILITY OF OFFSHORE STRUCTURES

Course Content:

Introduction to uncertainty, probability and random variables. Calculations of failure probability by simple methods (R-S). General formulation for the reliability problem – FORM, SORM methods, Calculations of failure probability using unions and intersections, Uncertainty modeling of loads and resistances, Calculation of failure probability by Monte Carlo Method, Computational aspects. Updating of reliability, Reliability of time dependent loads and resistances. Probability, inspection and planning. Codal regulations. Uncertainties in material characteristics used in offshore structures- Reliability estimates for different types of offshore structures- Case studies. Seismic and fatigue reliability.

Text Books:.

1. **HO Madsen, S Krenk and NC Lind**. 2006, Methods of structural safety, Dover.
2. **R. Ranganathan**, 1999 Structural reliability analysis and design, Jaico Publishing House.
3. **A Haldar and S Mahadevan**. 2000. Probability, reliability and statistical methods in engineering design. John Wiley and Sons, NY.
4. **P Throft-Christensen and MJ Baker**, 1982, Structural reliability theory and applications, Springer Verlag, Berlin.
5. **RE Melchers**. 1999, Structural reliability: analysis and prediction, 2nd Edition, John Wiley
6. **AHS Ang and W H Tang**. 1984, Probability concepts in engineering planning and design, Volume II Decision, Risk & reliability, John Wiley, NY.

Reference Books:

1. **AHS Ang and WH Tang**, 1975, Probability concepts in engineering and design, Volume 1 - Basic concepts, John Wiley, NY
2. **A Papoulis, and SU Pillai** 1991, Probability, random variables and stochastic processes, 3rd Edition, McGraw-Hill, New York.
3. **J R Benjamin and C A Cornell**, 1970, Probability, statistics and decisions for civil engineers, John Wiley, New York.
4. **I Elishakoff**. 1999, Probabilistic theory of structures, Dover.
5. **PH Wirsching,TL Paez and K Ortiz** 2006 Random Vibrations: Theory and Practice, Dover.
6. **N C Nigam and S Narayanan**. 1994 Applications of random vibrations, Springer.
7. **G Augusti, A Baratta and F Casciati**, 1984, Probabilistic methods in structural engineering, Spon Press.

Prerequisite:

Consent of teacher

OE6020: MESHFREE METHODS APPLIED TO HYDRODYNAMICS

Course Content:

Numerical modelling; Basics of fluid mechanics; NS – Eulerian and Lagrangian Formulations; Free surface and Body boundary conditions; Time split algorithms; Strong and Weak forms; Weighted Residual methods. Overview of mesh based methods and meshfree methods; Basic techniques; Categories of meshfree methods; shape function constructions – Issues; SPH; Point Interpolations; Moving least square method; Shepard Functions; Error estimations; Support domain and Influence domain; Weight functions; Meshfree Integrations; Computational Cost; Conservation and Convergence. Meshfree methods based on Global weak form – EFG; Meshfree methods based on Local weak form – MLPG; Smoothed Particle Hydrodynamics; Moving Particle Semi-Implicit method; Essential Boundary conditions – Issues; Turbulence – Sub-particle scale; Meshfree methods applied to fluid dynamics problem; Matrix formulations and solution methods in meshfree methods; application to floating bodies, coastal engineering.

Text Books:

1. **G.R. Liu (2006),** "Mesh free methods: Moving beyond the finite element method", CRC Press, Taylor and Francis, US.

Reference Books:

1. **J. Anderson** (1995), "Computational Fluid Dynamics: The basics with applications", McGraw-Hill, USA.
2. **Li H and Mulay SS** (2013), "Meshless methods and their numerical properties", CRC Press, Taylor and Francis, US.
3. **S.N. Atluri** (2004), "The Meshless method (MLPG) for domain and BIE discretizations", Tech Science Press.
4. **G.R. Liu and M.B. Liu** (2003), "Smoothed Particle Hydrodynamics", World Scientific, Singapore. (also available as E-book)

Prerequisite:

Consent of teacher

OE6200: DESIGN OF FIXED OFFSHORE STRUCTURES

Course Content:

Wind profile; gusting and averaging of wind speed; wind pressure and forces; Wave kinematics; Wave theory selection; drag and inertia regimes; wave and current interaction; Morison equation applied to spatially distributed framed structures; hydrodynamic coefficients and marine growth; Seismic zone in India on land and offshore/coastal area; Recurrence interval and selection of design seismic acceleration; Return period for strength and ductility; Seismic loads; loads due to fire and blast; loads due to ship impact and ice impact; Design principles of jackets and pile foundations; main and skirt pile arrangements; wellhead and process platforms; concepts and geometry; Material selection for different classes of structural members; Structural analysis (linear and nonlinear); Pushover analysis procedure; Tubular Members, Slenderness effects; Column Buckling, Design for Hydrostatic pressure; Design for combined axial and bending stresses; Simple tubular joints, design using allowable loads; design of T, K and Y joints; Parametric equations; stress concentration factors; Design using pseudo static methods; Design of ring stiffened joints; Introduction to fatigue failure; cracking and Paris law; fracture mechanics and material selection for joints; material toughness class; S-N curves and fatigue damage calculations; deterministic and spectral fatigue analysis; Introduction to corrosion; corrosion protection coatings and design of cathodic protection; design of anodes; cathodic protection monitoring system

Text Books:

1. **Chakrabarti, SK**. 1994. Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0-90545-166-4
2. **Chakrabarti, SK**. 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
3. **Chen,WF, E.M. Lui.** 1987. Structural stability: Theory and implementation, Elsevier, New York, ISBN: 0-444-01119-6.
4. **Ben C. Gerwick Jr**. 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7
5. UEG Offshore Research. 1985. Design of Tubular Joints for offshore structures, Vol. 1-3, UEG Publications, ISBN: 978-086-0172-314
6. **Bjorn Skallerud and Jorgen Amdahl**. 2002. Nonlinear analysis of offshore structures, Research Studies Press, Baldock, ISBN: 978-086-3802-584
7. **Srinivasan Chandrasekaran, Gaurav Srivastava**. 2022. Fire-resistant design of structures, CRC Press, FLORIDA, USA, ISBN: 978-103-2358-116

Reference Books:

1. API-RP 2A. 2000. Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design, 21st Edition, Errata and Supplement 1, December 2002, Errata and Supplement 2, September 2005, Errata and Supplement 3, October 2007.
2. FABIG. 1992. Interim Guidance Notes for the design of and protection of topside structures against explosion and fire, FABIG Technical Notes, Ascot, UK.
3. AWS D1.1. 2000. Structural welding code- Steel, American Welding Society, FL, USA, pp. 449.
4. DNV-RP-401. 2010. Cathodic protection design, Det Norske Veritas, Norway.
5. Chandima Ratnayake, RM and Samindi Samarakoon, SM. 2017. Modeling and Simulation techniques in structural engineering: Structural Integrity Assessment and Control of Ageing Onshore and Offshore Structures, IGI Global publishers, USA, pp. 445-476.
6. N-006. 2009. Assessment of structural integrity for existing offshore load bearing structures, 1st Ed., NORSOK Standards, Norway.
7. DNV Report 95-3203. 1996. Guidelines for offshore structural reliability analysis: Application to Jacket Platforms, Det Norske Veritas, Norway.

Prerequisite:

Nil

OE6300: PLATED STRUCTURES AND SHELLS

NO COURSE NUMBER

OE6930: COMP. AID. SURFACE DEV. FOR MARINE VEHICLES

Course Content:

Theories of wind - generated ocean waves - Wind-wave Modelling: Third generation Wind – Wave modelling: WAM, SWAN & STWAVE for wave hind-casting and forecasting. Deformation of water waves: Solution of Helmholtz and Mild slope equations; Near shore wave propagation in phase-averaging and phase-resolving models; Boussinesq wave model; applications to large bodies and harbours - computations in 2D; introduction to public domain and industry software. Ocean hydrodynamics: Circulation with Tide, Temperature & Salinity; Turbulence in Ocean; Shallow Water Equations and their solution; applications to Nearshore circulation; Storm surge & Tsunami. Modelling of scalar transport and morphodynamics.

TextBooks:

1. **Dyke, P**. Modeling Coastal and Offshore Processes. Imperial College Press, 2007.
2. **Komen, G.J., Cavaleri, L., Donelan, M., Hasselmann, K., Hasselmann, S., Janssen, P.A.E.M.** Dynamics and modeling of ocean waves, Cambridge university press, New York, 1994.
3. **Nielsen, P.** Coastal and Estuarine Processes, World Scientific, 2009.

ReferenceBooks:

1. **Mellor G.L.,** User Guide for a three-dimensional, primitive equation, numerical ocean model, 1998.

Prerequisite:

Consent of teacher

OE6980: COMP. AID. SURFACE DEV. FOR MARINE VEHICLES

Course Content:

Module 1: Introduction and classification of geometric modeling forms for curves, surfaces and volumes; differential geometry of curves and surfaces; introduction to spline curves; Bezier splines; Uniform/non-uniform Rational B-splines; and fitting, fairing and generalized cylinders. Module 2: Introduction to blending surfaces; intersection problems in geometric design; offsets of parametric curves, surfaces and volumes; constructive solid geometry, boundary representation; decomposition models; and advanced topics in differential geometry. Module 3: Object matching; finite element and boundary element meshing algorithms; robustness of geometric computations; introduction to interval methods; scientific visualization; variational geometry; tolerances; inspection methods; feature representation and recognition; and shape interrogation for design, analysis, and manufacturing.

Text Books:

1. **G. Farin** (2001), Curves and Surfaces for CAGD: A Practical Guide, The Morgan Kaufmann Series in Computer Graphics, 5th edition, Morgan Kaufmann, USA.
2. **D. F. Rogers and J. A. Adams** (1989), Mathematical Elements for Computer Graphics, 2nd edition, Tata McGraw-Hill, India.

Reference Books:

1. **K. K. Dube** (2009), Differential Geometry and Tensors, I. K. International Publishing House PL, India.
2. **Q. Khan** (2012), Differential Geometry of Manifolds, Prentice Hall India Learning Private Limited, India.
3. **N. M. Patrikalakis and T. Maekawa** (2010), Shape Interrogation for Computer Aided Design and Manufacturing, Springer.
4. **D. Somasundaram** (2008), Differential Geometry: A First Course, Narosa Book Distributors, India.

Prerequisite:

Consent of teacher

OE6990: ADVANCED MARINE VEHICLES

Course Content:

1. An introduction in advanced marine vehicle (AMV) types. 2. The basic principles of the different types of advanced marine vehicles will be explained, supported by data of recently build vessels. 3. Hydrodynamic aspects, the contradiction between resistance and propulsion and on the other hand ships movements will be dealt with. 4.Design strategies in the design of advanced marine vehicles. 5. Several types of propulsion systems such as but not limited to water jets, cavitating and non cavitating propellers. 6. Structural Aspects of AMVs 7. An introduction to warship and Submarines 8. Hydrostatic and hydrodynamic aspects of warship and Submarine

Text Books:

1. **Thomas Lamp** “Ship Design and Construction” Vol1 and Vol 2 published by SNAME

Reference Books:

1. **Liang Yun** “ High Performance marine vessels” Springer publication
2. **PJ Gates** “Surface Warship-An Introduction to design principles” 1987 Brassey’sDefence Publishers

Prerequisite:

Consent of teacher

PE6060 - HSE MANAGEMENT IN PETROLEUM AND OFFSHORE ENGINEERING

NO COURSE DATA

Dual Degree –B.Tech & M.Tech
In
Naval Architecture & Ocean Engineering

CURRICULUM AND COURSE CONTENTS

(Updated in Senate 301 held on 24.02.2023)

INDIAN INSTITUTE OF TECHNOLOGY MADRAS
CHENNAI 600 036

B.TECH - NAVAL ARCHITECTURE & OCEAN ENGINEERING

Course Category Codes:

S : Basic Science; E : Basic Engineering; H : Humanities; P : Professional; F : Free Elective

Semester and Category-wise Credit Distribution – B.Tech (NA&OE)

category	S1	Win	S2	Sum	S3	S4	S5	S6	Sum	S7	S8	Total	CTF
S	20		37		**9**	9+**9**						84	**84**
E	32	3		3	10							48	**45**
H			**9**		**9**						**9**	27	**27**
P	6		10		32	41	49	20	6	**9+**9	**18**	200	
Total	**58**	**3**	**56**	**3**	**60**	**59**	**49**	**20**	**6**	**9**	**27**	**359**	
Free Electives (**F**) **(suggested)**							**9**	**36**		**27**	**9**	72	**72-96**
Overall	**58**	**3**	**56**	**3**	**60**	**59**	**58**	**56**	**6**	**36**	**36**	**431**	**432**
EL & HS			**9**		**18**	**9**	**27**	**36**		**36**	**36**	**171**	**172**
Honors*								**9**		**9**	**9**	**27**	**27**

*** OE courses of 5000 & above**

SEMESTER I

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
MA1101	Functions of Several Variables	3	1	0	0	6	10	S
PH1010	Physics I	3	1	0	0	6	10	S
AM1100	Engineering Mechanics	3	1	0	0	6	10	E
CS1100	Introduction to Programming	3	0	0	3	6	12	E
ME1100	Thermodynamics	3	1	0	0	6	10	E
OE1101	Introduction to Naval Architecture & Ocean Engineering	2	0	0	0	4	6	P
	Total	**17**	**4**	**0**	**3**	**34**	**58**	
	NCC/NSS	0	0	0	0	2	0	
	LIFE SKILLS	0	0	0	0	3	0	

WINTER

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
WS1301	Workshop I	0	0	0	3	0	3	E

SEMESTER II

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
MA1102	Series and Matrices	3	1	0	0	6	10	S
PH1020	Physics II	3	1	0	0	6	10	S
PH1030	Physics Lab	0	0	0	3	1	4	S
CY1001	Chemistry I	3	1	0	0	6	10	S
CY1002	Chemistry Lab	0	0	0	3	0	3	S
HSxxxx	Humanities Elective – I	3	0	0	0	6	9	H
OE1012	Ship Hydrostatics and Stability	3	1	0	0	6	10	P
	Total	**15**	**4**	**0**	**6**	**31**	**56**	
	NCC/NSS	0	0	0	0	3	0	

SUMMER

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
WS1302	Workshop I	0	0	0	3	0	3	E

SEMESTER III

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
MA	Mathematics Elective-I	3	0	0	0	6	9	S
EE1100	Basic Electrical Engg.	3	1	0	0	6	10	E
HSxxxx	Humanities Elective – II	3	0	0	0	6	9	H
OE2044	Ship Hydrodynamics	3	1	0	0	6	10	P
AM2200	Strength of Materials	3	1	0	0	6	10	P
OE2013	Ship Drawing and Calculations	1	3	0	3	3	10	P
OE2023	Marine Instrumentation Lab	0	0	0	2	0	2	P
	Total	**16**	**6**	**0**	**5**	**33**	**60**	
	Ecology & Environment	2	0	0	0	0	0	

SEMESTER IV

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
MA	Mathematics Elective – II	3	0	0	0	6	9	S
BT1010	Life Sciences	3	0	0	0	6	9	S
OE2014	Marine Engineering	3	1	0	0	6	10	P
OE2024	Analysis of Structures	3	1	0	0	6	10	P
OE2034	Ship Resistance and Propulsion	3	1	0	1	6	11	P
OE2054	Ocean Wave Hydrodynamics	3	0	0	1	6	10	P
	Total	**18**	**4**	**0**	**1**	**36**	**59**	

SEMESTER V

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OE3015	Ship Structural Analysis	3	1	0	0	6	10	P
OE3035	Motion of Ships & Floating Systems	3	1	0	1	6	11	P
OE3016	Ship Design	3	1	0	0	6	10	P
OE3045	Vibration of Marine Structures	3	0	0	0	6	9	P
OE3190	Design of Ocean Structures	3	0	0	0	6	9	P
	Free Elective – I	3	0	0	0	6	9	F
	Total	**18**	**2**	**0**	**2**	**36**	**59**	

SEMESTER VI

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OE3036	Maneuvering & Control of Marine Vehicles	3	1	0	0	6	10	P
OE3046	Ship Structural Design	3	1	0	0	6	10	P
	Free Elective – II	3	0	0	0	6	9	P
	Free Elective – III	3	0	0	0	6	9	F
	Free Elective – IV	3	0	0	0	6	9	F
	Free Elective – V	3	0	0	0	6	9	F
OExxxx	**Honours Elective – I**	**3**	**0**	**0**	**0**	**6**	**9**	**HE**
	Total	**15+3**	**2**	**0**	**0**	**36**	**56+9**	

SUMMER

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OE3026	Shipyard Training (Summer)	0	0	0	0	6	6	P

SEMESTER VII

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OExxxx	Professional Elective - I	3	0	0	0	6	9	P
OE5320	Non-Linear Problems in Ocean Engg.	3	0	0	0	6	9	P
OE5545	Marine Geotechnical Engineering	3	0	0	0	6	9	P
	Free Elective-VI	3	0	0	0	6	9	F
	Free Elective-VII	3	0	0	0	6	9	F
	Honours Elective – II	**3**	**0**	**0**	**0**	**6**	**9**	**HE**
	Total	**15**	**1**	**0**	**0**	**30**	**45+9**	
	Professional Ethics	2	0	0	0	0	0	

SEMESTER VIII

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
HSxxxx	Humanities Elective - III	3	0	0	0	6	9	H
OE6200	Design of Fixed Offshore Structures	3	1	0	0	6	10	P
OE5500	FEM Applied to Ocean Engineering	3	0	0	0	6	9	P
	Professional Elective - IV	3	0	0	0	6	9	P
	Free Elective – VIII	3	0	0	0	6	9	F
	Honours Elective – III	**3**	**0**	**0**	**0**	**6**	**9**	**HE**
	Total	**12**	**0**	**0**	**0**	**24**	**46+9**	

SUMMER

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OE5371	DD Project – Phase 1	0	0	0	15	10	25	P

SEMESTER IX

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OE5372	DD Project – Phase 2	0	0	0	10	10	20	P
OEXXX	Professional Elective - V	3	0	0	0	6	9	P
OEXXX	Professional Elective - VI	3	0	0	0	6	9	P
Total	**Total**	**9**	**0**	**0**	**10**	**28**	**38**	

SEMESTER X

Course No.	Course Title	L	T	ExT	Lab	Home	Cr	Cat
OE5373	DD Project – Phase 3	0	0	0	25	15	40	P
	Total	**0**	**0**	**0**	**25**	**15**	**40**	

*Credits and grades for DD Project (OE5370) will be awarded at the end of X semester.

BTech (honours) + MTech program: (Total credit requirement: 552 + 27 = **579)**

1. ***Eligibility***: minimum CGPA of 8.5 at the end of 5th sem without U or W grade in any course. They need to maintain these conditions until graduation.
2. ***Extra credit requirement***: 27 elective credits over and above regular program. These credits ***have*** to be completed in VI, VII and VIII semesters. These credits should be obtained by taking OE 5000 or higher level courses.
3. 45 credits (instead of 18 for regular) out of 90 BTech elective credits to be taken in OE. Dept. at 5000 level or higher.

LIST OF ELECTIVES

No	Title	L	T	Ext	Lab	Home	Cr
	ELECTIVE (A) - Mathematics						
MA2010	Complex Variables	3	0	0	0	6	9
MA2030	Differential Equations	3	0	0	0	6	9
MA2040	Probability, Stochastic Process &Statisics	3	0	0	0	6	9
MA2060	Discrete Mathematics	3	0	0	0	6	9
MA2130	Basic Graph Theory	3	0	0	0	6	9
ELECTIVE (E) – Professional / Free for NA&OE (BTech&DD)							
ME3350	Design of Machine Elements	3	0	0	0	6	9
MM3012	Joining and NDT Lab	3	0	0	0	6	9
MM3060	Metal Joining Technology	3	0	0	0	6	9
MM5320	Corrosion Engineering	3	0	0	0	6	9
MM5750	Welding Application Technology	3	0	0	0	6	9
OE3190	Design of Ocean Structures	3	0	0	0	6	9
OE4300	Ocean Energy	3	0	0	0	6	9
OE4400	Drilling vessels and Support Crafts	3	0	0	0	6	9
OE4600	Advance ship Hydrodynamics	3	0	0	0	6	9
OE4xxx	Shipbuilding Material & Production Processes	3	0	0	0	6	9
OE5011	Marine Robotics	3	0	0	0	6	9
OE5080	Marine Instrumentation	3	0	0	0	6	9
OE5120	Geomechanics for offshore Oil and Gas Applications	3	0	0	0	6	9
OE5170	Ocean Acoustics	3	0	0	0	6	9
OE5310	Guidance and control of Marine Vehicles	3	0	0	0	6	9
OE5330	Advanced Marine Structures	3	0	0	0	6	9
OE5xxx	Advanced Structural Analysis of Marine Vehicles	3	0	0	0	6	9
OE5xxx	Design of Fishing Vessels	3	0	0	0	6	9
OE4xxx	Design of Ship Outfit Systems	3	0	0	0	6	9
OE5xxx	Design of Submarine and Submersible	3	0	0	0	6	9
OE5xxx	Marine Corrosion, Prevention and Control	3	0	0	0	6	9
OE4xxx	Ship Electrical and Electronic Systems	3	0	0	0	6	9
OE4xxx	Ship Positioning Systems	3	0	0	0	6	9
OE5xxx	Design of High Speed Vessels	3	0	0	0	6	9
OE5xxx	Warship Design	3	0	0	0	6	9
OE4xxx	Analysis and Design Tools in Marine Hydrodynamics	3	0	0	0	6	9
OE4xxx	Laboratory Modeling in Marine Hydrodynamics	3	0	0	0	6	9
OE5xxx	Design, Construction and Operation of LNG Carriers and Terminals	3	0	0	0	6	9
OE5450	Numerical Techniques in Ocean Hydrodynamics	3	0	0	0	6	9
OE5600	Advanced Wave Dynamics	3	0	0	0	6	9
OE5800	Coastal Engineering	3	0	0	0	6	9
OE6005	Reliability of Offshore Structures	3	0	0	0	6	9
OE6020	Mesh-free Methods Applied to Hydrodynamics	3	0	0	0	6	9
OE6300	Plated Structures and Shells	3	0	0	0	6	9
OE6930	Modeling of Offshore and Coastal Processes	3	0	0	0	6	9
OE6980	Computer Aided Surface Development of Marine vehicles	3	0	0	0	6	9
OE6990	Advanced Marine Vehicles	3	0	0	0	6	9
PE6060	HSE Management in Petroleum and Offshore Engineering	3	0	0	0	6	9

CURRICULUM – B.TECH - NAVAL ARCHITECTURE & OCEAN ENGINEERING

SEMESTER 1

MA 1101: FUNCTIONS OF SEVERAL VARIABLES

Course Content:

Limits, continuity and differentiability of functions of several variables. Taylor's theorem and applications to unconstrained and constrained optimization. Vector calculus: Gradient, Divergence, Curl, Line integral, conservative fields, Green's theorem, surface area of solids of revolution, surface area, surface integral, Triple integrals and Gauss Divergence theorem, Stokes' theorem.

Text Books:

1. **G.B. Thomas Jr., M.D. Weir and J.R. Hass,** Thomas Calculus, Pearson Education, 2009.

Reference Books:

1. **E. Kreyszig**, Advanced Engineering Mathematics, 10th Ed., John Willey & Sons, 2010.
2. **N. Piskunov,** Differential and Integral Calculus Vol. 1-2, Mir Publishers, 1974.
3. **G. Strang,Calculus**, Wellesley-Cambridge Press, 2010.
4. **J.E. Marsden, A.J. Tromba, A. Weinstein**, Basic Multivariable Calculus, Springer Verlag, 1993.

Prerequisite:

PH1010: PHYSICS I

Course Content:

Use of vectors in practical mechanics. Unit vectors in spherical and cylindrical polar coordinates. Conservative vector fields and their potential functions -gravitational and electrostatic examples. Gradient of a scalar field. Equipotentials, states of equilibrium. Work and energy, conservation of energy. Motion in a central force and conservation of angular momentum. Physics concepts in vector fields, Continuity equations and conservation principles for matter, energy and electrical charge. Flux, divergence of a vector. Gauss' theorem, physical applications in gravitation and electrostatics. Irrotational versus rotational vector fields. Physical significance of circulation, curl of a vector field. Stokes' theorem, physical applications. Oscillatory motion, Wave motion in one dimension. Wave equation and travelling wave solutions. Wave velocity, group velocity and dispersion. Shallow water waves. Wave equation in three dimensions, spherical waves.

Text Books

Reference Books:

1. **Kittel C., Knight W.O. and Ruderman M.A.**, Mechanics - Berkeley Physics Course, Vol. 1, Tata McGraw-Hill
2. **Purcell E.M. Electricity and Magnetism** - Berkeley Physics Course, Vol.2, Tata McGraw-Hill
3. **Crawford F.S. - Waves and Oscillations**, Berkeley Physics Course, Vol. 3, McGraw-Hill
4. **Feyman R.P., Leighton R.B. and Sands M. (Narosa)** The Feyman Lectures on Physics, Vol. 1
5. **Feyman R.P., Leighton R.B. and Sands M. (Narosa)** The Feyman Lectures on Physics, Vol. 26. Davis D. (Academic) - Classical Mechanics

Prerequisite:

AM 1100: ENGINEERING MECHANICS

Course Content:

Equilibrium of rigid bodies, free body diagram, Analysis of beams and trusses, Equilibrium of continuous systems -derivation of relation between load, shear force and bending moment. Energy conservation in rigid bodies -potential energy and elastic energy. Virtual work in multibody assemblies. Lumped mass models in Dynamics -Particle motion in cylindrical c0ordinates, engineering applications of central force motion. Kinetics of rigid bodies -translation and rotation motion of a rigid body, relative motion with translating and rotating axes and Coriolis acceleration. Kinematics of rigid bodies -3-D properties of sections, angular momentum of rigid bodies and energy relations for rigid bodies. Mechanical vibrations of single degree of freedom systems -free vibration of rigid bodies, general equations of motion and response to forced sinusoidal loading.

Text Books:

Reference Books:

1. **Beer F.P. and Johnston E.R.,** Vector Mechanics for Engineers - Volume I - Statics, Volume II - Dynamics, McGraw Hill, New York.
2. **Merlam J.L and Kraige L.G.,** Engineering Mechanics, Volume I - statics, Volume 11-dynamics, John Wiley & Sons, New York.
3. **Shames L.H.,** Engineering Mechanics, Prentice HaII, New Delhi

Prerequisite:

NULL

CS1100: INTRODUCTION TO PROGRAMMING

Course Content:

Module 1 : (Introduction to Computing) - 6 lectures Fundamentals of Computing, Historical perspective, Early computers. Computing machine. Problems, Pseudo-code and flowcharts. Memory, Variables, Values, Instructions, Programs. Module 2 : (Introduction to C) 10 lectures The language of C : Phases of developing a running computer program in C. Data concepts in C :Constants, Variables, Expressions, Operators, and operator precedence in C. Statements : Declarations, Input-Output Statements, Compound statements, Selection Statements. Conditions, Logical operators, Precedences. Repetitive statements, While construct, Do-while Construct, For construct. Data types, size and values. Char, Unsigned and Signed data types. Number systems and representations. Constants, Overflow. Arrays. Strings. Multidimensional arrays and matrices. Module 3 : (Modular Programming and Example Problems) : 10 lecture Functions :The prototype declaration, Function definition. Function call : Passing arguments to a function, by value, by reference. Scope of variable names. Recursive function calls, Tail recursion. Analysing recursion, Tree of recursion, linear recursion. Sorting problem : Selection Sort, Insertion Sort, Comparison between sorting algorithms. Sorting in multidimensional arrays. Sorting in strings. Search problem : Linear search and binary search. Comparison between search procedures. Recursive and Iterative formulations. Module 4 : (More Data Types in C) 14 lectures Pointers : Pointer variables. Declaring and dereferencing pointer variables. Pointer Arithmetic. Examples. Accessing arrays through pointers. Pointer types, Pointers and strings. String operations in C. Structures in C : Motivation, examples, declaration, and use. Operations on structures. Passing structures as function arguments. type defining structures. Self-referential structures. Dynamic Data Structures. Linked Lists. Examples. File input-output in C. Streams. Input, output and error streams. Opening, closing and reading from files. Programming for command line arguments. Numerical errors due to data representations and machine precision. Approximation and error analysis. Illustration through examples.

Text Books:

Reference Books:

Prerequisite:

ME1100: THERMODYNAMICS

Course Content:

Fundamentals - System & Control volume; Property, State & Process; Exact & Inexact differentials; Work - Thermodynamic definition of work; examples; Displacement work; Path dependence of displacement work and illustrations for simple processes; Other forms of work - electrical, spring and shaft Temperature - Definition of thermal equilibrium and 0th (Zero) law; Temperature scales; Various Thermometers Heat - Definition; examples of heat/work interaction in systems First Law - Cyclic & Non-cyclic processes; Concept of total energy E ; Demonstration that E is a property; Various modes of energy; Pure substance Ideal Gases and ideal gas mixtures Properties of two phase systems - Const. temperature and Const. pressure heating of water; Definitions of saturated states; P-v-T surface; Use of steam tables and R134a tables; Saturation tables; Superheated tables; Identification of states & determination of properties First Law for Flow Processes - Derivation of general energy equation for a control volume; Steady state steady flow processes including throttling; Examples of steady flow devices; Unsteady processes Second law - Definitions of direct and reverse heat engines; Definitions of thermal efficiency and COP; Kelvin-Planck and Clausius statements; Definition of reversible process; Internal and external irreversibility; Carnot cycle; Absolute temperature scale Entropy - Clausius inequality; Definition of entropy S ; Demonstration that entropy S is a property; Evaluation of ΔS for solids, liquids, ideal gases and ideal gas mixtures undergoing various processes; Determination of s from steam tables; Principle of increase of entropy; Illustration of processes in T-s coordinates; Definition of Isentropic efficiency for compressors, turbines and nozzles Thermodynamic cycles - Basic Rankine cycle; Basic Brayton cycle; Basic vapor compression cycle

Text Books:

1. **Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner and Margaret B. Bailey, Wiley, 7th edition,** Fundamentals of Engineering Thermodynamics,

Reference Books:

Nil

Prerequisite:

Nil

OE1101: INTRODUCTION TO NAVAL ARCHITECTURE & OCEAN ENGINEERING

Course Content:

Physical Oceanography: Physical properties of seawater, Different types of ocean waves and their importance, tides, ocean currents, ocean circulation, ocean basin oscillations, Tsunamis, storm surge, Air-sea interaction. Marine Vehicles: Oceangoing, ship types, types of small crafts, high speed crafts, vehicles for Inland water transport, special ship types, e.g. warships, icebreakers, types of propulsion systems, marine safety regulation, underwater vehicles and submersibles. Introduction to Ship general arrangement, Ship terms and terminologies; Outfits – deck, accommodation, cargo, machinery, etc., Life saving appliances, Fire fighting appliances, Communication and navigation systems, Mooring and anchoring systems, Different piping systems, Ship board electrical systems.Offshore Structures for oil and gas: Fixed offshore platforms (jackets, gravity platforms, articulated towers); superstructure & foundation, floating platforms (semi-submersibles, jack-ups, TLPS, FPSOs, pipe laying barges); Mooring, station keeping, berthing systems for floating platforms; towing launching & installation of platforms, Nearshore structures.

Text Books:

1. Practical: Visit to a ship - identification and familiarisation of various spaces and parts of ship, Make sketches of general arrangement of different ships types.

Reference Books:

1. **Thomas Lamp:** Ship Design and Control Vol I & II, SNAME.

Prerequisite:

GN1101: LIFE SKILLS 1

Course Content:

The contents of the program are aimed at creating a confident ,mature individual. The curriculum is built around one single topic which is the Ability to Get Along. Under this topic are sub topics, like Cross cultural skills, Personal grooming, Dining etiquette, falling in love with oneself and body language.

Text Books:

Carnegie, Dale. How to win friends and influence people. Simon and Schuster, 2010. Pease, Allan. Body language: how to read other thoughts by their gestures. Sheldon Press, 1981. Hofstede, Geert, Gert Jan Hofstede, and Michael Minkov. Cultures and organizations: Software of the mind. Vol. 2. London: McGraw-Hill, 1991.

Reference Books:

1. **Morris, Desmond. Manwatching:** A field guide to human behaviour. Ed. G. Desebrock. New York, NY: HN Abrams, 1977.

Prerequisite:

WINTER

WS1301: WORKSHOP-I-WS1301

Course Content:

Text Books:

Reference Books:

Prerequisite:

NULL

SEMESTER II

MA1102: SERIES AND MATRICES

Course Content:

Series: Sequences of real numbers, Series, ratio and root test, improper integral, integral test, alternating series, absolute and conditional convergence, power series, radius and interval of convergence of power series, term by term differentiation and integration of power series, Taylor's formula, Taylor series, periodic functions and Fourier series, convergence of Fourier series, functions of any period, even and odd functions, half-range expansions. Matrices: Matrix operations, special types of matrices, matrices as linear transformations, linear independence, basis and dimension, rank of a matrix, nullity of a matrix, elementary operations, inverse of a matrix, orthogonalization, determinant, existence-uniqueness of solutions of a linear system, Gaussian elimination, Gauss-Jordan elimination, Eigenvalues, eigenvectors, eigenvalues of special types of matrices, similarity of matrices, basis of eigenvectors, diagonalization.

Text Books:

1. **G.B. Thomas Jr., M.D. Weir and J.R. Hass**, Thomas Calculus, Pearson Education, 2009.
2. **E. Kreyszig**, Advanced Engineering Mathematics, 10th Ed., John Willey & Sons, 2010.

Reference Books:

1. **J. Hefferon**, Linear Algebra, http://joshua.smcvt.edu/linearalgebra, 2014.
2. **S. Lang**, Introduction to Linear Algebra, 2nd Ed., Springer-Verlag, 1986.
3. **M.T. Nair**, Calculus of One Variable, Ane Books, 2014.
4. **N. Piskunov**, Differential and Integral Calculus Vol. 1-2, Mir Publishers, 1974.
5. **G. Strang**, Linear Algebra and its Applications, Cengage Learning, 4th Ed., 2006.

Prerequisite:

PH1020: PHYSICS II

Course Content:

Unit 1: Electrostatics and magnetostatics Maxwell’s equation-I, work and energy in electrostatics, displacement and polarization, boundary conditions. Maxwell’s equation-II, Ampere’s law, magnetic vector potential, magnetism in matter. Unit 2: Electrodynamics and electromagnetic radiation Lorentz force, Faraday’s law and Lenz’s law, electromagnetic induction. Displacement current, Maxwell’s equations III and IV, energy stored in an electromagnetic field, electromagnetic waves in vacuum and in matter, Snell’s law. Unit 3: Introduction to quantum mechanics The quantum nature of radiation, interference experiment with radiation and particle beams. Postulates of quantum mechanics, Schrodinger wave equation. Applications to simple physical systems such as free particle, particle in a box and barrier penetration, spin, two-state systems.

Text Books:

1. Introduction to Electrodynamics **David J. Griffiths**, Pearson Education India Learning Private Limited; 4 Edition, 2015
2. Intro to Quantum Mechanics **David J. Griffiths**, Pearson Education India Learning Private Limited, 2015
3. Fundamentals of Physics II - Electromagnetism, Optics, and Quantum Mechanics: 2 (The Open Yale Courses) **R. Shankar** Yale University Press; 1 edition, 2016

Reference Books:

1. The Feynman Lectures on Physics Vol 2, **Richard P. Feynman and R. B. Leighton** Narosa Publishing House, 2008
2. The Feynman Lectures on Physics Vol 3, **Richard P. Feynman and R. B. Leighton** Narosa Book Distributors, 2008
3. Quantum Physics **H C Verma**, TBS, 2nd edition, 2012

Prerequisite:

None

PH1030: PHYSICS LABORATORY I

Course Content:

Experiments in Mechanics Properties Materials, Heat, Electromagnetism and Optics.

Text Books:--

Reference Books:

1. **Smith E. V.** -Manual of Experiments in Applied Physic$, London,"' Butterworth, 1970.
2. **Workshop B.L., and Flint H.P.** -Advanced Practical Physics for Students, Methuen and Co. Ltd. London.
3. **Jerrad H.G. and Mc Neil D.B.** -Theoretical and Experimental Physics.
4. **Fretter W.B.** -Introduction to Experimental Physics, Blackiee
5. **M. Nelkon and J.rlJl. Ogborn** -Advanced Level Practical Physics, English Language Book Society, 1955.

Prerequisite:

CY1001: CHEMISTRY I: STRUCTURE, BONDING & REACTIVITY

Course Content:

Chemical Thermodynamics Second Law of Thermodynamics – Entropy change accompanying various processes (isothermal expansion, phase transition, heating, entropy of mixing of perfect gases); Absolute entropy and the Third Law of Thermodynamics; Statistical entropy; Spontaneity of a chemical reaction and Gibbs energy; Standard Gibbs energies of formation and reactions; Thermodynamic functions (A, G, U & H) and four fundamental equations, Maxwell relationships; variation of G with T and P, Gibbs-Helmholtz equation, Chemical potential; G versus extent of reaction ( ), Equilibrium constant through chemical potential (gas equilibria), relation between Kp & Kc; Phase equilibria, Gibbs phase rule, phase diagrams of water and carbon dioxide (supercritical H2O & CO2), Clausius-Clapeyron equation; Liquid-solid phase diagrams – two-component eutectic systems and cooling curves. Chemical Kinetics Parallel, opposing and consecutive reactions; Mechanism of complex chemical reactions; Analysing mechanisms using the steady-state approximation, Chain reactions (hydrogen-bromine reaction); Unimolecular reactions (Lindemann-Hinshelwood approach); Transition State Theory for bimolecular reactions (thermodynamic approach); Enzyme catalysis (Michaelis-Menten Mechanism). Chemisorption and Langmuir Isotherm. Basic Concepts of Quantum Chemistry Uncertainty principle; Motion of a quantum mechanical particle in one dimension; The Schrödinger wave equation for the hydrogen atom; physical meaning of a wave function, radial wave functions and probability densities, quantum numbers, wave functions and orbital shapes. Transition metal chemistry Bonding in transition metal complexes; coordination compounds; crystal field theory, octahedral, tetrahedral and square planar complexes; CFSE; Jahn-Teller theorem; Spectral, electronic and magnetic properties of coordination complexes.. Organometallic chemistry Synthesis structure and reactivity of metal carbonyls; 16 and 18 electron rules; Variety of ligands and hapticity; Type of reactions: Oxidative addition, Reductive elimination, Migratory insertion; Homogeneous catalysis, Hydrogenation, Hydroformylation, Monsanto process, Wacker process. Aromaticity Aromatic, non-aromatic and anti-aromatic compounds. Aromatic nucleophilic substitution reactions. Pericyclic reactions Definition, classifications, electrocyclic reaction of butadiene and hexatriene, photochemical [2+2] and thermal [4+2] cycloadditions, Sigmatropic rearrangements – limited to Cope and Claisen rearrangements, FMO approach – Woodward Hoffmann rules and basic stereochemistry aspects of the above reactions.

Text Books:

1. Atkin’s Physical Chemistry by **PW Atkins and J de Paula**, 8th and 9th Eds., Oxford University Press.
2. Organic Chemistry by **J Clayden, N Greeves and S Warren**, 2nd Edition 2012, Oxford University Press.
3. Shriver and Atkin’s Inorganic Chemistry by **P Atkins, T Overton J Rourke, M Weller and F Armstrong,** 4th Edition 2009, Oxford University Press.

Reference Books:

Nil

Prerequisite:

NIL

CY1002: CHEMISTRY LAB I

Course Content:

Determination of reaction rate constant and acid strength, Preparation of gold nanoparticles, Estimation of copper, iron and nickel ions, Preparation of dibenzalproposanone, Bromination of stilbene, qualitative analysis of organic compounds

Text Books:

Nil

Reference Books:

1. Laboratory Manual for Undergraduates, Department of Chemistry, IIT Madras (CY 1002)

Prerequisite:

COT

HSXXX: HUMANITIES ELECTIVE – NO COURSE NO

OE1012: SHIP HYDROSTATICS AND STABILITY

Course Content:

Lines plan and hull form coefficients – Hull forms of different types of ships and boats – Numerical techniques for ship calculations- Bonjean calculation and curves, Hydrostatic particulars – definition and derivations.Weight estimation – lightship, deadweight, centre of gravity, CoG, CoB, Metacentre, Conditions of equilibriumTransverse stability at small angles – angles of heel, trim, list, loll, effects of weight shift, fee surface, wind, waves, grounding; Inclining experiment; Stability at large angles – cross curves of stability, dynamical stability; Ship longitudinal stability; Submarine stability; Stability of modern vehicles.Floodable length, and subdivision; Damaged stability – deterministic and probabilistic approaches and IMO criteria.Capacity and tonnage calculations; Trim and stability bookletPracticals: Lines plan drawing and fairing; Calculation and drawing of ship bonjean and hydrostatic data; Stability calculation and GZ curve; Floodable length calculation and drawing;

Text Books:

1. **Rawson, K.J and Tupper, E.C**. Basic Ship Theory, B&H, 2001
2. **Robert B. Zubaly** , Applied Naval Architecture, Cornell Maritime Press Inc.,2010.
3. **E. C. Tupper**, "Introduction to Naval Architecture", Butterworth-Heinemann, 2013.

Reference Books:

1. **Lewis,E.U,** Principles of Naval Architecture,Vol.1, SNAME, New Jersey, U.S.A, 2010.Thomas Lamp: Ship Design and Control Vol I & II, SNAME.

Prerequisite:

GN1102: LIFE SKILLS 2

Course Content:

As in the first semester, the main content is about handling change. Under this, the subsets are overcoming fear, understanding and handling failure, creating alternatives, accepting new situations and embracing change.

Text Books:

1. **Covey, Stephen**. "The seven habits of effective people." New York: Simon 1989.

Reference Books:

1. **Carnegie, Dale**. How to stop worrying and start living. Simon and Schuster, 2004.

Prerequisite:

SUMMER

WS1302: WORKSHOP-II

Course Content:

Text Books:

Reference Books:

Prerequisite:

NULL

SEMESTER III

MAXXX - MATHEMATICS ELECTIVE – I

NO COURSE NUMBER

EE1100: BASIC ELECTRICAL ENGINEERING

Course Content:

1. Properties of resistance, Ohms law, KVL, KCL, mesh and nodal analysis, Network theorems: Superposition, Thevenin, Norton and maximum power transfer. 2. Properties of inductance and capacitance, DC transients: Series RL, RC, RLC and parallel RLC. 3. Single phase AC, voltage and current phasors, impedance, network theorems application to AC, frequency response of ac circuits, resonance, filters, active power, reactive power, apparent power, power factor. 4. Balanced Three phase AC, three phase power, star and delta connection. 5. Single phase transformer: Principle of operation, equivalent circuit, OC and SC test, voltage regulation, efficiency. 6. Three phase Induction motor: Construction, rotating magnetic field, principle of operation, slip, torque, equivalent circuit, efficiency. 7. DC machines: Principle of operation, excitation, equivalent circuit, emf, speed and torque characteristics. 8. Diodes and applications: Diode characteristics, voltage and current relationship, diode circuits-rectifiers, peak and envelop detectors, solar cell. 9. Operational amplifiers: Description of amplifiers as a black box and definition of gain, effect of feedback on gain, Operational amplifier circuits: Non-inverting, inverting, summing, differential, integrators, differentiators, buffers.

Text Books:

1. Electrical Engineering Fundamentals, **Vincent Del Toro**, Prentice Hall, 2006.

Reference Books:

1. Electrical Circuit Theory and Technology**, John Bird**, Elsevier, 2011.
2. Essentials of Electrical and Computer Engineering, **Kerns & Irwin**, Pearson, 2004.
3. Electrical Engineering Concepts and Applications, **Carlson and Gisser**, Addison Wesley, 1990.

Prerequisite:

HSXXX : HUMANITIES ELECTIVE -II

NO COURSE NUMBER

OE2044: SHIP HYDRODYNAMICS

Course Content:

Continuity, Euler, Laplace, Navier-Stokes (N-S) and Bernoulli equations; Divergence and Stokes theorems; Potential flow and stream function; Elementary potential flows: parallel flow / source and sink (2D & 3D) sink / vortex / doublet, flow over circular cylinder with and without circulation.Role of compressibility; Vector and tensor forms of fluid dynamic equations; Common dimensional groups (Froude / Reynolds / Cavitation / Euler / Weber / Strouhal numbers); Stokes law of viscosity for shear and normal stresses; Circulation and Stokes theorem (2D & 3D); Helmholtz's vorticity theorems; Vortex line and tube; Vorticity transport equation, convection and diffusion of vorticity; Boundary conditions - rigid and oscillating body or surface, free surface etc., Superposition of elementary flows, Rankine half and closed bodies etc., method of images, source or vortex near wall; Kutta-Joukowski theorem and lift; D'Alembert's paradox; Unsteady flow past circular cylinder and sphere: added mass; Munk moment; Cavitation; Lifting surfaces; Foil section characterizations; Flow around a foil: generation of lift, Kutta condition; Linearised lifting surface theory of thin 2D hydrofoil, thickness and camber problems and their solutions, lift and moment coefficients.N-S equations to Prandtl boundary layer (BL) equations by order of magnitude analysis; Dynamic similarity and boundary conditions; Laminar flow, BL thickness, displacement and momentum thicknesses; BL separation, bluff and streamlined bodies; Vortex shedding by cylinders, Karman vortex street, role of Strouhal no.; Vortex induced vibration; Skin friction, BL along a flat plate at zero incidence, its solution; Blasius formula; Plane Couette flow and Poiseuille flow; Impulsively started plate; Momentum integral equation of BL; Characteristics of turbulent flow; Drag crisis in circular cylinder and sphere; Friction due to turbulent BL over flat plate, power law, roughness effect;

Text Books:

1. **J.N.Newman**, Marine Hydrodynamics, MIT Press, 1977
2. **O.M.Faltinsen**, Hydrodynamics of High Speed marine Vehicles, Cambridge Press, 2005
3. **V.Betram**, Practical Ship Hydrodynamics, B&H, 2000

ReferenceBooks:

1. Principles of Naval Architecture, **E. V. Lewis (Ed.),** SNAME Publications, 1989

Prerequisite:

AM2200: STRENGTH OF MATERIALS

Course Content:

The course content is as follows: 1. Definiation of stress and strain in 1D, 2D and 3D 2. Transformation of stress and strain in 2D, Mohr's Circle 3. Constitutive relations, understanding of plane stress and plane strain phenomenon 4. Stress, strain, deformation of determinate and indeterminate axial members 5. Stress, strain, rotation of determinate and indeterminate torsional members 6. Bending stress and strain in beams 7. Composite beams, equivalent theory 8. Shear stresses in beams 9. Unsymmetric beams 10. Deflections in beams, Compatability conditions for indeternminate beams 11. Stability in columns 12. Introduction to strain energy and determination of deflection 13. Introduction to failure theories

TextBooks:

1. Mechanics of Materials, 8th Edition **| Russell C. Hibbeler |** Pearson Education
2. Elements Of Strength Of Materials **| SP Timoshenko |**

ReferenceBooks:

1. An Introduction to Mechanics of Solids, 3rd Edition **| SH Crandall, NC Dahl, TJ Lardner, MS Sivakumar | Mc Graw Hill**
2. Lecture notes

Prerequisite:

NA

OE2013:SHIP DRAWING AND CALCULATIONS

Course Content:

Introduction to Engineering drawing and graphics. Construction of plane curves. Coordinate system-projection of lines and planes. Projection of right regular solids. Section and intersection of solids and development of surfaces; Systems of projections-principles, conventions and applications of orthographic and isometric projections. Dimensioning principles and conventional representations. Drawing and faring of lines plan from supplied offset data; Calculations for launching, subdivision, damage stability, trim and stability booklet, sounding tables.

Text Books:

1. **Rawson, K.J and Tupper, E.C**. Basic Ship Theory, B&H, 2001
2. **E. C. Tupper**, Introduction to Naval Architecture, Butterworth-Heinemann, 2013.
3. **N. D. Bhat,** Engineering drawing, Charotar publishing house Pvt. Ltd, 2019

Reference Books:

1. **Lewis,E.U**, Principles of Naval Architecture,Vol.1, SNAME, New Jersey, U.S.A, 2010.
2. **Thomas Lamp**: Ship Design and Control Vol I & II, SNAME.

Prerequisite:

OE2023: ARINE INSTRUMENTATION LAB

Course Content::

Basics of instrumentation systems; Working principles of different transducers and their calibration : Strain gauges, Potentiometers, LVDT, Velocity probes, Inclinometers, Accelerometers, Pressure transducers, Wave probes, Load cells. Introduction to signal conditioning and data acquisition, and sources of errors in instrumentation systems

Text Books:

1. Instrumentation lab manual

Reference Books:

1. **Beckwith,T.G., Marangoni, R.D. and Lienhard, J.H.**, Mechanical Measurements, Addison Wesley, USA, 1993.
2. **Collacot, R.A.,** Structural Integrity Monitoring, Chapman and Hall, London, 1985.

Prerequisite:

ID1200: ECOLOGY AND ENVIRONMENT

Course Content:

The course is divided into different modules that are taught by different teachers: This a two credit course – with two instruction classes every week for 14 weeks. The modules and the current set of teachers are as follows: 1. Introduction to Sustainability: Dr. B.S. Murty (Civil Engg.) • Introduction • Definition of Sustainability • Sustainability Goals, • Climate Change • Case Studies (Eg: Dams, Chemicals, e-waste, IOT, Landfill siting etc) 2. Ecology : Dr. Susy Varughese (Chemical Engg.) • Ecology – definitions of Ecological Systems • Biodiversity and Examples • Historical Impact of Economy on Ecology • Restoration / Ecological Engineering 3. Energy: Dr. Srinivas Jayanti (Chemical Engg.) • Energy Demand / Resources • Pollution from Energy generation • Energy and Climate Change (Global Warming) • Energy and Sustainability • Long Range and Short Range Solutions, (Global vs. India) 4. Water Quality and Waste Management: Dr. Ligy Philip (Civil Engg.) • Water Quality and Treatment • Waste Management and Treatment • Case Studies 5. Water Management and Resources: Dr. B. S. Murty (Civil Engg.) • Urban Drainage • Water Resource Management • Impact of Climate Change 6. Sustainability – Economics/Ethics : Dr. Sudhir Chella Rajan (Humanities and Social Sciences) • Sustainability and Economics • Sustainability and Ethics • Urban Planning Sprawl and Sanitation • Transportation • Energy and Smart Grid • Water , Waste and Governance 7. Environmental Management and Life Cycle Assessment: Dr. R. Ravi Krishna (Chemical Engg.) • Risk Assessment - Definition • Pollutant Pathways / Safety/ Exposure • Liability • Life Cycle Assessment and Environmental Management • Case Study Wrap up – Emphasis on Climate Change and Adaptation Course Structure: • Online Recorded Video Lectures • Live sessions for interaction / Q&A • Assignments and Poster • Two Exams – Online on Moodle

Text Books:-

Reference Books:-

Prerequisite:

SEMESTER IV

MAXXX: MATHEMATICS ELECTIVE – II

NO COURSE NUMBER

BT1010: LIFE SCIENCES

Course Content:

Students will be exposed to basic biology concepts and their applications: What is life and how did it originate on earth? ; What is evolution?; The fundamental molecules of life (Biomolecules), cellular metabolism, energy aspects; DNA replication; Cell replication and its quantification; How are proteins made in the cell? – Transcription and translation; Mendelian genetics as a useful tool; The coordinated function of cells in a biological system – Human organ systems; Applications of life sciences in healthcare and industrial biotechnology.

Text Books:

1. **Campbell, N. A., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., and Reece, J. B,** Biology: A Global Approach, Global edition, 11th edition, Pearsons, 2017.
2. **David S.** Goodsell, The Machinery of Life, 2nd Edition, 2009, Springer

Reference Books:

1. **Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter,** Molecular Biology of the Cell, 5th Edition, 2007, Garland Science
2. **Karp, G,** Cell and Molecular Biology: Concepts and Experiments, 7th edition, Wiley, 2013.
3. **Paul Davidovits**, Physics in Biology and Medicine, 3rd Edition, 2007, Academic Press
4. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 3rd Edition, 2006, Cambridge University Press
5. **Suraishkumar G. K.,** Biology for Engineers, Oxford University Press, 2019.

Prerequisite:

NULL

OE2014: MARINE ENGINEERING

Course Content:

Introduction to marine machinery -Types of marine power systems-Engine room layout -Marine diesel engines and their cycles, Fuels Super charging, Ignition and combustion problems-Fuel oil, lubricating oil-Compressed air cooling water systems. Turbines, pumps, their types and characteristics, cavitation etc. Marine boilers, Composite boilers-Exhaust gas and heat exchangers-Economizers, Super heaters. Auxiliary machineries-Choice of power systems for ships. Fire fighting, Navigational aids, Steering gear, shafting, stern tubes and transmission system

Text Books:

1. **Harrington,R.L.** Marine Engineering, SNAME,New York (1992)
2. **Taylor,D.A.,**Introduction to Marine Engineering,Butterworths,London(1983)
3. **Woodward, J.B.,**Low Speed Marine Diesel,Ocean Engineering,A Wiley series(1981)

Reference Books:

1. Any standard text books on thermodynamics and IC engines

Prerequisite:

OE2024: ANALYSIS OF STRUCTURES

Course Content:

Work and energy theorems, Reciprocal theorem, Analysis of indeterminate frames and trusses, Unit load and conjugate beam methods, introduction to Influence lines diagram, Strain energy of beams, bars and torsion members, Matrix formulation of displacement method for frame, truss, bar and torsion members, Beam on elastic foundation and its stiffness matrix, 3D beam element, Transformation, assembly of stiffness matrices.Beam Column theory, Geometric stiffness matrix, Buckling of bars and frames, Introduction to finite element method with application to buckling; 2D and 3D theory of elasticity, Equilibrium and compatibility equations in cartesian and polar coordinates, Strain-displacement relations, Plane stress and plane strain, Use of stress function in 2D problems. Application of matrix methods to problems of marine structures.

Text Books:.

1. **L S Srinath**, “Advanced Mechanics of Solid”, Tata McGraw Hill. New Delhi, 2003
2. **F Guarracino and A Walker**, “Energy Methods in Structural Mechanics”, Thomas Telford Publishing, London, 1999.
3. **Madhulit Mukhopadhyay, Abdul Hamid Sheikh,** “Matrix and Finite Element Analysis of Structure”, Ane Books Pvt Ltd, New Delhi., 2009.

Reference Books:

1. **R D Cook, D S Malkus and M E Plesha**, “Concepts and applications of Finite Element Analysis”, John Wiley & Sons, 1988
2. **D Menon**, “Structural analysis”, Narosa, New Delhi, 2010.
3. **D Menon**, “Advanced Structural analysis”, Narosa, New Delhi, 2010

Prerequisite:

OE2034: SHIP RESISTANCE AND PROPULSION

Course Content:

Components of resistance; Form factor; Wave making resistance - ship wave systems,interference effects, theoretical calculation of wave making resistance, wave breaking resistance, bulbous bows and their effects.Dimensional analysis - laws of comparison – geometrical, dynamical and kinematical similarity,Newton’s, Froude’s and Reynold’s laws, model-ship correlation; Model testing – tank testing facilities, testing, prediction of resistance from model tests, extrapolation (ITTC 78), Froude's Concept, laminar influence and tank wall effect, comparison of resistance prediction with results of full scale trials. Air and wind resistance, resistance of appendages, added resistance in waves; Resistance in restricted waterways – resistance in shallow water, resistance in canals; Determination of resistance from series test results; Resistance of planing crafts, multi-hull vessels, hovercrafts,hydrofoils, SES. Introduction to different propulsion systems in ships; Screw propeller-screw propeller geometry,sections, propeller drawing; Propeller theories - momentum theory, blade element theory,circulation theory.Interaction between hull and propeller- wake and wake fraction; thrust deduction factor,propulsive efficiency in open water and behind conditions, hull efficiency, quasi propulsive coefficient; Powering; Cavitation - types, cavitation number, effects of cavitation, prevention of cavitation, design for minimum cavitation, cavitation tests. Propeller design - propeller series, open water diagrams, design charts; Propeller design and performance study using design charts; Engine selection; Propeller model tests - test facilities,laws of comparison, open water test, self propulsion test; Strength of propellers Practicals: 1. Resistance calculation using Guldhammer - Harvald series 2. Shallow water resistance calculation 3. Propeller design using series chart 4. Propeller drawing Experiments: 1. Model test for ship resistance determination 2. Flow-line test for identifying bilge keel position 3. Propeller model open water test in towing tank 4. Model test for wake fraction determination 5. Self propulsion model test for thrust deduction fraction determination

Text Books:

1. **John Letcher, Randolph Paulling**: Principles of Naval Architecture series-Ship Resistance and flow, SNAME, U.S.A., 2009.
2. **Antony F Molland, Stephen R turnock**, Ship resistance and propulsion-practical estimation of propulsive power,2011.

Reference Books:

1. **Harvald S.A.**; “Resistance and Propulsion of Ships”, John Wiley & Sons., 1983. 137
2. **John Carlton**, Marine Propellers and propulsion, 2007. Baker George Stephen, Ship form, Resistance and screw propulsion, Hard press publishing, 2013.
3. **D. W. Taylor** ; Resistance of Ships and Screw Propulsion, Unikum, 2012.
4. **J P GHOSE and R P GOKARN**. Basic Ship Propulsion, KW Publishers Pvt Ltd. 2015.

Prerequisite:

OE2054: OCEAN WAVE HYDRODYNAMICS

Course Content:

Review of Basic Fluid Mechanics: Conservation of mass and momentum, Euler Equations, Bernoulli's equation, velocity potential, stream function. Ocean Environment, Waves: Classification of water waves – Two-dimensional wave equation and wave characteristics – wave theories – Small amplitude waves – Finite amplitude waves – Stokian, Solitary and Cnoidal wave theories – Water particle kinematics – wave energy, power. Wave deformation – Reflection, Refraction, Diffraction, Breaking of waves – Spectral description of Ocean Waves – Design wave. Wave-Currents Interactions, Radiation Stress. Forces: Wave forces – Morison equation – Wave loads on vertical, inclined and horizontal cylinders. Diffraction theory – wave slamming and slapping. Lab : Measurement of wave properties such as L, H, T, C and Cg. Wave Reflection, pressure measurements, force estimations, mass transport velocity, random waves, wave paddle transfer function

Text Books:

1. **Dean, R.G. and Dalrymple, R.A**., Water wave mechanics for Engineers and Scientists, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1994

ReferenceBooks:

1. **Sarpkaya, T. and Isaacson, M**., Mechanics of Wave Forces on Offshore Structures, Van Nostrand Reinhold Co., New York, 1981
2. **Weigel, R.L**.Oceanographical Engineering, Prentice Hall Inc, 1982
3. **Sorenson, R.M.,** Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978.

Prerequisite:

SEMESTER V

OE3015: SHIP STRUCTURAL ANALYSIS

Course Content:

Loads acting on ships; Longitudinal strength-shear force and bending moment-still water and wave loads-deflections unsymmetrical bending-bending stresses and design of mid-ship section, Shear flow analysis of multi-cell sections-Torsional analysis-Warping torsion-Determination of shear and normal stresses-shear lag and effective breadth. Bending of plates-stiffened, plates-orthotropic, plates-large deflection theories and applications. Buckling and ultimate strengths of columns, plates and stiffened panels-concept of effective width-ultimate strength of the hull girder. Finite elements for simple plated structures-use of computer packages for the analysis of ship structures. Review of SDOF systems, Sources of ship vibrations – propeller excited, wave-induced and machinery – Calculation procedure for torsional vibration of propulsion systems – empirical methods. Hull girder vibration. Practicals: 1. Longitudinal strength calculation for ships 2. Transverse strength calculation for ships

Text Books:

1. **Hughes, O.E,** Ship Structural Analysis and Design, SNAME , 2010
2. **Mansour, A. and Liu, D**. Strength of Ships and Ocean Structures, PNA series, SNAME 2008

Reference Books:

1. **Jensen, J.J**, Load and Global Responses of Ships, Elsevier, 2001
2. **Bai, Y**. Marine Structural Design, Elsevier, 2003

Prerequisite:

OE3035: MOTION OF SHIPS & FLOATING SYSTEMS

Course Content:

Ship motions – coordinate systems, 6 dof, uncoupled and coupled equation of motion; hydrodynamic coefficients; encounter frequency; motion damping effects, magnification and tuning factors. Ship responses in regular waves. Ship in seaway and dynamic effects – Linear superposition, response amplitudes operator, motions in irregular waves, local and relative motions, green water effects, slamming, parametric rolling, broaching, added resistance, powering in waves; motion sickness. Linear wave induced motions on floating structures- Responses in regular and irregular seas, Wave induced motions and loads on a tension leg platform and spar. Heave and pitch motion of a semi-submersible, discussion of natural period, damping and excitation. Ship and floating system motion control – Control of roll - bilge keel, free surface tanks, U-tanks, moving weight;, fin stabilisers, gyro, active-tank;, rudder stabilization; Control of pitch. Practical : 1. Estimation of hydrodynamic coefficients and RAOs using strip theory. Experiments: 2. Roll and heave damping coefficient estimation using free oscillation tests 3. Ship and floating body motion response in regular waves

Text Books:

1. **Lewis,E.U**, Principles of Naval Architecture, SNAME, New Jersey, U.S.A, 2010.
2. **Lewandowski, E.M.** The Dynamics of Marine Crafts – Seakeeping & Maneuvering, World Scientific, 2004

Reference Books:

1. **Faltinsen, M.O.** Sea Loads on Ships and Offshore Structures, Cambridge Ocean Technology Series, 1999
2. **Bhattacharyya..R**; ‘Dynamics of Marine vehicles’, 1978, Wiley Inter Science, New York
3. **Faltinsen, M.O**. Hydrodynamics of High Speed Marine Vehicles, Cambridge Press, 2005

Prerequisite:

OE3016: SHIP DESIGN

Course Content:

Marine transportation and trade routes, ship categorization - dead-weight carrier, capacity carrier, linear dimension ship; Service ships and offshore support vessels; Advanced marine vehicles; Ship design requirements. Ship design methods – design using basic type ships, design using coefficients, design using iteration methods; design spiral; Ship parameters – displacement, displacement coefficient, displacement equation, volume equation, solution of the cubic equation; Ship dimensions, hull form, form coefficients; Mass estimation - lightship mass – steel mass, outfit mass, engine plant mass; dead weight. Design of hull form – conventional method of lines, distortion of existing forms; stem and stern contours, bulbous bow.; General arrangement - Subdivision of the ship's hull and erections, arrangement of spaces, arrangement of tanks, superstructure and deckhouses, arrangement of engine plants, cargo handling capacity, hold capacity and stowage factor. Effect of form on Ship's performance: Freeboard and load line regulation; Stability – stability booklet, IMO Regulations, Checks on stability, trim; Watertight integrity; damage stability, Behaviour of ships in sea, resistance, powering, propulsion Cargo handling equipment, cargo hatches; Anchoring and mooring systems; Accommodation requirements, layout and design. Access equipment –hatches, manholes, doors, other closing & opening devices, load line rules, gang ways and ladders; LSA and FFA; Steering gear systems, navigational systems. Tender specification; Economic considerations in ship design and building; Operational Economics; Introduction to ship design softwares. Practicals: 1. Computer-Aided ship design - owner's requirement of ship (given), design of main dimensions, design of form, weight estimation, hydrostatics, checks on stability, trim, capacity, general arrangement, etc. 2. Practicals on softwares dealing with basic ship calculations and ship design.

Text Books:

1. **D.G.M.Watson**, "Practical Ship Design", Elsevier 2002
2. **Thomas Lamb**, "Ship Design and Construction", SNAME 2003
3. **ApostolosPapanikolaou**, Ship Design: Methodologies of preliminary design, SNAME,2014.

Reference Books:

1. **Schneekluth, H**; Ship Design for Efficiency and Economy, Butterworths, 1987
2. **Taggart**; Ship Design and Construction, SNAME, 1980.
3. **IndraNath Bose**, Energy Efficiency and Ships, SNAME, 2012.
4. **Antony F Molland**, A Guide to ship design, construction and operation, SNAME, 2008

Prerequisite:

OE3045: VIBRATION OF MARINE STRUCTURES

Course Content:

Equations of motion, D'Alembert's principle. Analysis of single degree of freedom systems (free and forced), Dynamic amplification factor and resonance, Viscous and structural damping, Impulse response system, Time & Frequency domain methods, Duhamel integral, Vibration isolation, Concept of Lagrange • Discrete MDOF systems, Modes of vibration, Normal modes, Natural frequencies, modal Participation factor, orthogonality applications, forced vibration using eigen functions expansions, vibration absorbers, Shear building models • Continuous systems: Vibration of cables, rods and beams – Sources of vibration – propeller excited, wave-induced and machinery, Hull girder vibration. • Dynamic effects of earthquake, wind and moving loads, vehicular impacts. Random vibrations, Calculation procedure for torsional vibration of propulsion systems – empirical methods. • Approximate methods, Rayleigh's quotient, Rayleigh Ritz and Galerkin methods.

Text Books:

1. **L Meirovitch** 1997, Principles of techniques of vibration, Prentice Hall, NJ
2. **A K Chopra** 2007, Dynamics of structures, Pearson Education India.
3. **R W Clough and J Penzien** 2015, Dynamics of Structures, CBS Publishing; 2nd edition.
4. **S. S. Rao** 2019, Vibration of Continuous Systems, Wiley-Blackwell.
5. **E. V Lewis** 1990, Principles of Naval Architecture, SNAME

Reference Books:

1. **L Fryba** 2012, Vibration of solids and structures under moving loads, Springer
2. **R. D. Blevins** 2006, Flow-Induced Vibration, Krieger Publishing Company
3. **M.Y.H. Bangash** 2009, Shock, Impact and Explosion: Structural Analysis and Design, Springer.
4. **J. P. Den Hartog** 1985 Mechanical Vibrations, Dover
5. **L. Meirovitch** 2007, Methods of Analytical Dynamics, Dover.
6. **L D Lutes and S Sarkani**, “Random Vibrations”, Elsevier Butterworth, Burlington, USA, 2004

Prerequisite:

OE3190: DESIGN OF OCEAN STRUCTURES

Course Content:

Coastal Structures:Design principles of breakwater, seawall, groynes, berthing structures, quay walls and open sea jetty, breasting and mooring dolphins; Dry Docks, Slipways; Code Provisions : IS 4651, IS 2911 and BS 6349 Offshore Structures:Concepts and design principles of jacket and topside structures,Tension Leg Platforms, Spar Structures, Jackups and FPSO's; Concepts and design of foundation for offshore structures; Code Provisions : API RP 2A and API RP2T.

Text Books:

1. Coastal Hydrualics by **A.M.M. Wood and C.A. Fleming**, Macmillan Press Limited, 1981.
2. Coastal Engineering by **K. Horikawa**, University of TokyoPress, 1978
3. Design and Construction of Port and Marine Structures by **A. D. Quinn**, McGraw-Hill Book Company
4. Port Design : Guidelines and recommendations by **C. A. Thoresen**, Tapir Publications
5. Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels by **J. W. Gaythwaite**, VanNostrand;

Reference Books:

1. Handbook of Offshore Engineering by **S.K. Chakrabarti**, Elseviers, 2005

Prerequisite:

Core Course

FREE ELECTIVE – I

SEMESTER VI

OE3036: MANOEUVRING AND CONTROL OF MARINE VEHICLES

Course Content:

Controllability fundamentals of ships and submarines–Introduction- Kinematics of rotating frame, Nonlinear 6-DoF and 3-DoF rigid body equation of motion, nonlinear and linear hydrodynamic derivatives, linear equations of motion for ship, longitudinal and lateral models for submarines, stability indices; Stability and control in the horizontal and vertical planes; Munk moment Definitive manoeuvres – turning tests, overshoot and zigzag tests, spiral and pullout tests, accelerating, stopping and backing tests. Control surface hydrodynamics – rudder geometry, aspect ratio, influence of fixed structures; Control surface design - specification of requirements and constraints on rudder design, types of rudder, rudder stock; Influence of ship features on controls fixed stability. Experimental determination of hydrodynamic derivatives - straight line test, rotating arm technique, planar motion mechanism; Numerical methods used in ship manoeuvring problems, ship manoeuvring simulators; IMO Rules and Recommendations. Ship manoeuvring sea trials. Control fundamentals-introduction-(Linear and nonlinear control, PID) , Linear system representation, first and second order Nomoto Equation, State-space modelling, Converting State-space model to transfer function, PD & PID controllers, Tuning, PID controller with acceleration feedback Practicals : 1. Calculation of free stream characteristics of rudder. 2. Rudder design – dimensions, form, structure and system Experiments: 1. Straight line test in towing tank 2. PMM tests in the towing tank 3. Free running models tests in the basin

Text Books:

1. **Lewis,E.U,** Principles of Naval Architecture, SNAME, New Jersey, U.S.A, 2010.
2. **Fossen, T.I,** Guidance and Control of Marine Vehicles, John Wiley & Sons, 1999
3. **Molland,A.F and Turnock, S.R.,** Marine Rudders and Control Surfaces, Elsevier, 2007
4. **Lewandowski, E.M**. The Dynamics of Marine Crafts – Seakeeping & Maneuvering, World Scientific, 2004

Reference Books:

1. **Abkowitz,M.A**.; Lectures on Ship Hydrodynamics – Steering and Manoeuvrability, Danish Technical Press, Copenhagen, Denmark, 1964
2. Lecture notes – Maneuvering and control of marine vehicles**, Michael S. Triantafyllou, Franz S. Hover** , Department of Ocean Engineering Massachusetts Institute of Technology Cambridge, Massachusetts USA
3. **Khac Duc Do and Jie Pan**, Control of Ships and Underwater Vehicles , Springer, 2009
4. **Faltinsen, M.O**. Hydrodynamics of High Speed Marine Vehicles, Cambridge University Press, 2009
5. **Newman J.N**; 'Marine Hydrodynamics', MIT Press, USA, 1977

Prerequisite:

OE3046: SHIP STRUCTURAL DESIGN

Course Content:

Review on Shipbuilding materials, joining techniques, structural design steps, basic approach and use of classification rules. Ship framing systems; Structural systems and components at bottom, side, deck, bulkheads, fore-end, aft-end, engine room and their design using classification rules. Design of superstructures, accommodation area, forecastle, hatch covers, chain locker, rudder, cargo handling systems, nozzle, etc. Practicals: 1. Structural design and drawing of mid-ship section, fore-peak, aft-peak, engine room, bulkhead, rudder 2. Shell expansion drawing

TextBooks:

1. **Taggart;** Ship Design and Construction, SNAME, 1980.
2. **Eyres D.J.;** Ship Construction, William Heinemann Ltd, London, 2011.
3. **Okumoto,Y.** Design of Ship Hull Structures- A practical guide for Engineers, Springer – Verlag, 2009.

ReferenceBooks:

1. **Jensen, J.J**, Load and Global Responses of Ships, Elsevier, 2001
2. **Bai, Y**. Marine Structural Design, Elsevier, 2003
3. **Paik, J.K and Thayamballi, A.K.**, Ultimate Limit State Design of Steel-Plated Structures, John Wiley, 2003

Prerequisite:

FREE ELECTIVE – II

FRE ELECTIVE – III

FREE ELECTIVE – IV

FRE ELECTIVE – V

OEXXX – HONOURS ELECTIVE

NO COURSE NUMBER

SUMMER

OE3026: SHIPYARD TRAINING

Course Content:

As per industry requirements in concurrence with one faculty advisor

Text Books:

As per manuals from instructor

Reference Books:

As per manuals from instructor

Prerequisite:

SEMESTER VII

OEXXXX – PROFESSIONAL ELECTIVE – I

NO COURSE NUMBER

OE5320: NONLINEAR PROBLEMS IN OCEAN ENGINEERING

Course Content:

Nonlinearity – definition and sources; examples of offshore systems involving nonlinear analysis Degrees of freedom, Generalized coordinates, Behaviour of Dynamical systems about Equilibrium points, System with non-linearity, Conservative and Non-conservative systems – Nonlinear Stiffness and damping.- Duffing, van-der-Pol equation Analytical solutions – Perturbation solution Forced oscillations – Sub and super harmonic motions; Chaotic motions. Systems with periodic coefficients-Mathieu's equations, Floquet's theory, Stability; Moorings, Nonlinear wave theories and wave loading; Responses of structures excited by Second-Order Effects; Nonlinear wave loading on large floating systems, Random response and statistical analysis.

Text Books:

1. Nonlinear Methods in Offshore Engineering by **SK. Chakrabarti**
2. Stochastic Dynamics of Marine Structures by **Arvid Naess, Torgeir Moan**
3. Nonlinear Dynamics and Chaos by **SH. Strogatz**
4. Nonlinear Oscillations by **Ali H. Nayfeh and DT Mook**

Reference Books:

1. Nonlinear Dynamics and Chaos by **J. M. T. Thompson and H. B. Stewart**
2. Hydrodynamics of Offshore Structures by **SK Chakrabarti**
3. Wave Forces on Offshore Structures by **T Sarpkaya**
4. Fluid Structure Interaction in Offshore Engineering by **S. K. Chakrabarti**
5. An Introduction to Random Vibrations, Spectral & Wavelet Analysis by **D. E. Newland**
6. Ocean Waves: The Stochastic Approach by **Michel K. Ochi**
7. Random Data: Analysis and Measurement Procedures by **Julius S. Bendat and Allan G. Piersol**

Prerequisite:

OE5545: MARINE GEOTECHNICAL ENGINEERING

Course Content:

Classification of marine sediments and soils; basic soil properties, correlation between engineering parameters, geotechnical investigation, bore techniques; Soil testing methods in laboratory and fields; very soft and recent deposits in river mouth; characteristics of thixotropic soils; Advanced testing methods for soft marine clays; sensitivity of soils; time-dependent behaviour of marine sediments. Upper and lower bound soil characteristics; Soil stabilization; fills and reclamations; soil treatments and ground improvement methods; stone columns and band drains; coastal protections and reclamation dykes; Bearing capacity, sliding stability, over-turning stability, short-term and long-term settlements, factor of safety; Bucket foundation; Suction anchors; Gravity foundation; Earth retaining structures; Diaphragm walls; stability of breakwater on soft soils; RC bored piles; Driven piles, drilled and grouted steel piles; Axial and lateral capacity, point bearing and skin friction, factor of safety, lateral load on piles, p-y, t-z and q-z curves, linear spring methods; bearing capacity in soils, weathered rock, and intact rock. Pile group effect, scour around piles, seabed subsidence and design of piles against seabed movement, negative skin friction, cyclic degradation. Pile driving and monitoring; pile testing and correlations; Pile remedial measures

TextBooks:

ReferenceBooks:

1. **Chakrabarti, SK**. 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
2. **Tomlinson, MJ**. 1994. Pile Design and Construction practice, 4th Ed., E&FN Spon, London, UK, ISBN: 0-203-47457-0.
3. **Joseph E. Bowles**. 1988. Foundation analysis and design, 5th Ed., McGraw-Hill, Singapore, ISBN: 0-07-118844-4
4. **Ben C. Gerwick Jr**. 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7

Prerequisite:

FREE ELECTIVE – VI

FREE ELECTIVE – VII

HONOURS ELECTIVE – II

SEMESTER VIII

HSXXXX: HUMANITIES ELCTIVE – III

OE6200: DESIGN OF FIXED OFFSHORE STRUCTURES

Course Content:

Wind profile; gusting and averaging of wind speed; wind pressure and forces; Wave kinematics; Wave theory selection; drag and inertia regimes; wave and current interaction; Morison equation applied to spatially distributed framed structures; hydrodynamic coefficients and marine growth; Seismic zone in India on land and offshore/coastal area; Recurrence interval and selection of design seismic acceleration; Return period for strength and ductility; Seismic loads; loads due to fire and blast; loads due to ship impact and ice impact; Design principles of jackets and pile foundations; main and skirt pile arrangements; wellhead and process platforms; concepts and geometry; Material selection for different classes of structural members; Structural analysis (linear and nonlinear); Pushover analysis procedure; Tubular Members, Slenderness effects; Column Buckling, Design for Hydrostatic pressure; Design for combined axial and bending stresses; Simple tubular joints, design using allowable loads; design of T, K and Y joints; Parametric equations; stress concentration factors; Design using pseudo static methods; Design of ring stiffened joints; Introduction to fatigue failure; cracking and Paris law; fracture mechanics and material selection for joints; material toughness class; S-N curves and fatigue damage calculations; deterministic and spectral fatigue analysis; Introduction to corrosion; corrosion protection coatings and design of cathodic protection; design of anodes; cathodic protection monitoring system

Text Books:

1. **Chakrabarti, SK**. 1994. Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0-90545-166-4
2. **Chakrabarti, SK.** 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
3. **Chen,WF, E.M. Lui**. 1987. Structural stability: Theory and implementation, Elsevier, New York, ISBN: 0-444-01119-6.
4. **Ben C. Gerwick Jr**. 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7
5. UEG Offshore Research. 1985. Design of Tubular Joints for offshore structures, Vol. 1-3, UEG Publications, ISBN: 978-086-0172-314
6. **Bjorn Skallerud and Jorgen Amdahl**. 2002. Nonlinear analysis of offshore structures, Research Studies Press, Baldock, ISBN: 978-086-3802-584
7. **Srinivasan Chandrasekaran**, Gaurav Srivastava. 2022. Fire-resistant design of structures, CRC Press, FLORIDA, USA, ISBN: 978-103-2358-116

Reference Books:

1. API-RP 2A. 2000. Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design, 21st Edition, Errata and Supplement 1, December 2002, Errata and Supplement 2, September 2005, Errata and Supplement 3, October 2007.
2. FABIG. 1992. Interim Guidance Notes for the design of and protection of topside structures against explosion and fire, FABIG Technical Notes, Ascot, UK.
3. AWS D1.1. 2000. Structural welding code- Steel, American Welding Society, FL, USA, pp. 449.
4. DNV-RP-401. 2010. Cathodic protection design, Det Norske Veritas, Norway.
5. **Chandima Ratnayake, RM and Samindi Samarakoon, SM.** 2017. Modeling and Simulation techniques in structural engineering: Structural Integrity Assessment and Control of Ageing Onshore and Offshore Structures, IGI Global publishers, USA, pp. 445-476.
6. N-006. 2009. Assessment of structural integrity for existing offshore load bearing structures, 1st Ed., NORSOK Standards, Norway.
7. DNV Report 95-3203. 1996. Guidelines for offshore structural reliability analysis: Application to Jacket Platforms, Det Norske Veritas, Norway.

Prerequisite:

Nil

OE5500: FEM APPLIED TO OCEAN ENGINEERING

Course Content:

Introduction – Different approaches to finite element formulation – Different types of element and interpolation functions, Lagrange & Hermitian Polynomials, natural co-ordinates – Derivation of element property matrices – Assembly – solution of finite element equations – Structural and geotechnical problems – Nonlinear analysis. Application to fluid mechanics problems, Fluid-structure interaction – Diffraction of waves, 2D formulation using mild – slope equation – use of infinite elements – Added mass and damping matrices for floating bodies, 2D formulation – Harbour resonance, Liquid sloshing – Vibrations of underwater structures Introduction to Boundary element techniques.

Text Books:

1. **J.N. Reddy.** 1984. An Introduction to the finite element method. McGraw Hill. (third edition, 2005)
2. **O.C. Zienkiewicz, R.W. Lewis and K.G. Stagg (eds.)** 1978. Numerical methods in Offshore Engineering. Wiley

Reference Books:

1. **R.D. Cook**. 1981. Concepts and applications of finite element analysis. Wiley.
2. **O.C. Zienkiewicz**. 1977. The Finite Element Method. McGraw Hill. (vol.I, II, III)
3. **K.J. Bathe.** 1981. FE procedures in Engineering Analysis.

Prerequisite:

PROFESSIONAL ELECTIVE – IV

FREE ELECTIVE – VIII

HONOURS ELECTIVE – III

SUMMER

OE5371: NAVAL ARCHITECTURE AND OCEAN ENGINEERING DD PROJECT - PHASE I

Course Content:

Students should be able to find out the appropriate numerical/analytical/ experimental tools required and learn them.

Text Books:

As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Reference Books:

As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Prerequisite:

SEMESTER – IX

OE5372: NAVAL ARCHITECTURE AND OCEAN ENGINEERING DD PROJECT - PHASE II

Course Content:

In the second half, the initial results and the pilot problem as well as the hands-on experience in the tools (analytical, numerical and experimental) should be finalized so as to obtain results from the proposed research.

Text Books:

1. As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Reference Books:

1. As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Prerequisite:

PROFESSIONAL ELECTIVE – V

PROFESSIONAL ELECTIVE – VI

SEMESTER – X

OE5373: NAVAL ARCHITECTURE AND OCEAN ENGINEERING DD PROJECT - PHASE III

Course Content:

Experiments and /or simulations and / or computations related to the project. Analysis of outcomes and presentation of the results from the proposed research. Present any theoretical proofs of any new methods / findings (if applicable).

Text Books:

1. As prescribed by the faculty guide e.g., existing literature and previously carried out projects

Reference Books:

1. As prescribed by the faculty guide e.g., existing literature and previously carried out projects

Prerequisite:

LIST OF ELECTIVES

ELECTIVE A: MATHEMATICS

MA2010: COMPLEX VARIABLES

Course Content:

Analytic functions: Limits and continuity, differentiability and analyticity, analytic branches of inverse of functions, branches of logarithm, Cauchy-Riemann equations, harmonic conjugates. Complex integral: Cauchy's theorem and integral formula, series of complex functions and the Weierstrass M-test, Taylor series, identity theorem, isolation of zeros of an analytic function, statements of open mapping, inverse function, Liouville's theorem, fundamental theorem of Algebra. Residue Calculus: Singularities and their classification, Laurent series, residue theorem and argument principle, computing real integrals using residues. Bilinear transformation: Bilinear transformation, conformal mapping, elementary properties of the mapping of exponential, sine and cosine functions. Complex integrals: Line integral, Cauchy's integral theorem and integral formula, Taylor and laurent series, Residue theorem and applications, Bilinear transformations. Transforms: Fourier transformations Fourier transforms (exp, sin, cos), Laplace transforms inversion integrals, Convolutions, Applications.

Text Books:

1. **E. Kreyszig**, Advanced Engineering Mathematics, 10th Ed., John Willey & Sons, 2010.

Reference Books:

1. **R.V Churchill & J.W. Brown:** Complex Variables and Applications, Mc-Graw Hill, 1990.
2. **S. Ponnusamy and H. Silverman**, Complex Variables with Applications, Birkhauser, 2006.

Prerequisite:

NULL

MA2030: DIFFERENTIAL EQUATIONS

NO DATA

MA2040: PROBABILITY, STATISTICS AND STOCHASTIC PROCESS

Course Content:

Probability: Probability models and axioms, conditioning and Bayes' rule, independence discrete random variables; probability mass functions; expectations, examples, multiple discrete random variables: joint PMFs, expectations, conditioning, independence, continuous random variables, probability density functions, expectations, examples, multiple continuous random variables, continuous Bayes rule, derived distributions; convolution; covariance and correlation, iterated expectations, sum of a random number of random variables. Stochastic processes: Bernoulli process, Poisson process, Markov chains. Weak law of large umbers, central limit theorem. Statistics: Bayesian statistical inference, point estimators, parameter estimators, test of hypotheses, tests of significance.

TextBooks:

1. **D. Bertsekas and J. Tsitsiklis**, Introduction to Probability, 2nd ed, Athena Scientific, 2008.

ReferenceBooks:

1. **K.L. Chung**, Elementary Probability Theory with Stochastic Process, Springer Verlag, 1974.
2. **A. Drake**, Fundamentals of Applied Probability Theory. McGraw-Hill, 1967.
3. **O. Ibe**, Fundamentals of Applied Probability and Random Processes, Academic Press, 2005.
4. **S. Ross**, A First Course in Probability. 8th ed. Prentice Hall, 2009.

Prerequisite:

NULL

MA2060: DISCRETE MATHEMATICS

Course Content:

Sets and cardinality. Propositional logic, predicates and quantification, Methods of proof. Modular Arithmetic: Divisibility, modular arithmetic, prime numbers, induction proofs. Introduction to graphs: Graphs, paths, connectivity. Combinatorics: Counting, Binomial theorem and Bijective counting.. pigeonhole principle, inclusion-exclusion principle, generating functions and recurrences. Discrete Probability: Probabilistic counting (after introducing Probability, independence, random variables, expectation).

Text Books:

1. **Kenneth .H. Rosen**, Discrete Mathematics and its Applications, 7th Ed., McGraw Hill, 2012.
2. A walk through combinatorics - **Miklos Bona**, 4th edition. World scientific.

Reference Books:

1. Elements of Discrete Mathematics - **C L Liu, D Mohapatra**. 4th edition. Mcgraw Hill. 2017.

Prerequisite:

MA2130: BASIC GRAPH THEORY

Course Content:

Fundamentals:Graphs, subgraphs, isomorphism, representation of graphs, degrees and graphic sequences, walks, trails, Paths, Cycles, connectivity, bipartite graphs Trees: Characterisations of trees, minimum -spanning -trees, number of trees, cayley's formula connectivity: cut-seats, characterization of blocks. Search algorithms: DS,BFS, shortest peth algorithms, identification of cut-vertices and cut-edges. Eulerian and Hamilton graph; Characterizations, Necessary / sufficient conditions, Fleury's algorithms. Converings, independent sets:Basic relations, Matchings in bipartite graphs, Tutte's perfect matching theorem and consequences. Colorings, Edge-colorings of bipartite graphs, Gupta Vizing's theorem (without Proof), greedy algorithm for vertex-colorings, Brook's theorem, clique-number and vertex shromatic number. Planar graphs: Euler's formua V-E+F=2 and its consequences, Kuratowski's Characterization(without proof), DMP planarity algorithm. Direct graphs: Basics, various connectivities and tournaments.

Text Books:

1. **J.A.Bondy and U.S.R.Murthy**; Graph theory with applications, Macmillan (1976)

Reference Books:

1. **D.B.West**; Introduction to graph theory, P.H.I.(1999).

Prerequisite:

NULL

<u>ELECTIVE (E) – PROFESSIONAL FOR NA & OE (B.TECH & DD)</u>

ME3350: DESIGN OF MACHINE ELEMENTS

NO DATA

MM3012: JOINING & NDT LAB

Course Content:

Demonstration of joint preparation for welding. Demonstration of manual metal arc welding, gas tungsten arc welding, plasma arc welding, gas metal arc welding and resistance spot welding with regard to equipment details, operational parameters and execution of the process. Demonstration of Liquid penetration testing, Magnetic particle testing, Ultrasonic testing and Radiographic testing and familiarization with corresponding equipment.

Text Books:

NA

Reference Books:

NA

Prerequisite:

MM3060: METAL JOINING TECHNOLOGY

NO DATA

MM5320: CORROSION ENGINEERING

Course Content:

Corrosion principles: Electrochemical aspects, environmental effects, metallurgical aspects, economics of corrosion Thermodynamical aspects: Electrified interface (metal-electrolyte interface), potential difference, EMF series, Nernst Equation and Pourbaix diagram Kinetic aspect: Corrosion rate, Current density, Exchange current density, Mixed potential theory, Polarization, relation between corrosion rate and overpotential, Passivation Forms of corrosion characteristics, mechanisms, prevention, and testing. Corrosion testing: DC and AC methods of testing, polarization measurements- Corrosion rate assessment by Tafel's extrapolation method, Linear polarization resistance (LPR).

Text Books:

1. Corrosion Engineering, **Mars. G. Fontana**. Published by Tata McGraw Hill Education Pvt. Ltd., 2005.
2. Electrochemical Techniques in Corrosion Science and Engineering. **R.G. Kelly, J.R. Scully, D.W. Shoesmith, R.G. Buchheit**. Published by Marcel Dekker Inc., 2002

Reference Books:

1. Corrosion: Metal / Environment Reactions, Volume 1, **L.L. Shreir, R.A. Jarman, G.T. Burstein, Butterworth-Heinemann**, 1994.
2. Principles and Prevention of Corrosion, **Denny A. Jones**, Prentice Hall, 1995.
3. Corrosion and Surface Chemistry of Metals, **Dieter Landolt**, EPFL Press, 2007.
4. Corrosion of Stainless Steels, **A. John Sedriks, Wiley**-Interscience, 1996.

Prerequisite:

NIL

MM5750: WELDING APPLICATION TECHNOLOGY

Course Content:

Testing of Weldments: destructive and non-destructive. Fatigue behaviour of welded structures. Brittle fracture: metallurgical considerations. Notch toughness, transition temperature and their dependence on various factors. Fracture mechanics approach: plane strain toughness and crack opening displacement criteria, J-integral and R-curve method, application of above concepts in toughness characterization of weldments. Economics of welding: Cost evaluation and selection of process, comparison with other fabrication techniques. Training of welding personnel, safety precautions. Quality control in welding, standards and codes. Application of welding technology in a few industries. Pressure vessel fabrication, chemical industry, nuclear reactors, ship and offshore structures, aviation, automotive and railroad industries.

Text Books:

1. Advanced welding processes – Technologies and Process Control by **John Norrish**, ISBN: 978-1-84569-130-1., Woodhead Publishing, reprint by Elsevier, 2006.
2. Welding Engineering and Technology by **R.S. Parmar**, Khanna Publishers., ISBN: 81-7409-028-2, 2010

Reference Books:

1. International Institute of Welding – Codes and Standards (iwelding.sharepoint.com)
2. **Li, Leijun. et. al**. eds.. ASM Handbook: Welding Fundamentals and Processes, vol. 6A. Materials Park, OH: ASM International, 2011.

Prerequisite:

NIL

OE3190: DESIGN OF OCEAN STRUCTURES

Course Content:

Coastal Structures:Design principles of breakwater, seawall, groynes, berthing structures, quay walls and open sea jetty, breasting and mooring dolphins; Dry Docks, Slipways; Code Provisions : IS 4651, IS 2911 and BS 6349 Offshore Structures:Concepts and design principles of jacket and topside structures,Tension Leg Platforms, Spar Structures, Jackups and FPSO's; Concepts and design of foundation for offshore structures; Code Provisions : API RP 2A and API RP2T.

Text Books:

1. Coastal Hydrualics by **A.M.M. Wood and C.A. Fleming**, Macmillan Press Limited, 1981.
2. Coastal Engineering by **K. Horikawa**, University of TokyoPress, 1978
3. Design and Construction of Port and Marine Structures by **A. D. Quinn**, McGraw-Hill Book Company
4. Port Design : Guidelines and recommendations by **C. A. Thoresen**, Tapir Publications
5. Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels by **J. W. Gaythwaite**, VanNostrand;

Reference Books:

1. Handbook of Offshore Engineering by **S.K. Chakrabarti**, Elseviers, 2005

Prerequisite:

Core Course

OE4300: OCEAN ENERGY

Course Content:

Importance of generation of Ocean Energy, Various forms of ocean energy, Generation of waves ; Wave theories Systems generating power from oceans Offshore Wind – Wind as an offshore resource, wind loads and aerodynamics. Wave load and hydrodynamics, Design loads for wind turbines- wind and wave spectra, Support structures – fixed and floating. Offshore Waves -- Major forms of ocean wave energy devices, Physics behind conversion – interaction between oscillation and waves, Hydrodynamics of devices, Wave energy resource- wave spectra analysis and design loads, Tides, Currents and Thermal gradients - Energy From Tides, Currents and Offshore Thermal Energy Conversion (OTEC), Tide and Current Generation, OTEC System Concepts – Open and Closed System. Special reference to Indian scenarios in each case

Text Books:

1. Energy Harvesting Solar, Wind, and Ocean Energy Conversion Systems: Authors: **Alroza Khaligh Omar G. Onar.**
2. Offshore Wind Power. Authors: **J Twidell and G Gaudiosi**
3. Wind Energy Explained: Theory, Design and Application. Authors: **JF Manwell, JG McGowan and AL Rogers**
4. Ocean Wave Energy: Current Status and Future Perspectives. Author: **Joao Cruz.**
5. Ocean Energy: Tide and Tidal Power. Authors**: R. H. Charlier and Charles W. Finkl**
6. Renewable Energy From the Ocean: A Guide to OTEC (Johns Hopkins University Applied Laboratory Series in Science and Engineering) 1994 Authors: **William H. Avery and Chih Wu**

Reference Books:

1. Wind Energy Handbook. Authors: **T Burton, N Jenkins, D Sharpe and E Bossanyi**.
2. Ocean Waves and Oscillating Systems: Linear Interactions Including Wave-Energy Extraction. Author: **Johannes Falnes**

Prerequisite:

OE4400: DRILLING VESSELS AND SUPPORT CRAFTS – NO DATA

OE4600: ADVANCED SHIP HYDRODYNAMICS

Course Content:

i. Introduction. Review of basic hydrodynamics, wave mechanics and complexities of practical Ship Hydrodynamics problems. ii. Navier-Stokes Equation: Formulation and derivation of ship hydrodynamics in real fluids. Some exact solutions including of impulsively started plate. Boundary-Layer theory. Blasius solution. Friction lines of ships. iii. Computational Fluid Dynamics: Introduction to boundary-integral and finite-difference methods applied for ship hydrodynamics problems. Application of vortex-lattice and panel methods for lifting surface hydrodynamics. iv. Approximate Methods: Slender body theory; Strip theory for determining ship motion in waves. Michell's thin ship theory to determine wave resistance.

Text Books:

1. **Faltinsen, M.O**. Hydrodynamics of High Speed Marine Vehicles, Cambridge Press, 2005
2. **Newman J.N**; 'Marine Hydrodynamics', MIT Press, USA, 1977

Reference Books:

1. **Newman J.N**; 'Theory of Ship Motions', Advances in Applied Mechanics, Vol., 1980.

Prerequisite:

OE4XXX: SHIPBUILDING MATERIAL & PRODUCTION PROCESSES

NO COURSE NUMBER

OE5011: MARINE ROBOTICS

Course Content:

Introduction to marine robotics and robotic configurations; autonomous underwater gliders (AUGs), autonomous underwater vehicles (AUVs), and remotely operated underwater vehicles. Actuation and sensing systems; communication; manipulation; interaction; guidance, navigation and control; and mission control systems. Algorithms for simultaneous localization and mapping (SLAM), fault detection/tolerance systems; multiple coordinated vehicles; and networked vehicles. Signature detection, analysis and optimization; sensor networks for radar, sonar and navigation; design of propulsion systems; and trajectory measurements and simulations. Design and analysis of thrusters for AUGs/AUVs, motion prediction and control systems, and co-operative adaptive sampling techniques. Design of variable buoyancy systems for UVs. Design of DCDM based controllers for UVs. Remote sensing and environmental monitoring with AUGs/AUVs, underwater vehicle-manipulator systems, bio-mimetic underwater robotics, and bio-inspired robotic systems. Case studies from India, Republic of Korea, Japan and USA.

Text Books:

1. **T. Fossen** (1994), “Guidance and Control of Ocean Vehicles”, Chichester New York, USA.
2. **J. N. Newman** (1997), “Marine Hydrodynamics”, MIT Press, USA.
3. **T. Fossen** (2002), “Marine Control Systems: Guidance, Navigation and Control of Ships, Rigs and Underwater Vehicles”, Marine Cybernetics, Trondheim, Norway

Reference Books:

1. **K. D. Do and J. Pan** (2009), "Control of Ships and Underwater Vehicles: Design for Underactuated and Nonlinear Marine Systems", Advances in Industrial Control, 1st edition, Springer, Germany.
2. **G. Griffiths** (2002), "Technology and Applications of Autonomous Underwater Vehicles", Ocean Science and Technology, Vol. 2, CRC Press, USA.
3. **R. Sutton and G. Roberts** (2006), "Advances in Unmanned Marine Vehicles", IEE Control Series, Institution of Engineering and Technology, USA.

Prerequisite:

Consent of teacher

OE5080: MARINE INSTRUMENTATION

Course Content:

Dynamic response of measuring instruments (with examples), acoustic instruments and transducers, CTD construction and operation, expendable ocean instruments, current profilers, strain gauges, acoustic positioning systems, sampling, spectral analysis, basic filtering, measuring system response using spectral analysis (magnitude and phase response), optical instruments.

Text Books:

1. “Mechanical Measurements,” by **Thomas G. Beckwith, Roy D. Marangoni, and John H.Lienhard V**, 6th Edition, 2009
2. “Encyclopedia of OceanSciences” 2nd Edition Six Volumes set, 2009 ISBN9780122274305 published by Academic Press

Reference Books:

1. “Mechanical Measurements,” by **Thomas G. Beckwith, Roy D. Marangoni, and John H.Lienhard V**, 6th Edition, 2009
2. “Encyclopedia of OceanSciences” 2nd Edition Six Volumes set, 2009 ISBN9780122274305 published by Academic Press

Prerequisite:

NIL

OE5120: GEOMECHANICS FOR OFFSHORE OIL AND GAS APPLICATIONS

NO DATA

OE5170: OCEAN ACOUSTICS

Course Content:

Introduction. Physical properties of seawater. Effects of density, salinity and temperature on sound speed. Underwater sound channels (USC). Surface and bottom effects. Ambient noise. Sound Propagation: Wave equation;Helmholtz equation; Lighthill's acoustic analogy; Point source and plane wave solutions; Refraction of sound waves; Snell's Law; Caustics and shadow zones; Ray theory. Reflection and Transmission: Changes at an interface between two immiscible liquids. Transmission of sound from air to water and vice versa; Reflection from ocean bottom; Propagation of sound in shallow water. Sound propagation in Underwater Sound Channel (USC): Ray theory for USC; Munk's model; Acoustic field as sum of normal modes; Analysis based on a parabolic equation, Scattering of Sound: Scattering at rough boundary surfaces; Method of small perturbation (MSP); Scattering of sound by surface waves and internal waves. Sound Radiation: Generation of sound by marine vehicles and offshore platforms. Acoustics Applications: Remote sensing; Underwater communication; Sonar principle and use; Acoustic tomography; Geophysical seismic exploration.

Text Books:

1. **Kinsler, Frey, Coppens and Sanders**, "Fundamentals of Acoustics", 4th edition, 1999.

Reference Books:

1. **L. M. Brekhovskikh and Yu. P. Lysanov**, "Fundamentals of Ocean Acoustics," Springer Series on Wave Phenomena (Edited by L.B. Felsen), Springer-Verlag, 1982. 2. Class and lecture notes

Prerequisite:

NIL

OE5310: GUIDANCE & CONTROL OF MARINE VEHICLES

Course Content:

Controllability, elements of ship motion control system, ship motions, coordinate transformation, basic equations of motion, hydrodynamic forces during a maneuver, force derivatives, model tests, linearised equations of motion, types of stability, ship maneuvering mathematical models – linear, nonlinear coupled and uncoupled, standard maneuvering tests, free-running model tests, IMO maneuvering criteria, numerical and experimental determination of hydrodynamic derivatives, ship motion control. Control surface and devices, rudder design, automatic control of ships – open and closed loop systems, dynamic positioning of ships, roll and pitch stabilization, control of high-speed vessels, Remotely operated vehicles, autonomous underwater vehicles, equations of motion of underwater vehicles, stability and control of underwater vehicles.

Text Books:

1. **T.I.Fossen**, "Guidance and Control of Marine Vehicles", John Wiley & Sons, 1994.
2. **E,V.Lewis**, "Principles of Naval Architecture", Vol.3, SNAME, 1989
3. **Lewis,E.U**, Principles of Naval Architecture, SNAME, New Jersey, U.S.A, 2010.
4. **E.M.Lewandowski**, "The Dynamics of Marine Crafts – Manoeuvring and Seakeeping", World Scientific, 2004

Reference Books:

1. **A.F.Molland and S.R.Turnock**, "Marine Rudders and Control Surfaces", Elsevier, 2007
2. **O.M.Faltinsen**, "Hydrodynamics of High Speed Marine Vehicles", Cambridge University Press, 2005.
3. **T.Perez**, "Ship Motion Control", Springer, 2005
4. **T.I.Fossen**, "Handbook on Marine Craft Hydrodynamics and Motion Control", Wiley, 2011

Prerequisite:

B.Tech/DD /M.Tech/MS/PhD in Naval Architecture & O

OE5330: ADVANCED MARINE STRUCTURES

Course Content:

Ultimate load design, Principles; Factors affecting strength, Ultimate behavior of bars and beams; Plastic capacity of sections, Plastic capacity of beams and frames, Plastic capacity of plates, Influence of membrane forces, Application to ships and offshore structures, Collision problems, Fundamentals of impact analysis, Impact capacities of steel jackets, local and global; Capacities of tubular joints, Column, flexural and torsional buckling, Design. Structural response to underwater explosion, Design issues Fluid Structure interaction, Framed offshore structures, Elements of flow-induced vibration, Vibration of underwater structures; Sound radiation and scattering by structures Design of stiffened structures, Reliability design and simulation concepts, FOSM and AFOSM methods, Partial safety factors and code calibration Fatigue and Fracture: Fatigue failure, cumulative fatigue damage models, Fracture mechanics approach to fatigue failure, Fatigue analysis and design of marine structures.

Text Books:

1. Construction of Marine and Offshore Structures, by **Ben C. Gerwick Jr**
2. Offshore Structures: Design, Construction and Maintenance by **Mohamed A. El-Reedy**
3. Stochastic Dynamics of Marine Structures by **Arvid Naess, Torgeir Moan**
4. Fatigue and Fracture Mechanics of Offshore Structures by **Linus Etube**
5. Fluid Structure Interaction in Offshore Engineering by **S. K. Chakrabarti**

Reference Books:

1. Matrix Analysis of Framed Structures by **William Weaver and James M. Gere**
2. Numerical Models in Fluid-Structure Interaction by **S. K. Chakrabarti**
3. Fatigue Handbook: Offshore Steel Structures by **A. Almar-Naess**
4. Advanced Marine Structures by **S Chandrasekaran**

Prerequisite:

Consent of teacher

OE5XXX - ADVANCED STRUCTURAL ANALYSIS OF MARINE VEHICLES

NO COURSE NUMBER

OE5XXX - DESIGN OF FISHING VESSELS

NO COURSE NUMBER

OE4XXX - DESIGN OF SHIP OUTFIT SYSTEMS

NO COURSE NUMBER

OE5XXX - DESIGN OF SUBMARINE AND SUBMERSIBLE

NO COURSE NUMBER

OE5XXX - MARINE CORROSION, PREVENTION AND CONTROL

NO COURSE NUMBER

OE4XXX - SHIP ELECTRICAL AND ELECTRONIC SYSTEMS

NO COURSE NUMBER

OE4XXX - SHIP POSITIONING SYSTEMS

NO COURSE NUMBER

OE5XXX - DESIGN OF HIGH SPEED VESSELS

NO COURSE NUMBER

OE5XXX - WARSHIP DESIGN

NO COURSE NUMBER

OE4XXX - ANALYSIS AND DESIGN TOOLS IN MARINE HYDRODYNAMICS

NO COURSE NUMBER

OE4XXX - LABORATORY MODELING IN MARINE HYDRODYNAMICS

NO COURSE NUMBER

OE5XXX - DESIGN, CONSTRUCTION AND OPERATION OF LNG CARRIERS AND TERMINALS

NO COURSE NUMBER

OE5450: NUMERICAL TECHNIQUES IN OCEAN HYDRODYNAMICS

Course Content:

Revisit Fluid Dynamics fundamentals. Numerical solution of Diffusion, Advection and Burgers' equations . Requirements of numerical solutions - Lax theorem; linear stability analysis. Introduction to CFD concepts: Pressure elimination, Pressure correction and Split algorithms; modeling of turbulence; introduction to LES, DES and DNS. Computations in solution of PDEs, Pressure elimination and Pressure correction. Introduction to computations using unstructured meshes. Introduction to Numerical Marine Hydrodynamics: Partial differential equations of inviscid hydrodynamics; Code development and computations of hydrodynamics of wave-structure interaction for fixed and floating bodies using BIEM, BEM and FEM techniques; Application of Fast methods; Time domain computation - non-linear velocity potential and acceleration potential approaches. Free surface computation in viscous models - VOF and Levelset. Computation of the motions of ships in waves. Forward speed problem and computation. Integral boundary layer equations and numerical solutions. Introduction to Parallel Machines and High Performance Computing.

Text Books:

1. **Anderson, D**. Computational Fluid Dynamics, McGraw Hill International Editions, 1995.

Reference Books:

1. **Tannehill, C., Anderson, D and Pletcher, R.** Computational Fluid Mechanics and Heat Transfer, 1997.
2. **Newman, JN.** Marine Hydrodynamics, MIT Press, Cambridge, MA, 1977.
3. Journal and thesis publications and prescribed by teacher.

Prerequisite:

Nil

OE5600: ADVANCED WAVE DYNAMICS

Course Content:

Introduction to wave generation, SMB and CEM approaches of wave estimation. Elements of probability theory and random processes - Sea as a stationary random process – Description of random sea waves – Statistical and Spectral analysis - Short term and Long term wave statistics – Directional Spectra – Design wave spectrum – Extreme value prediction. Non-stationary waves: Wavelet transforms and principal component analysis; Univariate and multivariate spectral analysis of signals; Hilbert transform; Bi-spectral analysis of nonlinear waves. Laboratory wave simulation, measurement & analysis: Wave groups, Breaking waves, Stokes 2nd order & Shallow water waves such as Cnoidal and Solitary waves. Multi-Directional waves – simulation and analysis using Fourier Method, MLM & MEM – single point measurement and array of gauges.

Text Books:

1. **Y.Goda**, Random Seas and Design of Maritime Structures, World Scientific Publishing Company, 2010. ISBN 10: 9814282405.

Reference Books:

1. **Chakrabarti S K**: Offshore Structure & Modeling, World Scientific, 1994.
2. **Ochi M K.:** Ocean Waves - The Stochastic Approach- Cambridge University Press, 1998.

Prerequisite:

Consent of teacher

OE5800: COASTAL ENGINEERING

Course Content:

Waves in shallow waters – Shoaling, refraction, diffraction and breaking– Interaction currents and waves- near shore currents-wave run-up and overtopping- coastal sediment characteristics- Initiation of sediment motion under waves- Radiation stress-wave set-up and wave set- down- mechanics of coastal sediment transport - Limits for littoral drift – Suspended and Bed Load – alongshore sediment transport rate – Distribution of alongshore currents and Sediment transport rates in Surf zone. Physical modeling in Coastal Engineering. Onshore offshore sediment transport – Stability of tidal inlets- Coastal features – Beach Features – Beach cycles – Beach Stability – Beach profiles -Coastal erosion, Planning and methods of coast protection works - Design of shore defense structures – Non-breaking and breaking wave forces on coastal structures -Breakwaters- Classification, Design and application in coastal protection and harbor planning- Case studies on coastal erosion and protection-Generation, propagation and effect of tsunami.

Text Books:

1. **Horikawa,K.,** Coastal Engineering, University of Tokyo press, 1978
2. **Sorenson, R.M.**, Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978
3. **Kamphius,J.W.** Introduction to coastal Engineering and Management, Advances on Ocean Engineering-Volume 16, World Scientific,2002.

Reference Books:

1. **Reeve,D., Chadwick, A. and Fleming,** C. Coastal Engineering-Processes, theory and design practice, Spon Press, Taylor & Francis Group, London & Paris,2004
2. **Silvester,R. and Hsu,J.R.C**. Coastal Stabilisation, Advances on Ocean Engineering-Volume 14, World Scientific, 1997.
3. Coastal Engineering Manual, U.S.Army Corps of Engineers, Washington, DC 20314-1000,, Vol. 1 to 3, July 2003.
4. **Wood,M.**, Coastal Hydraulics: Mcmillan, Civil Engineering Hydraulics, London, 1969 Decisions." CIFE Technical Report (177), Stanford University, Stanford.

Prerequisite:

Consent of teacher

OE6005: RELIABILITY OF OFFSHORE STRUCTURES

Course Content:

Introduction to uncertainty, probability and random variables. Calculations of failure probability by simple methods (R-S). General formulation for the reliability problem – FORM, SORM methods, Calculations of failure probability using unions and intersections, Uncertainty modeling of loads and resistances, Calculation of failure probability by Monte Carlo Method, Computational aspects. Updating of reliability, Reliability of time dependent loads and resistances. Probability, inspection and planning. Codal regulations. Uncertainties in material characteristics used in offshore structures-Reliability estimates for different types of offshore structures- Case studies. Seismic and fatigue reliability.

Text Books:.

1. **HO Madsen, S Krenk and NC Lind**. 2006, Methods of structural safety, Dover.
2. **R. Ranganathan**, 1999 Structural reliability analysis and design, Jaico Publishing House.
3. **A Haldar and S Mahadevan**. 2000. Probability, reliability and statistical methods in engineering design. John Wiley and Sons, NY.
4. **P Throft-Christensen and MJ Baker**, 1982, Structural reliability theory and applications, Springer Verlag, Berlin.
5. **RE Melchers**. 1999, Structural reliability: analysis and prediction, 2nd Edition, John Wiley
6. **AHS Ang and W H Tang**. 1984, Probability concepts in engineering planning and design, Volume II Decision, Risk & reliability, John Wiley, NY.

Reference Books:

1. **AHS Ang and WH Tang**, 1975, Probability concepts in engineering and design, Volume 1 - Basic concepts, John Wiley, NY
2. **A Papoulis, and SU Pillai** 1991, Probability, random variables and stochastic processes, 3rd Edition, McGraw-Hill, New York.
3. **J R Benjamin and C A Cornell**, 1970, Probability, statistics and decisions for civil engineers, John Wiley, New York.
4. **I Elishakoff**. 1999, Probabilistic theory of structures, Dover.
5. **PH Wirsching,TL Paez and K Ortiz** 2006 Random Vibrations: Theory and Practice, Dover.
6. **N C Nigam and S Narayanan**. 1994 Applications of random vibrations, Springer.
7. **G Augusti, A Baratta and F Casciati**, 1984, Probabilistic methods in structural engineering, Spon Press.

Prerequisite:

Consent of teacher

OE6020: MESHFREE METHODS APPLIED TO HYDRODYNAMICS

Course Content:

Numerical modelling; Basics of fluid mechanics; NS – Eulerian and Lagrangian Formulations; Free surface and Body boundary conditions; Time split algorithms; Strong and Weak forms; Weighted Residual methods. Overview of mesh based methods and meshfree methods; Basic techniques; Categories of meshfree methods; shape function constructions – Issues; SPH; Point Interpolations; Moving least square method; Shepard Functions; Error estimations; Support domain and Influence domain; Weight functions; Meshfree Integrations; Computational Cost; Conservation and Convergence. Meshfree methods based on Global weak form – EFG; Meshfree methods based on Local weak form – MLPG; Smoothed Particle Hydrodynamics; Moving Particle Semi-Implicit method; Essential Boundary conditions – Issues; Turbulence – Sub-particle scale; Meshfree methods applied to fluid dynamics problem; Matrix formulations and solution methods in meshfree methods; application to floating bodies, coastal engineering.

Text Books:

1. **G.R. Liu (2006),** "Mesh free methods: Moving beyond the finite element method", CRC Press, Taylor and Francis, US.

Reference Books:

1. **J. Anderson** (1995), "Computational Fluid Dynamics: The basics with applications", McGraw-Hill, USA.
2. **Li H and Mulay SS** (2013), "Meshless methods and their numerical properties", CRC Press, Taylor and Francis, US.
3. **S.N. Atluri** (2004), "The Meshless method (MLPG) for domain and BIE discretizations", Tech Science Press.
4. **G.R. Liu and M.B. Liu** (2003), "Smoothed Particle Hydrodynamics", World Scientific, Singapore. (also available as E-book)

Prerequisite:

Consent of teacher

OE6300: PLATED STRUCTURES AND SHELLS

NO COURSE NUMBER

OE6930: COMP. AID. SURFACE DEV. FOR MARINE VEHICLES

Course Content:

Theories of wind - generated ocean waves - Wind-wave Modelling: Third generation Wind – Wave modelling: WAM, SWAN & STWAVE for wave hind-casting and forecasting. Deformation of water waves: Solution of Helmholtz and Mild slope equations; Near shore wave propagation in phase-averaging and phase-resolving models; Boussinesq wave model; applications to large bodies and harbours - computations in 2D; introduction to public domain and industry software. Ocean hydrodynamics: Circulation with Tide, Temperature & Salinity; Turbulence in Ocean; Shallow Water Equations and their solution; applications to Nearshore circulation; Storm surge & Tsunami. Modelling of scalar transport and morphodynamics.

TextBooks:

1. **Dyke, P**. Modeling Coastal and Offshore Processes. Imperial College Press, 2007.
2. **Komen, G.J., Cavaleri, L., Donelan, M., Hasselmann, K., Hasselmann, S., Janssen, P.A.E.M.** Dynamics and modeling of ocean waves, Cambridge university press, New York, 1994.
3. **Nielsen, P.** Coastal and Estuarine Processes, World Scientific, 2009.

ReferenceBooks:

1. **Mellor G.L.,** User Guide for a three-dimensional, primitive equation, numerical ocean model, 1998.

Prerequisite:

Consent of teacher

OE6980: COMP. AID. SURFACE DEV. FOR MARINE VEHICLES

Course Content:

Module 1: Introduction and classification of geometric modeling forms for curves, surfaces and volumes; differential geometry of curves and surfaces; introduction to spline curves; Bezier splines; Uniform/non-uniform Rational B-splines; and fitting, fairing and generalized cylinders. Module 2: Introduction to blending surfaces; intersection problems in geometric design; offsets of parametric curves, surfaces and volumes; constructive solid geometry, boundary representation; decomposition models; and advanced topics in differential geometry. Module 3: Object matching; finite element and boundary element meshing algorithms; robustness of geometric computations; introduction to interval methods; scientific visualization; variational geometry; tolerances; inspection methods; feature representation and recognition; and shape interrogation for design, analysis, and manufacturing.

Text Books:

1. **G. Farin** (2001), Curves and Surfaces for CAGD: A Practical Guide, The Morgan Kaufmann Series in Computer Graphics, 5th edition, Morgan Kaufmann, USA.
2. **D. F. Rogers and J. A. Adams** (1989), Mathematical Elements for Computer Graphics, 2nd edition, Tata McGraw-Hill, India.

Reference Books:

1. **K. K. Dube** (2009), Differential Geometry and Tensors, I. K. International Publishing House PL, India.
2. **Q. Khan** (2012), Differential Geometry of Manifolds, Prentice Hall India Learning Private Limited, India.
3. **N. M. Patrikalakis and T. Maekawa** (2010), Shape Interrogation for Computer Aided Design and Manufacturing, Springer.
4. **D. Somasundaram** (2008), Differential Geometry: A First Course, Narosa Book Distributors, India.

Prerequisite:

Consent of teacher

OE6990: ADVANCED MARINE VEHICLES

Course Content:

1. An introduction in advanced marine vehicle (AMV) types. 2. The basic principles of the different types of advanced marine vehicles will be explained, supported by data of recently build vessels. 3. Hydrodynamic aspects, the contradiction between resistance and propulsion and on the other hand ships movements will be dealt with. 4.Design strategies in the design of advanced marine vehicles. 5. Several types of propulsion systems such as but not limited to water jets, cavitating and non cavitating propellers. 6. Structural Aspects of AMVs 7. An introduction to warship and Submarines 8. Hydrostatic and hydrodynamic aspects of warship and Submarine

Text Books:

1. **Thomas Lamp** "Ship Design and Construction" Vol1 and Vol 2 published by SNAME

Reference Books:

1. **Liang Yun** " High Performance marine vessels" Springer publication
2. **PJ Gates** "Surface Warship-An Introduction to design principles" 1987 Brassey'sDefence Publishers

Prerequisite:

Consent of teacher

PE6060 - HSE MANAGEMENT IN PETROLEUM AND OFFSHORE ENGINEERING

NO COURSE DATA

Master of Technology
in
Ocean Structures

CURRICULUM AND COURSE CONTENTS

(Applicable from 2023 batch)

INDIAN INSTITUTE OF TECHNOLOGY MADRAS
CHENNAI 600 036

M.TECH IN OCEAN STRUCTURES

Stream 1: Offshore and Ship Structures
Stream 2: Port, Harbour & Coastal Structures

SEMESTER I: COMMON TO BOTH STREAMS

No.	Subject	L	T	E	A	O	Credits
OE5525	Basics of Ocean Engineering	3	0	0	0	6	9
OE5030	Wave Hydrodynamics	3	0	1	0	6	10
OE5200	Dynamics of Ocean Structures	3	0	0	0	6	9
OE5545	Marine Geotechnical Engineering	3	0	0	0	6	9
OE5540	Conceptual Design of Marine Structures	3	0	0	0	6	9
OE5070	Statics and Dynamics of Floating Structures	3	0	0	0	6	9
						TOTAL	55

SEMESTER II: STREAM 1- OFFSHORE AND SHIP STRUCTURES

No.	Subject	L	T	E	A	O	Credits
OE6200	Design of Fixed Offshore Structures	3	1	0	0	6	10
OE5110	Experimental Methods and Measurements	3	0	1	0	6	10
OE6001	Materials and Fabrication of Ship and Offshore Structures	3	0	0	0	6	9
OE6004	Numerical Modelling of Offshore Structures	2	0	0	3	4	9
OE5500	FEM Applied to Ocean Engineering	3	0	0	0	6	9
SE-01	Stream Elective -01	3	0	0	0	6	9
						TOTAL	56

SEMESTER II: STREAM 2- PORT, HARBOUR AND COASTAL STRUCTURES

No.	Subject	L	T	E	A	O	Credits
OE5400	Port & Harbour Structures	3	0	0	0	6	9
OE5110	Experimental Methods and Measurements	3	0	1	0	6	10
OE5800	Coastal Engineering	3	0	0	0	6	9
OE5450	Numerical Techniques in Ocean Hydrodynamics	2	1	0	3	4	10
OE5500	FEM Applied to Ocean Engineering	3	0	0	0	6	9
SE-01	Stream elective -01	3	0	0	0	6	9
						TOTAL	56

M.TECH SUMMER TRAINING: (COMMON TO BOTH STREAMS)

No.	Subject	L	T	E	A	O	Credits
OE5555	Summer Training in Computer Modelling and Simulation	0	0	0	0	10	10
						TOTAL	10

SEMESTER III: STREAM 1- OFFSHORE AND SHIP STRUCTURES

No.	Subject	L	T	E	A	O	Credits
OE6007	Pipelines and Riser Engineering	3	0	0	0	6	9
SE-02	Stream Elective - 02	3	0	0	0	6	9
SE-03	Stream Elective - 03	3	0	0	0	6	9
OE6905	M.tech Ocean Structures Project (Phase I)	0	0	0	0	20	20
						TOTAL	47

SEMESTER III: STREAM 2- PORT, HARBOUR AND COASTAL STRUCTURES

No.	Subject	L	T	E	A	O	Credits
OE5560	Dredging and Reclamation	3	0	0	0	6	9
SE-02	Stream Elective - 02	3	0	0	0	6	9
SE-03	Stream Elective - 03	3	0	0	0	6	9
OE6905	M.Tech Ocean Structures Project (Phase I)	0	0	0	0	20	20
						TOTAL	47

SEMESTER IV (COMMON TO BOTH STREAMS)

No.	Subject	L	T	E	A	O	Credits
OE6906	M.Tech Ocean Structures PROJECT (Phase II)	0	0	0	0	40	40
						TOTAL	40

TOTAL CREDITS = 55+56+10+47+40 = 208

ANNEXURE A: LIST OF ELECTIVES

STREAM 1- OFFSHORE AND SHIP STRUCTURES

S.No	Course #	Course Name	L	T	E	A	O	Credits
1	OE6002	Installation of Offshore Structures	3	0	0	0	6	9
2	OE6010	Structural Integrity Assessment of Offshore Structures	3	0	0	0	6	9
3	OE5410	Advanced Steel Design	3	0	0	0	6	9
4	OE5012	Deep Sea Technology	3	0	0	0	6	9
5	OE5005	Marine Autonomous Vehicles	3	0	0	0	6	9
6	OE5970	Structural Health Monitoring	3	0	0	0	6	9
7	OE6005	Reliability of Offshore Structures	3	0	0	0	6	9
8	OE5530	Fire-Resistant Design of Offshore Structures	3	0	0	0	6	9
9	OE6090	HSE Practices in Offshore, Port, Harbour and Ship Building	3	0	0	0	6	9
10	OE6008	Design, Construction and Operation of LNG Carriers and Terminals	3	0	0	0	6	9
11	OE5510	Machine Learning for Ocean Engineers	3	0	0	0	6	9
12	OE5010	Marine Robotics	3	0	0	0	6	9
13	OE6300	Plated Structures and Shells	3	0	0	0	6	9
14	OE5300	Advanced Dynamics of Floating Bodies	3	0	0	0	6	9
15	OE5580	Impact Mechanics of Marine Structures	3	0	0	0	6	9

STREAM 2- PORT, HARBOUR AND COASTAL STRUCTURES

S.No	Course #	Course Name	L	T	E	A	O	Credits
1	OE5340	Ocean Environmental Policy and Coastal Zone Management	3	0	0	0	6	9
2	OE5520	Dock Engineering	3	0	0	0	6	9
3	OE5530	Fire-Resistant Design of Offshore Structures	3	0	0	0	6	9
4	OE6510	HSE Practices in Offshore, Port, Harbour and Ship Building	3	0	0	0	6	9
5	OE5970	Structural Health Monitoring	3	0	0	0	6	9
6	OE5570	Rehabilitation and Retrofitting Marine Structures	3	0	0	0	6	9
7	OE6020	Mesh-Free Methods Applied to Hydrodynamics	3	0	0	0	6	9
8	OE6930	Modeling of Offshore and Coastal Processes	3	0	0	0	6	9

CURRICULUM - M.TECH IN OCEAN STRUCTURES

Stream 1: Offshore and Ship Structures
Stream 2: Port, Harbour & Coastal Structures

SEMESTER I (COMMON TO BOTH STREAMS)

OE5525: BASICS OF OCEAN ENGINEERING

Course Content:

Physical oceanography; Ocean currents and circulation; seabed features; Coastal regions and special economic zones; Sea level rise and climate change effects; Sediments and minerals; Variation along the depth. Introduction to ocean structures; Fixed and floating structures for oil and gas exploration; Coastal structures such as breakwater, groin, and jetties for port and harbour development; Steel and RC structures; Floating structures for passenger and RoRo/RoPax facilities Basics of offshore wind, wave, current; tidal variations; regular and random waves; Tidal and wind-driven currents; Design water levels; Tide and storm surge; Deck and crest elevation for coastal and offshore structures; Joint Probability distribution between wave and current; Load combinations and risk assessment. Wave slamming and slapping effects Design life; encounter probability; Relationship between return period and encounter probability; Selection of design parameters for fixed and floating structures; Probability distributions; Weibull and Rayleigh distribution; Extreme wave prediction; Design wind, wave, and current.

Text Books:

1. **Turget Sarpkaya and Michael Isaacson**, Mechanics of wave forces on offshore structures, Van Nostrand Reinhold Company, USA, ISBN: 978-044-22-5402-5
2. **Turget Sarpkaya,** Wave forces on offshore structures, Cambridge university press, UK, ISBN: 978-113-91-9589-8, 2014
3. **Robert G Dean and Robert A Dalrymple**, Water wave mechanics for engineers and scientists, Advanced series on Ocean Engineering: Vol. 2, World Scientific, Singapore, ISBN: 978-981-02-0420-4, 1991
4. **Chakrabarti, SK,** Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0-90545-166-4, 1994
5. **Chakrabarti, SK,** Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1, 2005
6. **Ben C. Gerwick Jr,** Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7, 2007
7. **Barltrop, NDP and Adams, AJ.**, Dynamics of fixed marine structures, Butterworth-Heinemann, ISBN: 978-0-7506-1046-9, 1991
8. **Barltrop, NDP, ,** Floating structures: A guide for design and analysis, Marine Technology Directorate Ltd, USA, ISBN: 978-187-05-5335-3, 1998
9. **Journee, JMJ and Massie, WW.,** Offshore Hydromechanics, Delft University of Technology, pp. 570, 2001
10. **Srinivasan Chandrasekaran, and A.K. Jain, 2016,** Ocean structures: Construction, Materials and Operations, CRC Press, Florida, ISBN: 978-149-87-9742-9, 2001

Reference Books:

1. **API-RP 2A, 2000.** Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design, 21st Edition, Errata and Supplement 1, December 2002, Errata and Supplement 2, September 2005, Errata and Supplement 3, October 2007.
2. **IS 1893- Part 1 to V, 2002,** Criteria for Earthquake resistant design of structures, Bureau of Indian Standards, New Delhi.

Prerequisite:

Nil

OE 5030: WAVE HYDRODYNAMICS

Course Content:

Conservation of mass, moment and Energy. Euler Equation – Bernoulli's Equation. Potential and Stream function. Classification of Ocean Waves. Linear wave theory: Governing Equation, Boundary Conditions and solutions, Dispersion relation, Constancy of wave period. Wave Kinematics : Wave celerity, water particle velocities, accelerations, displacements and pressures. Approximations for deep and shallow water conditions. Integral properties of waves: Mass flux, Energy and energy flux, Group speed, Momentum and momentum flux. Wave Transformations: Shoaling, bottom friction and damping, refraction, reflection and diffraction. Wave Breaking: Type of breaking, Surf similarity parameter. Keulegan-Carpenter number, Ursell Parameter, Scattering parameter, Reynolds Number. Wave Loads: Non breaking wave forces on slender structures – Morison equation; Diffraction theory, source distribution method-Introduction to non-linear wave theories-Strokes, Cnoidal and Solitary wave theory. Mass transport velocity. Introduction to Random waves both spectral and statistical approaches -and directional waves.

Laboratory:
1. Wave Length, Profile and group velocity;
2. Wave profile trajectories – progressive and standing waves.
3. Pressure variations as a function of wave height, water depth and wave period.
4. Wave reflections.
5. Force measurements.

Text Books:

1. **Ippen, A.T.,** Estuary And Coastline Hydrodynamics, Mcgraw-Hill Book Company, Inc., New York, 1978
2. **Dean, R.G. And Dalrymple, R.A.,** Water Wave Mechanics for Engineers and Scientists, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1991
3. **Sarpkaya, T. And Isaacson, M.,** Mechanics Of Wave Forces On Offshore Structures, Van Nostrand Reinhold Co., New York, 1981.

Reference books:

1. **Shore Protection Manual Volume I And II**, Coastal Engineering Research Centre, Dept, Of The Army, Us Army Corps Of Engineers, Washington Dc, 1984
2. **Weigel, R.L.**Oceanographical Engineering, Prentice Hall Inc, 1982
3. **Sorenson, R.M.**, Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978.
4. **Sarpkaya, T. And Isaacson, M.,** Mechanics Of Wave Forces On Offshore Structures, Van Nostrand Reinhold Co., New York, 1981.
5. **Sundar.V.**, Ocean Wave Mechanics-Applications In Marine Structures, Ane Books Pvt Ltd, 2016.
6. **Sorenson, R.M.,** Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978.

Prerequisite:

Nil

OE 5200: DYNAMICS OF OCEAN STRUCTURES

Course Content:

SDOF systems; Time and frequency domain approaches - Formulation of equations of motion, Hamilton's principle; Lagrange equations of motions; continuous and discrete systems - Study of MDOF systems - Rayleigh – Ritz; Stodola and Holzer methods - Matrix methods for dynamic analysis; Eigen solution - Mode superposition. Vibrations of structures involving fluid - structure - solid interaction, dynamic behaviour of offshore towers - stochastic dynamics of offshore structures; Frequency domain response - Narrow band systems; fatigue predictions - Response to wave; and earthquake loadings.

Text Books:

1. **Chakrabarti, S. K. 2002**. The Theory and Practice of Hydrodynamics and Vibration. World Scientific, Singapore.
2. **2. Chakrabarti, S.K. 1987** Hydrodynamics of Offshore Structures: Computational Mechanics. WIT Press, Southampton, U.K.

Reference Books:

1. **Srinivasan Chandrasekaran. 2015**. Dynamic analysis and design of ocean structures. Springer. ISBN: 978-81-322-2276-7

Prerequisite:

OE 5545: MARINE GEOTECHNICAL ENGINEERING

Course content:

Classification of marine sediments and soils; basic soil properties, correlation between engineering parameters, geotechnical investigation, bore techniques; Soil testing methods in laboratory and fields; very soft and recent deposits in river mouth; characteristics of thixotropic soils; Advanced testing methods for soft marine clays; sensitivity of soils; time-dependent behaviour of marine sediments. Upper and lower bound soil characteristics; Soil stabilization; fills and reclamations; soil treatments and ground improvement methods; stone columns and band drains; coastal protections and reclamation dykes; Bearing capacity, sliding stability, over-turning stability, short-term and long-term settlements, factor of safety; Bucket foundation; Suction anchors; Gravity foundation; Earth retaining structures; Diaphragm walls; stability of breakwater on soft soils; RC bored piles; Driven piles, drilled and grouted steel piles; Axial and lateral capacity, point bearing and skin friction, factor of safety, lateral load on piles, p-y, t-z and q-z curves, linear spring methods; bearing capacity in soils, weathered rock, and intact rock. Pile group effect, scour around piles, seabed subsidence and design of piles against seabed movement, negative skin friction, cyclic degradation. Pile driving and monitoring; pile testing and correlations; Pile remedial measures.

Text books:

Reference books:

1. **Chakrabarti, SK. 2005.** Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1 2. Tomlinson, MJ. 1994. Pile Design and Construction practice, 4th Ed., E&FN Spon, London, UK, ISBN: 0-203-47457-0. 3. Joseph E. Bowles. 1988. Foundation analysis and design, 5th Ed., McGraw-Hill, Singapore, ISBN: 0-07-118844-4 4. Ben C. Gerwick Jr. 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7

Prerequisite:

OE 5540: CONCEPTUAL DESIGN OF MARINE STRUCTURES

Course content:

Principles of Working Stress and Load and Resistance Factor Design of steel structures; Allowable stresses and Partial Safety Factors Ship types and classification; cargo ships and passenger ships; estimation of displacement and buoyancy; sizing and structural arrangement; pontoon design; bulkheads and stiffeners; simple stability calculations Design principles of rubble mound structures; cross-section and geometry of breakwater, seawall, groins; sizing of armour layers; Layout and design berthing structures, diaphragm walls and open sea jetty, breasting, and mooring dolphins; Dry Docks, Slipways; Code Provision Concepts and design principles of fixed offshore structures and pile foundations; Design principles of floating structures such as Tension Leg Platforms, semi-submersible, and Spar.

Text Books

1. **Chakrabarti, SK.** 1994. Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0-90545-166-4
2. **Ben C. Gerwick Jr.** 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7
3. **Srinivasan Chandrasekaran, Arvind Kr. Jain, Nasir Shafiq, M. Mubarak A. Wahab.** 2021. Design aids for offshore platforms under special loads, CRC Press, Florida, pp. 280, ISBN: 9781032136844.
4. **Srinivasan Chandrasekaran**. 2020. Offshore Semi-Submersible Platform Engineering, CRC Press, Florida, pp. 240, ISBN: 978-0367673307.
5. **Vallam Sundar, Sannasiraj, SA.** 2019. Coastal Engineering: Theory and Practice, Adv series on Coastal engineering, Vol. 47, World Scientific, Singapore, ISBN: 978-981-3275-90-4
6. **Srinivasan Chandrasekaran**. 2019. Advanced steel design of structures, CRC press, Florida, ISBN: 978-036-72-3290-0
7. **Chen,WF, E.M. Lui.** 1987. Structural stability: Theory and implementation, Elsevier, New York, ISBN: 0-444-01119-6.
8. **Muir Wood, AM and Fleming, CA.** 1981. Coastal hydraulics, 2nd Ed., Palgrave Macmillan, NY, ISBN: 978-033-3261-293
9. **Horikawa, K.** 1978. Coastal Engineering, University of Tokyo Press, Japan.
10. **Alonzon De F. Quinn.** 1972. Design and construction of ports and marine structures, 2nd Ed., McGraw-Hill, USA, ISBN: 978-0070510647
11. **Carl A. Thoresen**. 1988. Port design: Guidelines and recommendations, Tapir, University of California, ISBN: 9788251908399
12. **Gaythwaite, JW.** 1990. Design of marine facilities for berthing, mooring and repair of vessels, Van Nostrand Reinhold, USA, ISBN: 978-0784407264

Reference books:

1. **Chakrabarti, SK.** 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
2. **API-RP 2A. 2000**. Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design, 21st Edition, Errata and Supplement 1, December 2002, Errata and Supplement 2, September 2005, Errata and Supplement 3, October 2007.
3. **Srinivasan Chandrasekaran, and A.K.Jain** 2016. Ocean structures: Construction, Materials and Operations, CRC Press, Florida, ISBN: 978-149-87-9742-9. 3

Prerequisite:

OE5070: STATICS AND DYNAMICS OF FLOATING STRUCTURES

Course content:

Fluid pressure and centre of pressure – estimation of weight and centre of gravity – conditions of equilibrium – definition of meta-centre – hydrostatic particulars – stability at small angles of inclinations – problems of heel and trim-free surface effect – inclining experiment – stability at large angles – dynamic stability, allowable KG – stability criteria – capacity, stowage, trim, and stability booklet – freeboard – damaged stability. Free surface effects; Linear equations of motion – time and frequency domain; Oscillations of floating bodies –Uncoupled equation of motion for heave pitch and roll motions; added mass and moment of inertia, damping coefficients – exciting forces and moments due to waves on small bodies; strip theory – motion in regular waves and irregular/random waves – statistics - model tests of floating bodies.

Text Books

1. **Chakrabarti, SK**. 1994. Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0- 90545-166-4
2. **Bhattacharyya, R**. 1978. Dynamics of marine vehicles, John Wiley & Sons, NY, ISBN: 978-047-1072-065
3. **Tupper, EC**. 2013. Introduction to Naval Architecture, Butterworth-Heinemann, ISBN: 978-008-0982-724
4. **Rawson, KJ and Tupper, EC**. 2001. Basic ship theory- Vol. 1, 5th Ed., Butterworth-Heinemann, ISBN: 978- 075-0653-961
5. **Srinivasan Chandrasekaran, and R. Nagavinothini**. 2020. Offshore compliant platforms: Analysis, design and experimental studies, Wiley, UK, ISBN: 978-1-119-66977-7.

Reference books:

1. **Srinivasan Chandrasekaran**. 2015. Dynamic analysis and design of ocean structures. Springer, INDIA, ISBN: 978-81-322-2276-7.
2. **Chakrabarti, SK.** 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
3. **Turget Sarpkaya and Michael Isaacson**. 1981. Mechanics of wave forces on offshore structures, Van Nostrand Reinhold Company, USA, ISBN: 978-044-22-5402-5

Prerequisite:

Nil

SEMESTER II: STREAM 1 – OFFSHORE AND SHIP STRUCTURES

OE 6200 DESIGN OF FIXED OFFSHORE STRUCTURES

Course content:

Wind profile; gusting and averaging of wind speed; wind pressure and forces; Wave kinematics; Wave theory selection; drag and inertia regimes; wave and current interaction; Morison equation applied to spatially distributed framed structures; hydrodynamic coefficients and marine growth; Seismic zone in India on land and offshore/coastal area; Recurrence interval and selection of design seismic acceleration; Return period for strength and ductility; Seismic loads; loads due to fire and blast; loads due to ship impact and ice impact; Design principles of jackets and pile foundations; main and skirt pile arrangements; wellhead and process platforms; concepts and geometry; Material selection for different classes of structural members; Structural analysis (linear and nonlinear); Pushover analysis procedure; Tubular Members, Slenderness effects; Column Buckling, Design for Hydrostatic pressure; Design for combined axial and bending stresses; Simple tubular joints, design using allowable loads; design of T, K and Y joints; Parametric equations; stress concentration factors; Design using pseudo static methods; Design of ring stiffened joints; Introduction to fatigue failure; cracking and Paris law; fracture mechanics and material selection for joints; material toughness class; S-N curves and fatigue damage calculations; deterministic and spectral fatigue analysis; Introduction to corrosion; corrosion protection coatings and design of cathodic protection; design of anodes; cathodic protection monitoring system

Text Books

1. **Chakrabarti, SK**. 1994. Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0-90545-166-4
2. **Chakrabarti, SK.** 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
3. **Chen,WF, E.M. Lui.** 1987. Structural stability: Theory and implementation, Elsevier, New York, ISBN: 0-444-01119-6.
4. **Ben C. Gerwick Jr.** 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7
5. **UEG Offshore Research.** 1985. Design of Tubular Joints for offshore structures, Vol. 1-3, UEG Publications, ISBN: 978-086-0172-314
6. **Bjorn Skallerud and Jorgen Amdahl.** 2002. Nonlinear analysis of offshore structures, Research Studies Press, Baldock, ISBN: 978-086-3802-584
7. **Srinivasan Chandrasekaran, Gaurav Srivastava.** 2022. Fire-resistant design of structures, CRC Press, FLORIDA, USA, ISBN: 978-103-2358-116

Reference books:

1. **API-RP 2A. 2000**. Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design, 21st Edition, Errata and Supplement 1, December 2002, Errata and Supplement 2, September 2005, Errata and Supplement 3, October 2007.
2. **FABIG. 1992**. Interim Guidance Notes for the design of and protection of topside structures against explosion and fire, FABIG Technical Notes, Ascot, UK.
3. **AWS D1.1. 2000**. Structural welding code- Steel, American Welding Society, FL, USA, pp. 449.
4. **DNV-RP-401. 2010.** Cathodic protection design, Det Norske Veritas, Norway.
5. **Chandima Ratnayake, RM and Samindi Samarakoon, SM**. 2017. Modeling and Simulation techniques in structural engineering: Structural Integrity Assessment and Control of Ageing Onshore and Offshore Structures, IGI Global publishers, USA, pp. 445-476.
6. **N-006. 2009**. Assessment of structural integrity for existing offshore load bearing structures, 1st Ed., NORSOK Standards, Norway.
7. **DNV Report 95-3203. 1996**. Guidelines for offshore structural reliability analysis: Application to Jacket Platforms, Det Norske Veritas, Norway.

Prerequisite: NIL

OE 5110: EXPERIMENTAL METHODS & MEASUREMENTS

Course content:

Dimensional Analysis with special reference to Model Studies in Hydrodynamic and Coastal Engineering problems. Principles of Similitude. Design of Models and Fabrication. Hydrodynamic test facilities, Wave makers, Wave absorbers, Modeling of Environment: 2-D and 3-D Wave generation, Transfer function. Modeling of fixed offshore structures: Measurement Techniques for Drag and Inertia Forces. Hydrodynamic models: Short-wave and Long wave hydrodynamic models. Modeling of Coastal Structures: Rubble mound Structures, floating structures. Laboratory measurement techniques: Basics of instrumentation systems , Different types of measurement systems and their principles ; Signal conditioning and data acquisition, Sources of noise, and errors in instrumentation systems , Filtering, data, and spectral analysis.Laboratory Class:• Calibration of wavemaker transfer function; Distorted model scale; Generation of different types of waves; difference inwave generation using 1st order and 2nd order transfer function; Pressure measurement under waves; Force measurements, Case studies. Calibration of following transducer: Wave probe, LVDT, Accelerometer, Pressure transducer, Load cell, Inclinometer.

Text Books

1. **Steven A.Hughes**, Physical Models and Laboratory Techniques in Coastal Engineering, World Scientific, Singapore, 1993
2. **Chakrabarti, S.K.**, Offshore Structure Modeling, World Scientific, Singapore, 1994

Reference Books:

1. **Clayton, B.R. and Bishop**, R.E.D., Mechanics of Marine Vehicles, Gulf Publishing Co., USA, 1982
2. **Hanna, R.L. and Reed, S.E.,** Strain Gauge-User's Handbook, 1992
3. **Beckwith,T.G., Marangoni, R.D. and Lienhard, J.H.,** Mechanical Measurements, Addison Wesley, USA, 1993
4. **Collacot, R.A.**, Structural Integrity Monitoring, Chapman and Hall, London, 1985

Prerequisite:

NIL

OE6001: MATERIALS AND FABRICATION OF SHIP AND OFFSHORE STRUCTURES

Course content:

Steel manufacturing processes; Tempered and quenched steel; Thermo-Mechanically Controlled Process (TMCP); Low carbon steel, high strength alloys, duplex and super duplex steels; ASTM / API steel products, chemical composition, carbon equivalent, mechanical properties, through thickness requirements, weldability, supplementary requirements, low temperature service, Charpy V-notch test and energy requirements, properties of steel at elevated temperature; Steel requirements for ship classification to IRS/ABS/DNV/BV etc. Functionally Graded Materials for corrosion resistance-applications to pipelines and risers. American Welding Society (AWS) guidelines, standard prequalified welds, Welding processes; SMAW and FCAW process; full penetration / fillet welds, heat affected zone (HAZ), Welding electrodes; Hydrogen induced cracking; Crack Tip Opening Displacement (CTOD) tests, fabrication tolerances, residual stresses; inspection and quality control requirements; NDT of welds; Ultrasonic tests; Magnetic particle inspection; X-rays methods; Jacket fabrication sequence; Quality Assurance Program; Rolling and fabrication of tubular; TKY joints, typical jacket fabrication and rollup procedure, frame rolling up and assembly; loadout arrangement; skidways; launch ways; quayside requirement; Ship fabrication arrangement; Dry docks; slipways; modular fabrication; assembly; longitudinal and transverse bulk heads; stiffeners and deck frame; machinery and outfitting; launching and testing.

Text Books:

1. **Ben C. Gerwick Jr.** 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7
2. **Srinivasan Chandrasekaran, Arvind Kr. Jain, Nasir Shafiq, M. Mubarak A. Wahab.** 2021. Design aids for offshore platforms under special loads, CRC Press, Florida, pp. 280, ISBN: 9781032136844.
3. **Srinivasan Chandrasekaran.** 2019. Advanced steel design of structures, CRC press, Florida, ISBN: 978-036-72-3290-0
4. **Srinivasan Chandrasekaran.** 2020. Design of Marine Risers with Functionally Graded Materials, Woodhead Publishing, Elsevier, pp. 200, ISBN: 978-0128235379
5. **UEG Offshore Research.** 1985. Design of Tubular Joints for offshore structures, Vol. 1-3, UEG Publications, ISBN: 978-086-0172-314

Reference books:

1. **AWS D1.1. 2000.** Structural welding code- Steel, American Welding Society, FL, USA, pp. 449.
2. **DNV-RP-401. 2010.** Cathodic protection design, Det Norske Veritas, Norway.
3. **Chandima Ratnayake, RM and Samindi Samarakoon, SM.** 2017. Modeling and Simulation techniques in structural engineering: Structural Integrity Assessment and Control of Ageing Onshore and Offshore Structures, IGI Global publishers, USA, pp. 445-476.

Prerequisite:

NIL

OE6004 – NUMERICAL MODELLING OF OFFSHORE STRUCTURES – NO DATA

Fixed Structures: Introduction to structural modeling and analysis of jacket structures; Main piled and skirt pile jacket models, In-service analysis for storm wave loads, load-out and launch analysis, sea transportation loads generation and analysis; Seismic analysis fixed offshore structures; Code guidance; Examples problems and case studies, tutorial problems;

Floating Structures: Static and dynamic stability of floating systems; ABS guidelines; Longitudinal strength calculation; Basics of motion analysis of floating structures; Motion analysis of flat bottom barges, heavy lift vessels and other floating systems such as SPAR, Tension leg platforms and semi-submersible; Generation of Response Amplitude Operators (RAOs); Motion analysis of multi-bodies; Heavy lift vessel and crane lifting system; Case studies and tutorial problems;

Mooring System analysis: Basics of mooring systems; Slack and catenary mooring systems; Spread mooring system analysis; Turret mooring system analysis; Case studies and tutorial problems.

OE5500: FEM APPLIED TO OCEAN ENGINEERING

Course content:

Introduction – Different approaches to finite element formulation – Different types of element and interpolation functions, Lagrange & Hermitian Polynomials, natural co-ordinates – Derivation of element property matrices – Assembly – solution of finite element equations – Structural and geotechnical problems – Nonlinear analysis. Application to fluid mechanics problems, Fluid-structure interaction – Diffraction of waves, 2D formulation using mild – slope equation – use of infinite elements – Added mass and damping matrices for floating bodies, 2D formulation – Harbour resonance, Liquid sloshing – Vibrations of underwater structures Introduction to Boundary element techniques.

Text Books:

1. **J.N. Reddy.** 1984. An Introduction to the finite element method. McGraw Hill. (Third edition, 2005)
2. **O.C. Zienkiewicz, R.W. Lewis and K.G. Stagg (eds.**) 1978. Numerical methods in Offshore Engineering. Wiley

Reference books:

1. **R.D. Cook.** 1981. Concepts and applications of finite element analysis. Wiley.
2. **O.C. Zienkiewicz.** 1977. The Finite Element Method. McGraw Hill. (vol.I, II, III)
3. **K.J. Bathe.** 1981. FE procedures in Engineering Analysis.

Prerequisite:

SE 01: STREAM ELECTIVE – 01

SEMESTER II: PORT, HORBOUR AND COASTAL STRUCTURES

OE5400: PORT AND HARBOUR STRUCTURES

Course content:

Vessel types, types of harbour, types of breakwaters and berthing structures. Port planning, navigation channel, turning circle and berth pockets, dredging methodology, Estimation of loads, Analysis, design and construction of Berthing Structures and Breakwaters. Bathymetry survey and soil investigation, return period for operational and extreme waves, fixing crest level of breakwater and deck level of berth Structural and foundation design of concrete and steel piles and concrete Diaphragm Walls and steel sheet pile walls. Limit state design, crack width calculations and deflection limits. Codal Requirements Slipways, marine travel lift, ship lift, Offshore terminals and Islands Types of mechanical handling and conveying systems Types of fenders and Mooring Facilities. Integrity analysis of berthing structures. Low strain and High strain integrity tests. UPV and HCP tests. Retrofitting of port structures, corrosion of steel piles and protection methods Case studies of breakwater failures and other types of structures.

Text Books:

1. Design and Construction of Port and Marine Structures by A. D. Quinn, McGraw-Hill Book Company

Reference Books:

1. Port Design – Guidelines and recommendations by C. A. Thoresen, Tapir Publications
2. Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels by J. W. Gaythwaite, Van Nostrand;
3. Handbook of Offshore Engineering by S.K. Chakrabarti, Elseviers, 2005.

Prerequisite:

COT for Non-OE students

OE 5110: EXPERIMENTAL METHODS & MEASUREMENTS

Course content:

Dimensional Analysis with special reference to Model Studies in Hydrodynamic and Coastal Engineering problems. Principles of Similitude. Design of Models and Fabrication. Hydrodynamic test facilities, Wave makers, Wave absorbers, Modeling of Environment: 2-D and 3-D Wave generation, Transfer function. Modeling of fixed offshore structures:Measurement Techniques for Drag and Inertia Forces. Hydrodynamic models: Short-wave and Long wave hydrodynamic models. Modeling of Coastal Structures: Rubble mound Structures, floating structures. Laboratory measurement techniques: Basics of instrumentation systems , Different types of measurement systems and their principles ; Signal conditioning and data acquisition, Sources of noise, and errors in instrumentation systems , Filtering, data, and spectral analysis.Laboratory Class:• Calibration of wavemaker transfer function; Distorted model scale; Generation of different types of waves; difference inwave generation using 1st order and 2nd order transfer function; Pressure measurement under waves; Force measurements, Case studies. Calibration of following transducer: Wave probe, LVDT, Accelerometer, Pressure transducer, Load cell, Inclinometer.

Text Books::

1. **Steven A.Hughes**, Physical Models and Laboratory Techniques in Coastal Engineering, World Scientific, Singapore, 1993
2. **Chakrabarti, S.K.,** Offshore Structure Modeling, World Scientific, Singapore, 1994

Reference books:

1. **Clayton, B.R. and Bishop**, R.E.D., Mechanics of Marine Vehicles, Gulf Publishing Co., USA, 1982
2. **Hanna, R.L. and Reed, S.E.,** Strain Gauge-User's Handbook, 1992
3. **Beckwith,T.G., Marangoni, R.D. and Lienhard, J.H.,** Mechanical Measurements, Addison Wesley, USA, 1993
4. **Collacot, R.A.,** Structural Integrity Monitoring, Chapman and Hall, London, 1985

PREREQUISITE:

NIL

OE 5800: COASTAL ENGINEERING

Course Content:

Waves in shallow waters – Shoaling, refraction, diffraction and breaking– Interaction currents and waves- near shore currents-wave run-up and overtopping- coastal sediment characteristics- Initiation of sediment motion under waves- Radiation stress-wave set-up and wave set- down- mechanics of coastal sediment transport - Limits for littoral drift – Suspended and Bed Load – alongshore sediment transport rate – Distribution of alongshore currents and Sediment transport rates in Surf zone. Physical modeling in Coastal Engineering. Onshore offshore sediment transport – Stability of tidal inlets- Coastal features – Beach Features – Beach cycles – Beach Stability – Beach profiles -Coastal erosion, Planning and methods of coast protection works - Design of shore defense structures – Non-breaking and breaking wave forces on coastal structures -Breakwaters- Classification, Design and application in coastal protection and harbor planning- Case studies on coastal erosion and protection-Generation, propagation and effect of tsunami.

Text Books:

1. **Horikawa,K.,** Coastal Engineering, University of Tokyo press, 1978
2. **Sorenson, R.M.,** Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978
3. **Kamphius,J.W.** Introduction to coastal Engineering and Management, Advances on Ocean Engineering-Volume 16, World Scientific,2002.

Reference books:

1. **Reeve,D., Chadwick, A. and Fleming, C.** Coastal Engineering-Processes, theory and design practice, Spon Press, Taylor & Francis Group, London & Paris,2004
2. **Silvester,R. and Hsu,J.R.C.** Coastal Stabilisation, Advances on Ocean Engineering-Volume 14, World Scientific, 1997.
3. Coastal Engineering Manual, U.S.Army Corps of Engineers, Washington, DC 20314-1000,, Vol. 1 to 3, July 2003.
4. **Wood,M.,** Coastal Hydraulics: Mcmillan, Civil Engineering Hydraulics, London, 1969 Decisions." CIFE Technical Report (177), Stanford University, Stanford.

Prerequisite:

Consent of teacher

OE5450: NUMERICAL TECHNIQUES IN OCEAN HYDRODYNAMICS

Course content:

Revisit Fluid Dynamics fundamentals. Numerical solution of Diffusion, Advection and Burgers' equations . Requirements of numerical solutions - Lax theorem; linear stability analysis. Introduction to CFD concepts: Pressure elimination, Pressure correction and Split algorithms; modeling of turbulence; introduction to LES, DES and DNS. Computations in solution of PDEs, Pressure elimination and Pressure correction. Introduction to computations using unstructured meshes. Introduction to Numerical Marine Hydrodynamics: Partial differential equations of inviscid hydrodynamics; Code development and computations of hydrodynamics of wave-structure interaction for fixed and floating bodies using BIEM, BEM and FEM techniques; Application of Fast methods; Time domain computation - non-linear velocity potential and acceleration potential approaches. Free surface computation in viscous models - VOF and Levelset. Computation of the motions of ships in waves. Forward speed problem and computation. Integral boundary layer equations and numerical solutions. Introduction to Parallel Machines and High Performance Computing.

Text Books:

1. **Anderson, D.** Computational Fluid Dynamics, McGraw Hill International Editions, 1995.

Reference books:

1. **Tannehill, C., Anderson, D and Pletcher, R.** Computational Fluid Mechanics and Heat Transfer, 1997.
2. **Newman, JN.** Marine Hydrodynamics, MIT Press, Cambridge, MA, 1977.
3. Journal and thesis publications and prescribed by teacher.

Prerequisite:

NIL

OE5500: FEM APPLIED TO OCEAN ENGINEERING

Course content:

Introduction – Different approaches to finite element formulation – Different types of element and interpolation functions, Lagrange & Hermitian Polynomials, natural co-ordinates – Derivation of element property matrices – Assembly – solution of finite element equations – Structural and geotechnical problems – Nonlinear analysis. Application to fluid mechanics problems, Fluid-structure interaction – Diffraction of waves, 2D formulation using mild – slope equation – use of infinite elements – Added mass and damping matrices for floating bodies, 2D formulation – Harbour resonance, Liquid sloshing – Vibrations of underwater structures Introduction to Boundary element techniques.

Text Books:

1. **J.N. Reddy.** 1984. An Introduction to the finite element method. McGraw Hill. (Third edition, 2005)
2. **O.C. Zienkiewicz, R.W. Lewis and K.G. Stagg (eds.)** 1978. Numerical methods in Offshore Engineering. Wiley

Reference books:

1. **R.D. Cook**. 1981. Concepts and applications of finite element analysis. Wiley.
2. **O.C. Zienkiewicz**. 1977. The Finite Element Method. McGraw Hill. (vol.I, II, III)
3. **K.J. Bathe**. 1981. FE procedures in Engineering Analysis.

Prerequisite:

SE-01 – STREAM ELECTIVE - 01

M.TECH SUMMER TRAINING: (COMMON TO BOTH STREAMS)

OE5555: SUMMER TRAINING IN COMPUTER MODELING AND SIMULATION

Course content:

Computer modeling in Offshore, Ships, Port, Harbour and coastal structures

Text Books:

Reference books:

Prerequisite:

SEMESTER III – STREAM 1 – OFFSHORE AND SHIP STRUCTURES

OE6007: PIPELINE & RISER ENGINEERING

Course content:

Introduction to subsea pipelines; Pipeline arrival and discharge conditions; Pipeline hydraulics; Pipeline sizing; Friction loss; Temperature profile; Slug formation and control. Installation of pipelines in shallow and deep water; S and J lay methods; Pipe lay barges and vessels; Pipeline initiation and termination. Pipeline design for stresses in service conditions; Static and dynamic stability; Pipeline flexibility and span analysis; Cathodic protection design. Rigid and flexible risers; Design and installation of risers; Intelligent pigging; Pipeline corrosion monitoring; Pipeline crossings; Bonded and unbonded flexibles

Text Books:

1. Subsea Pipelines and Risers (First Edition) by **Yong Bai and Qiang Bai**, Elsevier, 2005.
2. Offshore Pipelines by **Boyun Guo, Shanhong Song, Jacob Chacko and Ali Ghalambor**, Elsevier, 2005.

Reference Books:

1. Deepwater petroleum exploration and production : A non-technical guide **by William L. Leffler, Richard Pattarozzi, and Gordon Sterling, PennWell**, 2003.
2. Subsea Pipeline Engineering, (2nd Edition) by **Andrew C. Palmer and Roger A. King, PennWell**, 2008.
3. Fundamentals of Marine Riser Mechanics by **Charles P. Sparks, PennWell,** 2007.

Prerequisite:

Consent of teacher

SE-02

SE-03

COURSENO: OE6905

COURSENAME: M.Tech Ocean structures Project (Phase I)

CREDIT DISTRIBUTION: C: L: T: P: E: O: TH:

COURSE TYPE:

DESCRIPTION: Thesis project in the major stream

COURSE CONTENT: Thesis project in the major stream

Text Books:

Reference books:

Prereqisites:

SEMESTER III: STREAM 2 – PORT, HARBOUR AND COASTAL STRUCTURES

OE5560: DREDGING AND RECLAMATION

Course content:

Introduction to Dredging and dredging equipment; Need for reclamation; Introduction to Engineering aspects of Dredging and Reclamation. Marine investigations for Dredging and Reclamation – Standards, Requirements and Methods: Hydrographic survey; Geophysical – sidescan, sub-bottom, seabed refraction investigations; Geotechnical investigations; Sea bed and water sample analysis. Use of Marine investigations in Capital and Maintenance Dredging, and reclamation. Characterization of Soils and Rocks; PIANC guidelines (Report No. WG 144) and other international practices; Interpretation of marine investigation data in the context of characterization of soils for dredging. Methods of estimation of Dredging Production; Estimation cutter power. Dredging equipment selection; cutting tools and power estimation; pumps and capacity; dredging tolerances and dredging methods in river, open sea and inland water bodies; dredging near existing structures; Dredge spoil disposal; spoil dumping ground selection; methods of transportation of dredged spoil. Reclamation schemes; Burrow pit materials from land; dyke formation and peripheral shore protection; near shore and island reclamation; use of dredged materials for reclamation; direct dumping methods; rainbow discharge; pumping via pipelines; booster stations; layered soil dumping; suitability of materials for reclamation; Methods of ground improvement in reclamation; vibro-compaction etc. Estimation of cost; rate analysis for dredging; Cost standards (CIRIA C684); Dredging management to protect the environment; risks and cost escalation in dredging; siltation issues; dispersion of silt; silt curtains and containment booms.

Text Books:

1. **Vlasblom, WJ.** 2007. Dredging equipment and technology, University lecture notes, Delft University of Technology, Delft, The Netherlands.
2. **Sape A Miedema.** 2019. The Delft Sand, Clay and Rock, Cutting Model, TU Delft Open, ISBN: 978-946-3661-324
3. **Bray, N and COHEN, M (Ed.).** 2010. Dredging for development, Sixth Ed., Int. Association of Dredging Companies, The Netherlands and Int. Association of Ports and Harbors, Japan, ISBN: 978-9-07525-416-7
4. **Bray, RN., Bates, AD and Land, JM.** 1996. Dredging: A Handbook for Engineers, Butterworth Heinemann, London, UK, ISBN: 978-0-34054-524-9
5. **Vallam Sundar and Sannasiraj, SA.** 2019. Coastal Engineering: Theory and Practice, Adv series on Coastal engineering, Vol. 47, World Scientific, Singapore, ISBN: 978-981-3275-90-4

Reference Books:

1. **IADC.** 2018. Dredging for sustainable infrastructure, Int. Association of Dredging companies, The Netherlands.
2. **Offshore Shipping Online,** 2009. Dredgers of the world, 7th Ed., Offshore Energy Newsletter, The Netherlands.
3. **Bray, RN.** 2009. A guide to cost standards of dredging equipment C684, Construction Industry Research and Information Association (CIRIA), ISBN: 978-0-86017-684-8

Prerequisite:

SE-02 – STREAM ELECTIVE – 02

SE-03- STREAM ELECTIVE – 03

OE6905: M.TECH OCEAN STRUCTURES PROJECT (PHASE I)

THESIS PROJECT-OE6905

Course content:

Thesis project in the major stream

Text Books:

Reference books:

Prerequisite:

SEMESTER IV (COMMON TO BOTH STREAMS)

OE6906 – M.TECH OCEAN STRUCTURES PROJECT (PHASE II)

STREAM ELECTIVES: STREAM 1 – OFFSHORE AND SHIP STRUCTURES

OE6002: INSTALLATION OF OFFSHORE STRUCTURES

Course content:

:Concepts of offshore installations : Fixed and floating structures; Spars and TLP's; Modular topsides and integrated topsides; deck levels and jacket configurations; Spar and TLP hull arrangements; Loadout : Fabrication yard, grillage and foundation conditions; Fabrication sequence of Launch jacket, lift jackets, topsides and modules; Weighing and weight control; Skidded, Trailer and lifted Loadout methods; Transportation : Cargo barges; Launch barges; layout of cargo arrangement; Sea fastening layout and design; Static and dynamic stability of barge; Motion analysis of barge – cargo system; Transportation analysis. Transportation fatigue analysis; Installation Schemes: Lifting and launch schemes for jackets, upending and setting, on bottom stability; Float-over installations; Dynamics of barge – cargo system; Installation aids: Launch cradle design; Buoyancy tank design; Lift points – padeyes and trunnions; spreader frame and spreader bar concepts; Mudmat concepts and design methods; Lifting topside modules and towers; Bumpers and guides; Grouting and leveling of jackets;

Text Books:

1. Handbook of Offshore Engineering by **Subrata K. Chakrabarti,** Elsevier, 2005 2. Construction of Marine and Offshore Structures by Ben C. Gerwick, CRC Press, 2007

Reference Books:

1. Offshore Geotechnical Engineering by **E.T.R. Dean**, Thomas Telford publications, 2010

Prerequisite:

Consent of teacher

OE6010 – STRUCTURAL INTEGRITY ASSESSMENT OF OFFSHORE STRUCTURES

NO DATA

OE5410: ADVANCED STEEL DESIGN

Course content:

Introduction to various geometric forms of marine structures- Material properties of different structural steel under normal and high temperature - types of failure in 2d and 3d stress states- Design methods and code compliance. Plastic behavior of structures- shape factor- Moment curvature relationships- upper and lower bound theorems-estimate of collapse loads- plastic design. Stability analysis beam-columns with axial loads, both tension and compression- Beam-column with elastic support- stability analysis of frames using stiffness approach- Stability functions- Column design phenomenon- lateral buckling- torsional buckling- stiffeners- Beam-column design Open sections- lateral and torsional buckling of open sections Blast loads on offshore structures- impact loads- ice-infested loads on structures- blast-resistant framed structures- Design procedure- Architectural considerations- fire loads- fire rating of materials- fire-resistant design

Text Books:

1. **White**. 1993. Plastic hinge-based methods of advanced analysis and design of steel frames,
2. **Chen W F, Sohal I.** 1995. Plastic Design and Second-Order Analysis of Steel Frames. Springer-Verlag, New York

Reference Books:

1. **Chen W F, Lui E M, eds**. 2005. Steel frame design using advanced analysis, Handbook of Structural Engineering. 2nd ed., CRC Press.
2. **Chen W F, Lui E M.** Stability Design of Steel Frames. Boca Raton: CRC Press, 1992 5. SP: 6(1). 1972.
3. **Srinivasan Chandrasekaran.** 2017. Offshore structures under special loads including fire resistance, Video course under MOOC, NPTEL portal http://nptel.ac.in/courses/114106043 8.
4. **Srinivasan Chandrasekaran.** 2018. Computer methods of analysis of offshore structures, Video course under MOOC, NPTEL portal http://nptel.ac.in/courses/114106045
5. **Srinivasan Chandrasekaran.** 2013. Advanced Marine Structures, Video course on NPTEL portal. Available at:http://nptel.ac.in/courses/114106037
6. **Srinivasan Chandrasekaran.** 2018. Advanced structural analysis with Matlab. CRC Press, USA,
7. **Srinivasan Chandrasekaran and Gaurav Srivastava**. 2018. Design aids of offshore structures under special environmental loads including fire resistance, Springer, Singapore. ISBN: 978-981-10-7607-7
8. **Srinivasan Chandrasekaran.** 2019. Advanced steel design, CRC Press, USA.

Prerequisite:

Consent of teacher

OE5012: DEEP SEA TECHNOLOGY

Course content:

Introduction about ocean survey: bathymetry, seismic and side scan, robotics with AUVs and remotely - controlled diving robots. Introduction about the physical environment (i.e. winds, surface gravity water waves and currents) for oceans; Introduction to deep-sea resource exploration systems; Introduction to different types of deep water production systems (i.e. semi-submersible, FPSOs, SPAR, subsea systems and drill ships, etc.); Morrison, Froude-Krylov and diffraction theory for force estimation, issues in deep water riser mechanics; dynamic position system; and umbilical - design and development. Operation, maintenance and repair; Flow assurance challenges like hydrate formation, corrosion, sand control, erosion, MEG injection, subsea control system; marine growth prevention techniques; paints, ROVs and sliding marine growth preventer in splash zone.; underwater welding, ROV inspection, health monitoring, measurement of marine growth Case studies on few deepwater E&P systems in India and abroad; Technology demonstration project: At the end, a student or a group of students will need to do a project that will show at the conceptual level the application of a selected technological idea/concept to problems of interest in deep sea. Tutorials: The assignments will focus on hands-on exercises and application of case studies

Text Books:

1. **Roy Burcher and Louis J. Rydill** Concepts in Submarine Design, Cambridge University Press, USA.
2. **Norman Friedman** (1984) Submarine Design and Development, Naval Institute Press, USA.
3. **R. Sharma** (2017) Deep-Sea Mining: Resource Potential, Technical and Environmental Considerations, Springer, Germany.
4. **Kevin T. Pickering and Richard N. Hiscott** (2015) Deep Marine Systems: Processes, Deposits, Environments, Tectonics and Sedimentation, AGU, USA.

Reference Books:

1. **E. Eugene Allmendinger** (1990) Submersible Vehicle Systems Design, SNAME, USA.
2. **Günther Clauss, Eike Lehmann, Carsten Östergaard, M. J. Shields** (2013) Offshore Structures: Volume I: Conceptual Design and Hydromechanics (Volume 1), Springer, Germany.
3. **Günther Clauss, Eike Lehmann, Carsten Östergaard, M. J. Shields** (2013) Offshore Structures: Volume II Strength and Safety for Structural Design, Springer, Germany.
4. **C. M. Wang and B. T. Wang** (2014) Large Floating Structures: Technological Advances, Springer, Germany.
5. **Mohamed El-Reedy** (2012) Offshore Structures: Design, Construction and Maintenance, Gulf Professional Publishing, USA.
6. **Mohamed El-Reedy** (2014) Marine Structural Design Calculations, Butterworth-Heinemann, UK.
7. **Thomas Worzyk** (2012) Submarine Power Cables: Design, Installation, Repair, Environmental Aspects, Springer, Germany

Prerequisite:

Consent of teacher

OE5005: MARINE AUTONOMOUS VEHICLES

Course content:

Overview of autonomy: Autonomy levels for marine vehicles - Technology Readiness Levels, Regulatory concerns, IMO Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs) Kinematics and dynamics: Reference frames, coordinate transformations, Euler angles, quaternions, Newton-Euler equations of motion of marine vehicles, Coriolis forces and moments, Hydrostatic forces, Added mass, Dissipative forces, Wind, wave and current forces Traditional Guidance: Line of Sight (LOS) guidance law, Lyapunov stability, Vector field guidance law, Proportional LOS, Integral LOS Modern Guidance: Probabilistic Road Maps (PRM), Obstacle avoidance - Artificial potential fields (APF), Fuzzy logic based COLREGs Navigation: Sensors overview - GPS, IMU, Cameras, LiDAR, RADAR, Wave and Noise filtering, Fixed gain observer, Luenberger observer, Kalman Filter, Extended Kalman filter (EKF), Sensor fusion Traditional Control: PID Control, successive loop closure autopilot, Pole placement for SISO and MIMO systems, Control law stability Modern Control: Deep Reinforcement Learning - Markov decision process, Utility function, Bellman equations, Q-value iteration, Deep Q network (DQN), Deep Deterministic Policy Gradient (DDPG), Proximal Policy Optimization (PPO), Collision avoidance strategies Practical: The practicals will focus on implementation of the autonomy algorithms developed in Robot Operating System 2 framework and deployment on an autonomous surface vessel. This will involve coding exercises on IoT devices (Raspberry Pi and Arduino boards) and working with various sensors such as GPS, IMU and other sensors. Learning Objectives: After completing this course, the students should be able to: Recognize the different levels of autonomy and recollect the current regulations governing autonomy of marine vehicles Differentiate between traditional and modern methods of guidance, navigation and control Understand a simulation environment of a marine vehicle incorporating the kinematics and dynamics Implement guidance, navigation and control algorithms in a simulated environment Use ROS2 to interface with the sensors and actuators in a marine vehicle Design parameters of an Extended Kalman Filter (EKF) to fuse the data from multiple sensors Implement guidance, navigation and control algorithms in ROS2 and test them on real marine vehicles

Text Books:

1. T.I.Fossen (2021). Handbook on Marine Craft Hydrodynamics and Motion Control. John Wiley and Sons. Brunton, S. L., & Kutz, J. N. (2019). Data-driven science and engineering: Machine learning, dynamical systems, and control. Cambridge University Press. (Supplementary Material: http://www.databookuw.com/)

Reference Books:

1. T.I.Fossen, "Guidance and Control of Marine Vehicles", John Wiley & Sons, 1994. Lewis,E.U, Principles of Naval Architecture, SNAME, New Jersey, U.S.A, 2010. Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning. Cambridge: MIT press.

Prerequisite:

Programming

OE5970: STRUCTURAL HEALTH MONITORING

Course content:

Structural Health monitoring: Introduction-Necessity of monitoring health of civil engineering and marine structures- Challenges in implementation of SHM scheme in real time scale- various factors that influence the implementation- issues concerning concrete and steel structures- advantages of SHM along with the long-term and short-term benefits, both in economic and safety perspectives. Static and vibration-based health monitoring- Long-term and short term monitoring- triggered monitoring- static and dynamic monitoring- shear model, lumped mass model- elemental modal stiffness- using modal strain energy- using Eigen characteristicsDamage identification and assessment-Damage detection in linear systems- reliability of damage identification and detection- Mode shape analysis using signal processing- Mode shape curvature- Statistical pattern recognition- crack detectionSensor technologies used in SHM- Embedded and ultra-sonic sensors- sensor technologies for civil and marine structural Structural Health monitoring: Introduction-Necessity of monitoring health of civil engineering and marine structures- Challenges in implementation of SHM scheme in real time scale- various factors that influence the implementation- issues concerning concrete and steel structures- advantages of SHM along with the long-term and short-term benefits, both in economic and safety perspectives. Static and vibration-based health monitoring- Long-term and short term monitoring- triggered monitoring- static and dynamic monitoring- shear model, lumped mass model- elemental modal stiffness- using modal strain energy- using Eigen characteristics Damage identification and assessment-Damage detection in linear systems- reliability of damage identification and detection- Mode shape analysis using signal processing- Mode shape curvature- Statistical pattern recognition- crack detection Sensor technologies used in SHM- Embedded and ultrasonic sensors- sensor technologies for civil and marine structural systems- sensor layout and details of SHM scheme- component-level monitoring- wireless sensor networking. Non-destructive evaluation-Visual inspection- condition assessment- methods of NDT and NDE tools- NDE evaluation and correctness assessment Case studies of deployment of SHM- case-studies of SHM deployment in offshore structures in Lab scale- WSN design and reliability assessment- use of Artificial Intelligence in health monitoring- case study of real-time monitoring of Railway bridge in Rome, Heritage building in Siracusa, Italy

Text books:

1. Daniel Balageos, Clauss-Peter Fritza, and Alfredo Guemes. 2013. Structural Health monitoring, ISTE, U.K. 2. Wieslow Ostachowicz and Alfredo Guemes. New trends in Structural Health Monitoring. Springer

Reference Books:

1. Madsen, HO, Krenk, S. and NC Lind, NC. (2006). Methods of structural safety, Dover.
2. Chandrasekaran, S. 2016. Offshore structural engineering: Reliability and Risk Assessment, CRC Press, Florida.
3. Chandrasekaran, S, and A.K.Jain. 2016. Ocean structures: Construction, Materials, and Operations, CRC Press, Florida..
4. Srinivasan Chandrasekaran. 2018. Structural Health Monitoring, Video course under MOOC, NPTEL portal https://onlinecourses.nptel.ac.in/noc18_oe05/preview

Prerequisite:

Consent of teacher

OE6005: RELIABILITY OF OFFSHORE STRUCTURES

Course content:

Introduction to uncertainty, probability and random variables. Calculations of failure probability by simple methods (R-S). General formulation for the reliability problem – FORM, SORM methods, Calculations of failure probability using unions and intersections, Uncertainty modeling of loads and resistances, Calculation of failure probability by Monte Carlo Method, Computational aspects. Updating of reliability, Reliability of time dependent loads and resistances. Probability, inspection and planning. Codal regulations. Uncertainties in material characteristics used in offshore structures- Reliability estimates for different types of offshore structures- Case studies. Seismic and fatigue reliability.

Text Books:

1. **HO Madsen, S Krenk and NC Lind.** 2006, Methods of structural safety, Dover.
2. **R. Ranganathan**, 1999 Structural reliability analysis and design, Jaico Publishing House.
3. **A Haldar and S Mahadevan.** 2000. Probability, reliability and statistical methods in engineering design. John Wiley and Sons, NY.
4. **P Throft-Christensen and MJ Baker**, 1982, Structural reliability theory and applications, Springer Verlag, Berlin.
5. **RE Melchers.** 1999, Structural reliability: analysis and prediction, 2nd Edition, John Wiley.
6. **AHS Ang and W H Tang.** 1984, Probability concepts in engineering planning and design, Volume II Decision, Risk & reliability, John Wiley, NY.

Reference Books:

1. **AHS Ang and WH Tang,** 1975, Probability concepts in engineering and design, Volume 1 - Basic concepts, John Wiley, NY
2. **A Papoulis, and SU Pillai** 1991, Probability, random variables and stochastic processes, 3rd Edition, McGraw-Hill, New York.
3. **J R Benjamin and C A Cornell,** 1970, Probability, statistics and decisions for civil engineers, John Wiley, New York.
4. **I Elishakoff.** 1999, Probabilistic theory of structures, Dover.
5. **PH Wirsching,TL Paez and K Ortiz** 2006 Random Vibrations: Theory and Practice, Dover.
6. **N C Nigam and S Narayanan.** 1994 Applications of random vibrations, Springer.
7. **G Augusti, A Baratta and F Casciat**i, 1984, Probabilistic methods in structural engineering, Spon Press.

Prerequisite:

Consent of teacher

OE5530: FIRE-RESISTANCT DESIGN OF OFFSHORE STRUCTURES

NO DATA

OE6090: HSE PRACTICES IN OFFSHORE, PORT, HARBOUR AND SHIP BUILDING

NO DATA

OE6008: DESIGN, CONSTRUCTION AND OPERATION OF LNG CARRIERS AND TERMINALS

Course Content:

Introduction to the LNG carrier ships and terminals; Design of Different Types of Gas Carriers - Integral Tanks, Independent Tanks, Type 'A' Tanks, Type 'B' Tanks, Type 'C' Tanks, Membrane Tanks, Moss tanks (Spherical IMO type B tanks) IHI (Prismatic IMO type B tanks), TGZ Mark III, GT 96, and CS1, etc. LNG Containment Systems; Fully Pressurized Tanks; Semi Pressurized or Semi Refrigerated Tanks; and Fully Refrigerated Tanks. Ship handling at port: Factors affecting berthing/unberthing; Pilot; Support crafts; Mooring System; Ship/Shore Mooring Equipments; Mooring Hooks & Capstan; Fender arrangement; and Access gangway, etc. Concept design; Preliminary design and contract design; Basic hull form development; Estimation of the Basic Forces (i.e. weights of structure, cargo and other systems, and buoyancy etc.), Scantling; Estimation of Mass; Loading conditions analysis; and Local and global structural analyses. LNG terminals - Engineering parameter estimates; LNG terminal concept; Preliminary sizing of the 'Modified Gravity Based Concrete Structure (MGBCS)'; Offshore environmental loads on the structure (i.e. wave and wind loads); and Analysis of the terminal. Tutorials: Design and analysis problems with software solution systems.

Text Books:

1. **L. N. Patnaik** (2011), "Design of LPG and LNG jetties with navigation and risk analysis", CBS, India.
2. **Apostolos Papanikolaou** (2014), "Ship Design", Springer Nature, Singapore.
3. **Owen F. Hughes and Jeom Kee Paik** (2010), "Ship Structural Analysis and Design", The Society of Naval Architects and Marine Engineers (SNAME), USA.
4. **Suresh Chandra Misra** (2015), "Design Principles of Ships and Marine Structures", CRC Press, USA.

Reference Books:

1. DNV (2018), **"Rules for classification of ships: Newbuildings special service and type additional class",** PART 5 - CHAPTERs 5, 6, 7, 15; and PART 6 - CHAPTERs 36, 37; DNV GL, Germany.
2. DNV (2013), **"Strength Analysis of Liquefied Gas Carriers with Independent Type B Prismatic Tanks",** Classification notes 31.12, DNV GL, Germany.
3. DNV - GL (2018), **"GAS CARRIERS Leading the way – from concept to operation"**, DNV GL, Germany.

Prerequisite:

Consent of teacher

OE5510: MACHINE LEARNING FOR OCEAN ENGINEERS

Course Content:

Mathematical Preliminaries: Review of Linear Algebra and Probability, Singular Value Decomposition (SVD), pseudo inverse, least squares, regression, Principal Component Analysis (PCA), Fourier transforms. Classification and Regression: Introduction to machine learning, feature vectors, linear classifier, perceptron, hinge loss, objective function, margin boundaries, linear classification, regularization and generalization, gradient descent and stochastic gradient descent methods, higher order feature vectors, kernel methods, kernel composition, support vector machines (SVMs), radial basis kernels. Term project I (Project areas mentioned below) Neural Networks: Feedforward neural networks - activation functions, hidden layers, weights, deep neural networks, hidden layer models, backpropagation, stochastic gradient descent. Recurrent Neural Networks (RNNs) - encoding and decoding with RNNs, gating and LSTMs. Term project II (Project areas mentioned below) Unsupervised Learning: Clustering, generative models, maximum likelihood estimation, mixture models, Expectation-Maximization (EM) algorithm. Term project III (Project areas mentioned below) Reinforcement Learning: Markov decision process, Utility function, Bellman equations, Q-value iteration. Term project IV (Project areas mentioned below) Term project areas: Fluid dynamics, Ships and offshore structure dynamics, System identification, Marine robotics and autonomy, Underwater acoustics, Marine control, Coastal Engineering. Four topics will be selected from the list.

Text Books:

1. **Brunton, S. L., & Kutz, J. N.** (2019). Data-driven science and engineering: Machine learning, dynamical systems, and control. Cambridge University Press. (Supplementary Material: http://www.databookuw.com/)

Reference books:

1. **Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y.** (2016). Deep learning (Vol. 1, No. 2). Cambridge: MIT press. (Online Access: https://www.deeplearningbook.org/)

Prerequisite:

OE2054 or OE5030

OE5010: OCEANOGRAPHY

Course Content:

Introduction to Oceanography – Scientific concepts of its sub-disciplines namely physical, geological, chemical, biological, acoustical and optical oceanography; Understand the complexity of the sea as a natural system with the various physical, chemical, biological, and geological processes. Physical Oceanography – scientific concepts, seawater and its properties – temperature, salinity, pressure, depth, and density; pressure effects on temperature and density; TS diagrams, water types and water masses; conservative and non-conservative properties; scales of motion; Ocean circulation – Conservation equations and transport processes, momentum balances, geostrophy, large scale circulation, wind-driven circulation, abyssal ocean circulation, boundary currents, friction and Ekman layers; Waves – Origin and evolution, characteristics, classification, Tsunami, Tides – Origin, characteristics, tidal generation forces, equilibrium tide, tidal analysis and prediction, Vorticity – characteristics and types of vortices and their applications; Methods and measurements, observational tools, data analysis and methods; Special topics of current interest (El-nino, global warming, sea-level rise, coastal development, and environmental issues (contamination, oil spills, exploitation) are presented. Geological Oceanography – Origin of Earth, geodynamics, plate tectonics and Isostasy, continental drift and seafloor spreading, structure and evolution of ocean basins (continental margins, deep abyssal plains, ridges and trenches, sediments); Marine provinces, hypsography, technology; the geochemistry of seawater (salinity, dissolved and particulate matter, nutrient cycles, particulate fluxes and sedimentation); Marine sediments – Formation, types, distribution and classification; Deep-sea currents, processes and deposits; Mineral resources and exploration methods; Coastal morphodynamics and processes, coastal classification; Sea level changes and paleoceanography, important tools and techniques used by geological oceanographers.

Text Books:

1. **J. Weisberg, and H. Parija**, Introductory Oceanography, McGraw Hill, Tokyo, 1974.
2. **J.M. McCormick, and J.V. Thiruvathukal**, Elements of Oceanography, W.B. Saunders Company, 1976.
3. **D.A. Ross**, Introduction to Oceanography, Prentice-Hall, Inc., London, 1977.
4. **R.H. Stewart**, Introduction to Physical Oceanography, Orange Grove Texts Plus, 2009.

Reference Books:

1. **J. Marshall and R. Alan Plumb,** Atmosphere, Ocean, and Climate Dynamics, Elsevier, 2007.
2. **S. Pond, and G.L. Pickard,** Introductory Dynamical Oceanography, 2nd Edition, Butterworth-Heinemann, 1983.
3. **H. Medwin, and C.S. Clay,** Fundamentals of Acoustical Oceanography (Applications of Modern Acoustics), 1st edition, Academic Press Inc., 1997.

Prerequisite:

NIL

OE6300: PLATED STRUCTURES AND SHEELS

NO DATA

OE5300: ADVANCED DYNAMICS OF FLOATING BODIES

Course Content:

Review of Linear equations of motion; Oscillations of floating bodies – Concepts of small bodies and large bodies- Morisons for wave –current interactions- Added mass and Moment of Inertia and hydrodynamic damping, Exciting forces and moments due to waves - Froude Krylov theory Diffraction - MacCamy and Fuchs solution - Radiation Theory -General motion analysis of floating bodies - Time and frequency domain approaches – Response amplitude operators -strip theory for slender bodies with forward speed- Symmetric and unsymmetric coupled motions Directional spectra for waves - 3 D waves and responses Random response theory – Random response of linear systems under wave loading – response statistics – time frequency and probabilistic approach Introduction to multi-body structure - Two floating structures formulation

Text Books:

1. **Chakrabarti, SK.** 1994. Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0-90545-166-4
2. **Turget Sarpkaya and Michael Isaacson.** 1981. Mechanics of wave forces on offshore structures, Van Nostrand Reinhold Company, USA, ISBN: 978-044-22-5402-5

Reference Books:

1. **Chakrabarti, SK**. 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
2. **Michael E. McCormick.** 2010. Ocean Engineering Mechanics with Applications Cambridge University Press, pp. 580, ISBN: 978-052-1859-523

Prerequisite:

NIL

OE5580: IMPACT MECHANICS FOR MARINE STRUCTURES-OE5580

Course Content:

Review of continuum mechanics, jump conditions, plasticity theory, damage and failure theory, shock and wave propagation in both solid and fluid media using Eulerian, Lagrangian and Arbitrary Lagrangian-Eulerian frameworks, and the high pressure and high-rate response of materials. Fluid-structure interactions for marine structures. Design and analysis concepts for stiffened plate-shell structures Advanced materials mechanics: Constitutive relations and fracture criteria for materials subjected to dynamic loads; Analysis of large plastic deformations; damage and fracture criteria. Concepts of strain rate effects and equations of state for relevant applications. Impact and energy absorption: Energy absorption in materials and components; Models for penetration and blast loading; and Modelling of materials for large plastic deformations. Elastic and plastic impacts, elastic and plastic stress-wave theory. Penetration mechanics: Empirical, analytical and numerical methods and blast loading against marine structures (empirical, analytical, and numerical methods). Application-oriented examples: Effect of impact and explosion on stiffened plate structures; Estimation of crushing and the impact impulse in ship-to-ship and ship-to-offshore structures' collisions.

Text Books:

1. **James D. Walker** (2021), "Modern Impact and Penetration Mechanics", Cambridge University Press, UK.
2. **C. L. Rao, V. Naranmurthy, and K. R. Y. Sinha** (2016), "Applied Impact Mechanics", Ane Books, India.
3. **W. J. Stronge** (2000), "Impact Mechanics", Cambridge University Press, UK.

Reference Books:

1. **OTO 00053** (2000), "Collision Resistance of Ship Shaped Structures to Side Impact", MSL Engineering Limited, UK.
2. **Woisin G.** (1988), "Instantaneous loss of energy with unsymmetrical ship collisions", Vol. 40. Schiff and Hafen, 1988; 50-5.
3. **Pawlowski M**. (1995), "Energy loss in ship's collisions", Centrum Techniki Okretowej, Poland, 1995. International Maritime Organization (IMO). IMO Resolutions A265A, 1974.
4. **Pedersen PT, Jensen JJ.** (1991), "Ship impact analysis for bottom supported offshore structures", Advances in marine structures II. Elsevier Applied Sciences, Armsterdam, 1991; 276-95.

Prerequisite:

STREAM ELECTIVES: STREAM 2 – PORT, HORBOUR AND COASTAL STRUCTURES

OE5340: OCEAN ENVIRONMENT POLICY & COASTAL ZONE MGMT

Course Content:

Functions and utility of the Ocean environment; Essential parameters to frame Ocean Policy, regulation and laws; Sources of Ocean/ Marine pollution, their containment mitigation and impact on environmental degradation; pollution in Coastal Zones; Concept of sustainability with regard to marine environment. Resources of the ocean both living and nonliving, Management and Economic issues of resources. Exploration and exploitation of ocean resources in relation to utilisation and marine policy. Ocean governance; the international law commission of 1950; Geneva Convention - 1958; Conventions on the Territorial sea and contiguous zone; the Continental shelf; the high seas and on fishing and conservation of living resources of the high seas. Law of the sea – UNCLOS; most innovative components of the convention; importance of Exclusive economic zone (EEZ), a new regime for marine scientific research and its role in sustainable development; the principles of common heritage of mankind and reservation for peaceful purposes dealing with both. Post UNCLOS developments; UNCLOS and UNCED; Analysis and synthesis of agenda 21; Chapter 17 of UNCED; Marine sciences and Technologies in the new Ocean regime. Ocean governance in coastal states. Requirement for coastal zone management; Concept of integrated coastal zone management (ICZM) systems approach to ICZM; Coastal zone Regulations and their importance.

Text Books:

1. **E.M. Brogese,** Ocean Governance and the United Nations, Centre of Foreign Policy Studies, Dalhousie University, Halifax, 1995.
2. **E. Frankel,** Ocean Environmental Management, Prentice Hall PTR, Englewood Cliffs, Now Jersey, 1995.
3. **Luc Cuyvers**, Ocean Uses and their Regulation, Wiley Inter science, John Wiley and Sons,1984.
4. **R.R. Churchill and A.V. Lowe**. The law of the sea. Manchester: Manchester House, 1987.

Reference Books:

1. **B. Cicin - Sain and R.W. Knecht**, Integrated Coastal and Ocean Management, Island Press, Washington, 1998.
2. **United Nations Conference on Environment and Development.** "Protection of the Oceans, all Kinds of Seas, including enclosed and semi – Enclosed Seas, and Coastal Areas and the Protection, Rational Use and Development of their Living Resources "Agenda 21, Chapter 17. Rio de Janerio, 14 June 1992
3. **United Nations, 48th Session**. Agreement relating to the implementation of Part XI of the United Nations Convention on the Law of the Sea of 1982, 17 August 1994, A/RES/48/263.
4. **World Commission on Environment and Development.** Our Common Future. Oxford: Oxford University Press, 1987 (also Know as the Bruntland Report).
5. **Sustainable Development, Science and Policy** – The Conference Oslo: The Norwegian Research Council for Science and the Humanities, August 1990.

Prerequisite:

NIL

OE5520: DOCK ENGINEERING

NO DATA

OE5530: FIRE – RESISTANT DESIGN OF OFFSHORE STRUCTURES

NO DATA

OE6510: HSE PRACTICES IN OFFSHORE, PORT, HARBOUR AND SHIP BUILDING

Course Content:

Environmental issues and management that arise from process plants, drilling and oil exploration Safety assurance and assessment in design and operations- Safety guidelines- Safety procedures in preliminary design- Operational safety Hazard classification and assessments- accident modeling, risk assessment and management Qualitative and Quantitative Risk Assessment- PUFF and PLUME models in air dispersion- chemical pollution- Emergency Response Planning guidelines- industrial regulations and practices Case studies on Industrial and Process safety- Hazop and Hazid studies- Failure Mode and Effect Analysis for new engineering systems- Misuse of designed structure Reliability, Availability and Maintainability (RAM) analysis and applications to offshore plants.

Text Books:

1. **Jan Erik Vinnem.** 2007. Offshore Risk Assessment- Vol. 1: Principles, Modeling and Applications of QRA studies, 4th Ed., Springer, ISBN: 978-144-7174-431
2. **Stanislav Patin.** 1999. Environmental Impact of the Offshore Oil and Gas Industry. Eco Monitor Publishing, USA, ISBN: 978-096-7183-602
3. **Srinivasan Chandrasekaran.** 2016. Health, Safety and Environmental Management in Offshore and Petroleum Engineering, John Wiley & Sons, ISBN: 978-11-192-2184-5.
4. **Terje Aven and Jan Erik Vinnem.** 2007. Risk Management with applications from Offshore Petroleum Industry, Springer-Verlag, London, ISBN: 978-1-84628-652-0

Reference Books:

1. **Srinivasan Chandrasekaran** 2015. HSE in offshore and petroleum engineering, Lecture notes of online web course, Mass Open-source Online Courses (MOOC), National Program on Technology Enhancement and Learning (NPTEL), Govt. of India.
2. **Srinivasan Chandrasekaran**. 2016. Offshore structural engineering: Reliability and Risk Assessment. CRC Press, Florida, ISBN:978-14-987-6519-0
3. **Ramamurthy, K.** 2011. Modeling Explosions and blast waves, Springer Cham, ISBN: 978-3-030-74337-6
4. **Ramamurthy, R.** 2011. Explosion and explosion-safety, Tata McGraw Hill, ISBN: 978-007-0704-473
5. **Skelton, B.** 1997. Process safety analysis, Gulf Publishing Company, Houston, 210pp.

Prerequisite:

NIL

OE5970: STRUCTURAL HEALTH MONITORING

Course Content:

Structural Health monitoring: Introduction-Necessity of monitoring health of civil engineering and marine structures- Challenges in implementation of SHM scheme in real time scale- various factors that influence the implementation- issues concerning concrete and steel structures- advantages of SHM along with the long-term and short-term benefits, both in economic and safety perspectives. Static and vibration-based health monitoring- Long-term and short term monitoring- triggered monitoring- static and dynamic monitoring- shear model, lumped mass model- elemental modal stiffness- using modal strain energy- using Eigen characteristicsDamage identification and assessment-Damage detection in linear systems- reliability of damage identification and detection- Mode shape analysis using signal processing- Mode shape curvature- Statistical pattern recognition- crack detectionSensor technologies used in SHM- Embedded and ultra-sonic sensors- sensor technologies for civil and marine structural Structural Health monitoring: Introduction-Necessity of monitoring health of civil engineering and marine structures- Challenges in implementation of SHM scheme in real time scale- various factors that influence the implementation- issues concerning concrete and steel structures- advantages of SHM along with the long-term and short-term benefits, both in economic and safety perspectives. Static and vibration-based health monitoring- Long-term and short term monitoring- triggered monitoring- static and dynamic monitoring- shear model, lumped mass model- elemental modal stiffness- using modal strain energy- using Eigen characteristics Damage identification and assessment-Damage detection in linear systems- reliability of damage identification and detection- Mode shape analysis using signal processing- Mode shape curvature- Statistical pattern recognition- crack detection Sensor technologies used in SHM- Embedded and ultrasonic sensors- sensor technologies for civil and marine structural systems- sensor layout and details of SHM scheme- component-level monitoring- wireless sensor networking. Non-destructive evaluation-Visual inspection- condition assessment- methods of NDT and NDE tools- NDE evaluation and correctness assessment Case studies of deployment of SHM- case-studies of SHM deployment in offshore structures in Lab scale- WSN design and reliability assessment- use of Artificial Intelligence in health monitoring- case study of real-time monitoring of Railway bridge in Rome, Heritage building in Siracusa, Italy

Text Books:

1. **Daniel Balageos, Clauss-Peter Fritza, and Alfredo Guemes.** 2013. Structural Health monitoring, ISTE, U.K.
2. **Wieslow Ostachowicz and Alfredo Guemes.** New trends in Structural Health Monitoring. Springer

Reference Books:

1. **Madsen, HO, Krenk, S. and NC Lind, NC.** (2006). Methods of structural safety, Dover.
2. Chandrasekaran, S. 2016. Offshore structural engineering: Reliability and Risk Assessment, CRC Press, Florida.
3. **Chandrasekaran, S, and A.K.Jain**. 2016. Ocean structures: Construction, Materials, and Operations, CRC Press, Florida..
4. **Srinivasan Chandrasekaran.** 2018. Structural Health Monitoring, Video course under MOOC, NPTEL portal https://onlinecourses.nptel.ac.in/noc18_oe05/preview

Prerequisite:

Consent of Teacher

OE5570: REHABILITATION AND RETROFITTING OF MARINE STRUCTURES

Course Content:

Deterioration process; corrosion of embedded steel in concrete structures; Chloride induced corrosion; Carbonation induced corrosion; Crack induced corrosion; Chemical seawater attack; Cracking and spalling of concrete; Cover assessment; Condition assessment; Non-destructive testing of marine structures; Core testing; UPV tests; high strain and low strain tests; impact. Assessment of concrete strength using tests; Preventive maintenance and repairs; Pull tests and natural frequency analysis; Analysis of degraded structure for strength and durability; Probability analysis of concrete strength; Control of chloride ingress; Surface coatings; Design life extension analysis; Life cycle costing (LCC); Repair of beams and slab using spray mortar; Patch repairs; injection grouting; jacketing techniques; Cathodic protection of reinforcement; Under water inspection and repair techniques for RC piles; removal of marine growth; grouted clamps; Underwater grouting techniques; Polymer concrete surfacing and composite jacketing.

Text Books:

1. **Ben C. Gerwick Jr.** 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7
2. **Carl A. Thoresen**. 1988. Port design: Guidelines and recommendations, Tapir, University of California, ISBN: 9788251908399
3. **Gaythwaite, JW.** 1990. Design of marine facilities for berthing, mooring and repair of vessels, Van Nostrand Reinhold, USA, ISBN: 978-0784407264.

Reference Books:

1. **PIANC Report No. 162**, 2016, Recommendations for increased durability service life of new marine concrete infrastructure.

Prerequisite:

OE6020: MESHFREE METHODS APPLIED TO HYDRODYNAMICS

Course Content:

Numerical modelling; Basics of fluid mechanics; NS – Eulerian and Lagrangian Formulations; Free surface and Body boundary conditions; Time split algorithms; Strong and Weak forms; Weighted Residual methods. Overview of mesh based methods and meshfree methods; Basic techniques; Categories of meshfree methods; shape function constructions – Issues; SPH; Point Interpolations; Moving least square method; Shepard Functions; Error estimations; Support domain and Influence domain; Weight functions; Meshfree Integrations; Computational Cost; Conservation and Convergence. Meshfree methods based on Global weak form – EFG; Meshfree methods based on Local weak form – MLPG; Smoothed Particle Hydrodynamics; Moving Particle Semi-Implicit method; Essential Boundary conditions – Issues; Turbulence – Sub-particle scale; Meshfree methods applied to fluid dynamics problem; Matrix formulations and solution methods in meshfree methods; application to floating bodies, coastal engineering.

Text Books:

1. **G.R. Liu** (2006), "Mesh free methods: Moving beyond the finite element method", CRC Press, Taylor and Francis, US.

Reference Books:

1. J. Anderson (1995), "Computational Fluid Dynamics: The basics with applications", McGraw-Hill, USA.
2. **Li H and Mulay SS** (2013), "Meshless methods and their numerical properties", CRC Press, Taylor and Francis, US.
3. **S.N. Atluri** (2004), "The Meshless method (MLPG) for domain and BIE discretizations", Tech Science Press.
4. **G.R. Liu and M.B. Liu** (2003), "Smoothed Particle Hydrodynamics", World Scientific, Singapore. (also available as E-book)

Prerequisite:

Consent of Teacher

OE6930: MODELING OF OFFSHORE AND COASTAL PROCESSES

Course Content:

Theories of wind - generated ocean waves - Wind-wave Modelling: Third generation Wind – Wave modelling: WAM, SWAN & STWAVE for wave hind-casting and forecasting. Deformation of water waves: Solution of Helmholtz and Mild slope equations; Near shore wave propagation in phase-averaging and phase-resolving models; Boussinesq wave model; applications to large bodies and harbours - computations in 2D; introduction to public domain and industry software. Ocean hydrodynamics: Circulation with Tide, Temperature & Salinity; Turbulence in Ocean; Shallow Water Equations and their solution; applications to Nearshore circulation; Storm surge & Tsunami. Modelling of scalar transport and morphodynamics.

Text Books:

1. **Dyke, P**. Modeling Coastal and Offshore Processes. Imperial College Press, 2007.
2. **Komen, G.J., Cavaleri, L., Donelan, M., Hasselmann, K., Hasselmann, S., Janssen, P.A.E.M.** Dynamics and modeling of ocean waves, Cambridge university press, New York, 1994.
3. **Nielsen, P.** Coastal and Estuarine Processes, World Scientific, 2009.

Reference Books:

1. **Mellor G.L.,** User Guide for a three-dimensional, primitive equation, numerical ocean model, 1998.

Prerequisite:

Consent of Teacher

Master of Technology
in
OCEAN TECHNOLOGY

CURRICULUM AND COURSE CONTENTS

(Applicable from 2023 batch)

INDIAN INSTITUTE of TECHNOLOGY MADRAS
CHENNAI 600 036

M.TECH IN OCEAN TECHNOLOGY

REVISED CURRICULUM of M. TECH – OCEAN TECHNOLOGY (OE2)
(WITH EFFECT FROM JULY 2023 INTAKE)

SEMESTER I

No.	Subject	L	T	E	A	O	Credits
OE5525	Basics of Ocean Engineering	3	0	0	0	6	9
OE5030	Wave Hydrodynamics	3	0	1	0	6	10
OE5200	Dynamics of Ocean Structures	3	0	0	0	6	9
OE5070	Statics and Dynamics of Floating Structures	3	0	0	0	6	9
OE5545	Conceptual Design of Marine Structures	3	0	0	0	6	9
DPE1	Elective Basket 1	3	0	0	0	6	10/9
TOTAL							55/56

SEMESTER II

No.	Subject	L	T	E	A	O	Credits
OE5110	Experimental Methods and Measurements	3	0	1	0	6	10
OE5500	FEM Applied Ocean Engineering	3	0	0	0	6	9
OE6004	Numerical Modelling of offshore Structures	3	0	0	0	6	9
OE5546	Underwater Acoustics and instrumentation	3	0	0	0	6	9
DPE2	Elective Basket 2	3	1	0	0	6	10/9
DPE3	Elective Basket 2	3	0	0	0	6	9
TOTAL							55/56

M.TECH SUMMER TRAINING: (COMMON TO BOTH STREAMS)

No.	Subject	L	T	E	A	O	Credits
OE5190	Practical Training	0	0	0	0	10	10
TOTAL							10

SUMMER TRAINING For 45 DAYS

- **Internship at NIOT (Including Ship Visit and Training** in **Computational Software's) and industry.**

SEMESTER # III

No.	Subject	L	T	E	A	O	Credits
OE6007	Pipelines and Riser Engineering	3	0	0	0	6	9
DPE4	Elective Basket 3	3	0	0	0	6	9
DPE5	Elective Basket 3	3	0	0	0	6	9
OE6911	M.Tech Ocean Technology Project (Phase I)	0	0	0	0	20	20
TOTAL							47

SEMESTER # IV

No.	Subject	L	T	E	A	O	Credits
OE6912	M.Tech Ocean Technology Project (Phase II)	0	0	0	0	40	40
TOTAL							40

TOTAL CREDITS = 55/56+55/56+10+47+40 = 207/209

- **Basics of Ocean Engineering and Oceanography Course will be Revised to include a Substantial Portion of Oceanography.**

ELECTIVE BASKET 1: FROM THE POOL AND ADVISED BY FA

No.	Subject	L	T	E	A	O	Credits
OE5540	Marine Geotechnical Engineering	3	0	0	0	6	9
OE6002	Installation of offshore Structures	3	0	0	0	6	9
EE5130	Digital Signal Processing	4	0	0	0	8	12
EE5340	Micro Electromechanical System	3	0	0	0	6	9
ME5101	Advanced Heat and Mass Transfer	3	0	0	0	6	9
ME5280	Design Practice Using Cad tools	1	0	0	3	6	6
TOTAL							54

ELECTIVE BASKET 2: FROM THE POOL AND ADVISED by FA

No.	Subject	L	T	E	A	O	Credits
OE6200	Design of Fixed offshore Structures	3	1	0	0	6	10
OE6001	Materials and Fabrication of Ship and offshore Structures	3	0	0	0	6	9
OE5400	Port and Harbour Structures	3	0	0	0	6	9
EE5177	Machine Learning for Computer Vision	3	1	0	0	8	12
EE6403	Transducers for instrumentation	4	0	0	0	8	12
ME5105	Applied Thermodynamics	3	0	0	0	6	9
ME5205	Theory of Vibration	3	0	0	0	6	9
TOTAL							70

ELECTIVE BASKET 3: FROM THE POOL AND ADVISED BY FA

No.	Subject	L	T	E	A	O	Credits
OE5300	Advanced Dynamics of Floating Bodies	3	0	0	0	6	9
	Dredging and Reclamation	3	0	0	0	6	9
OE5450	Numerical Techniques in Ocean Hydrodynamics	2	1	0	3	4	10
EE5201	Modelling and Analysis of Electric Machines	3	0	0	0	6	9
EE5411	Synthesis of Control Systems	4	0	0	0	8	12
ME5303	Computer Aided Design in Manufacturing	3	0	0	0	6	9
ME7120	Sensors for intelligent Manufacturing and Condition Monitoring	3	0	0	0	6	9
TOTAL							67

ANY OTHER ELECTIVE TO BE APPROVED by DEPARTMENT DCC.

CURRICULUM - M.TECH IN OCEAN TECHNOLOGY

REVISED CURRICULUM of M. TECH – OCEAN TECHNOLOGY(OE2) (WITH EFFECT FROM JULY 2023 INTAKE)

SEMESTER #1

OE5525: BASICS OF OCEAN ENGINEERING

Course Content:

Physical oceanography; Ocean currents and circulation; seabed features; Coastal regions and special economic zones; Sea level rise and climate change effects; Sediments and minerals; Variation along the depth. Introduction to ocean structures; Fixed and floating structures for oil and gas exploration; Coastal structures such as breakwater, groin, and jetties for port and harbour development; Steel and RC structures; Floating structures for passenger and RoRo/RoPax facilities Basics of offshore wind, wave, current; tidal variations; regular and random waves; Tidal and wind-driven currents; Design water levels; Tide and storm surge; Deck and crest elevation for coastal and offshore structures; Joint Probability distribution between wave and current; Load combinations and risk assessment. Wave slamming and slapping effects Design life; encounter probability; Relationship between return period and encounter probability; Selection of design parameters for fixed and floating structures; Probability distributions; Weibull and Rayleigh distribution; Extreme wave prediction; Design wind, wave, and current.

Text Books:

1. **Turget Sarpkaya and Michael Isaacson**, Mechanics of wave forces on offshore structures, Van Nostrand Reinhold Company, USA, ISBN: 978-044-22-5402-5
2. **Turget Sarpkaya,** Wave forces on offshore structures, Cambridge university press, UK, ISBN: 978-113-91-9589-8, 2014
3. **Robert G Dean and Robert A Dalrymple**, Water wave mechanics for engineers and scientists, Advanced series on Ocean Engineering: Vol. 2, World Scientific, Singapore, ISBN: 978-981-02-0420-4, 1991
4. **Chakrabarti, SK,** Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0-90545-166-4, 1994
5. **Chakrabarti, SK,** Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1, 2005
6. **Ben C. Gerwick Jr,** Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7, 2007
7. **Barltrop, NDP and Adams, AJ.**, Dynamics of fixed marine structures, Butterworth-Heinemann, ISBN: 978-0-7506-1046-9, 1991
8. **Barltrop, NDP, ,** Floating structures: A guide for design and analysis, Marine Technology Directorate Ltd, USA, ISBN: 978-187-05-5335-3, 1998
9. **Journee, JMJ and Massie, WW.,** Offshore Hydromechanics, Delft University of Technology, pp. 570, 2001
10. **Srinivasan Chandrasekaran, and A.K. Jain, 2016,** Ocean structures: Construction, Materials and Operations, CRC Press, Florida, ISBN: 978-149-87-9742-9, 2001

Reference Books:

1. **API-RP 2A, 2000.** Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design, 21st Edition, Errata and Supplement 1, December 2002, Errata and Supplement 2, September 2005, Errata and Supplement 3, October 2007.
2. **IS 1893- Part 1 to V, 2002,** Criteria for Earthquake resistant design of structures, Bureau of Indian Standards, New Delhi.

Prerequisite:

Nil

OE 5030: WAVE HYDRODYNAMICS

Course Content:

Conservation of mass, moment and Energy. Euler Equation – Bernoulli's Equation. Potential and Stream function. Classification of Ocean Waves. Linear wave theory: Governing Equation, Boundary Conditions and solutions, Dispersion relation, Constancy of wave period. Wave Kinematics : Wave celerity, water particle velocities, accelerations, displacements and pressures. Approximations for deep and shallow water conditions. Integral properties of waves: Mass flux, Energy and energy flux, Group speed, Momentum and momentum flux. Wave Transformations: Shoaling, bottom friction and damping, refraction, reflection and diffraction. Wave Breaking: Type of breaking, Surf similarity parameter. Keulegan-Carpenter number, Ursell Parameter, Scattering parameter, Reynolds Number. Wave Loads: Non breaking wave forces on slender structures – Morison equation; Diffraction theory, source distribution method-Introduction to non-linear wave theories-Strokes, Cnoidal and Solitary wave theory. Mass transport velocity. Introduction to Random waves both spectral and statistical approaches -and directional waves.

Laboratory:
1. Wave Length, Profile and group velocity;
2. Wave profile trajectories – progressive and standing waves.
3. Pressure variations as a function of wave height, water depth and wave period.
4. Wave reflections.
5. Force measurements.

Text Books:

1. **Ippen, A.T.,** Estuary And Coastline Hydrodynamics, Mcgraw-Hill Book Company, Inc., New York, 1978
2. **Dean, R.G. And Dalrymple, R.A.,** Water Wave Mechanics for Engineers and Scientists, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1991
3. **Sarpkaya, T. And Isaacson, M.,** Mechanics Of Wave Forces On Offshore Structures, Van Nostrand Reinhold Co., New York, 1981.

Reference books:

1. **Shore Protection Manual Volume I And II**, Coastal Engineering Research Centre, Dept, Of The Army, Us Army Corps Of Engineers, Washington Dc, 1984
2. **Weigel, R.L.**Oceanographical Engineering, Prentice Hall Inc, 1982
3. **Sorenson, R.M.**, Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978.
4. **Sarpkaya, T. And Isaacson, M.,** Mechanics Of Wave Forces On Offshore Structures, Van Nostrand Reinhold Co., New York, 1981.
5. **Sundar.V.**, Ocean Wave Mechanics-Applications In Marine Structures, Ane Books Pvt Ltd, 2016.
6. **Sorenson, R.M.,** Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978.

Prerequisite:

Nil

OE 5200: DYNAMICS OF OCEAN STRUCTURES

Course Content:

SDOF systems; Time and frequency domain approaches - Formulation of equations of motion, Hamilton's principle; Lagrange equations of motions; continuous and discrete systems - Study of MDOF systems - Rayleigh – Ritz; Stodola and Holzer methods - Matrix methods for dynamic analysis; Eigen solution - Mode superposition. Vibrations of structures involving fluid - structure - solid interaction, dynamic behaviour of offshore towers - stochastic dynamics of offshore structures; Frequency domain response - Narrow band systems; fatigue predictions - Response to wave; and earthquake loadings.

Text Books:

1. **Chakrabarti, S. K. 2002**. The Theory and Practice of Hydrodynamics and Vibration. World Scientific, Singapore.
2. **2. Chakrabarti, S.K. 1987** Hydrodynamics of Offshore Structures: Computational Mechanics. WIT Press, Southampton, U.K.

Reference Books:

1. **Srinivasan Chandrasekaran. 2015**. Dynamic analysis and design of ocean structures. Springer. ISBN: 978-81-322-2276-7

Prerequisite:

OE5070 Statics and Dynamics of Floating Structures
Course Content:
Fluid pressure and centre of pressure – estimation of weight and centre of gravity – conditions of equilibrium – definition of meta-centre – hydrostatic particulars – stability at small angles of inclinations – problems of heel and trim-free surface effect – inclining experiment – stability at large angles – dynamic stability, allowable KG – stability criteria – capacity, stowage, trim, and stability booklet – freeboard – damaged stability. Free surface effects; Linear equations of motion – time and frequency domain; Oscillations of floating bodies –Uncoupled equation of motion for heave pitch and roll motions; added mass and moment of inertia, damping coefficients – exciting forces and moments due to waves on small bodies; strip theory – motion in regular waves and irregular/random waves – statistics - model tests of floating bodies.

TextBooks:

1. Chakrabarti, SK. 1994. Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0- 90545-166-4
2. Bhattacharyya, R. 1978. Dynamics of marine vehicles, John Wiley & Sons, NY, ISBN: 978-047-1072-065
3. Tupper, EC. 2013. Introduction to Naval Architecture, Butterworth-Heinemann, ISBN: 978-008-0982-724
4. Rawson, KJ and Tupper, EC. 2001. Basic ship theory- Vol. 1, 5th Ed., Butterworth-Heinemann, ISBN: 978- 075-0653-961
5. Srinivasan Chandrasekaran, and R. Nagavinothini. 2020. Offshore compliant platforms: Analysis, design and experimental studies, Wiley, UK, ISBN: 978-1-119-66977-7.

Reference Books:

1. Srinivasan Chandrasekaran. 2015. Dynamic analysis and design of ocean structures. Springer, INDIA, ISBN: 978-81-322-2276-7.
2. Chakrabarti, SK. 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
3. Turget Sarpkaya and Michael Isaacson. 1981. Mechanics of wave forces on offshore structures, Van Nostrand Reinhold Company, USA, ISBN: 978-044-22-5402-5

Prerequisite:

Nil

OE 5545: MARINE GEOTECHNICAL ENGINEERING

Course content:

Classification of marine sediments and soils; basic soil properties, correlation between engineering parameters, geotechnical investigation, bore techniques; Soil testing methods in laboratory and fields; very soft and recent deposits in river mouth; characteristics of thixotropic soils; Advanced testing methods for soft marine clays; sensitivity of soils; time-dependent behaviour of marine sediments. Upper and lower bound soil characteristics; Soil stabilization; fills and reclamations; soil treatments and ground improvement methods; stone columns and band drains; coastal protections and reclamation dykes; Bearing capacity, sliding stability, over-turning stability, short-term and long-term settlements, factor of safety; Bucket foundation; Suction anchors; Gravity foundation; Earth retaining structures; Diaphragm walls; stability of breakwater on soft soils; RC bored piles; Driven piles, drilled and grouted steel piles; Axial and lateral capacity, point bearing and skin friction, factor of safety, lateral load on piles, p-y, t-z and q-z curves, linear spring methods; bearing capacity in soils, weathered rock, and intact rock. Pile group effect, scour around piles, seabed subsidence and design of piles against seabed movement, negative skin friction, cyclic degradation. Pile driving and monitoring; pile testing and correlations; Pile remedial measures.

Text books:

Reference books:

1. **Chakrabarti, SK. 2005.** Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1 2. Tomlinson, MJ. 1994. Pile Design and Construction practice, 4th Ed., E&FN Spon, London, UK, ISBN: 0-203-47457-0. 3. Joseph E. Bowles. 1988. Foundation analysis and design, 5th Ed., McGraw-Hill, Singapore, ISBN: 0-07-118844-4 4. Ben C. Gerwick Jr. 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7

Prerequisite:

DPE1 – Elective Basket 1

SEMESTER #2

OE 5110: EXPERIMENTAL METHODS & MEASUREMENTS

Course content:

Dimensional Analysis with special reference to Model Studies in Hydrodynamic and Coastal Engineering problems. Principles of Similitude. Design of Models and Fabrication. Hydrodynamic test facilities, Wave makers, Wave absorbers, Modeling of Environment: 2-D and 3-D Wave generation, Transfer function. Modeling of fixed offshore structures: Measurement Techniques for Drag and Inertia Forces. Hydrodynamic models: Short-wave and Long wave hydrodynamic models. Modeling of Coastal Structures: Rubble mound Structures, floating structures. Laboratory measurement techniques: Basics of instrumentation systems , Different types of measurement systems and their principles ; Signal conditioning and data acquisition, Sources of noise, and errors in instrumentation systems , Filtering, data, and spectral analysis.Laboratory Class:• Calibration of wavemaker transfer function; Distorted model scale; Generation of different types of waves; difference inwave generation using 1st order and 2nd order transfer function; Pressure measurement under waves; Force measurements, Case studies. Calibration of following transducer: Wave probe, LVDT, Accelerometer, Pressure transducer, Load cell, Inclinometer.

Text Books

1. **Steven A.Hughes**, Physical Models and Laboratory Techniques in Coastal Engineering, World Scientific, Singapore, 1993
2. **Chakrabarti, S.K.**, Offshore Structure Modeling, World Scientific, Singapore, 1994

Reference Books:

1. **Clayton, B.R. and Bishop**, R.E.D., Mechanics of Marine Vehicles, Gulf Publishing Co., USA, 1982
2. **Hanna, R.L. and Reed, S.E.,** Strain Gauge-User’s Handbook, 1992
3. **Beckwith,T.G., Marangoni, R.D. and Lienhard, J.H.,** Mechanical Measurements, Addison Wesley, USA, 1993
4. **Collacot, R.A.**, Structural Integrity Monitoring, Chapman and Hall, London, 1985

Prerequisite:

NIL

OE5500: FEM APPLIED TO OCEAN ENGINEERING

Course content:

Introduction – Different approaches to finite element formulation – Different types of element and interpolation functions, Lagrange & Hermitian Polynomials, natural co-ordinates – Derivation of element property matrices – Assembly – solution of finite element equations – Structural and geotechnical problems – Nonlinear analysis. Application to fluid mechanics problems, Fluid-structure interaction – Diffraction of waves, 2D formulation using mild – slope equation – use of infinite elements – Added mass and damping matrices for floating bodies, 2D formulation – Harbour resonance, Liquid sloshing – Vibrations of underwater structures Introduction to Boundary element techniques.

Text Books:

1. **J.N. Reddy.** 1984. An Introduction to the finite element method. McGraw Hill. (Third edition, 2005)
2. **O.C. Zienkiewicz, R.W. Lewis and K.G. Stagg (eds.**) 1978. Numerical methods in Offshore Engineering. Wiley

Reference books:

1. **R.D. Cook.** 1981. Concepts and applications of finite element analysis. Wiley.
2. **O.C. Zienkiewicz.** 1977. The Finite Element Method. McGraw Hill. (vol.I, II, III)
3. **K.J. Bathe.** 1981. FE procedures in Engineering Analysis.

Prerequisite:

OE6004 – NUMERICAL MODELLING OF OFFSHORE STRUCTURES – NO DATA

Fixed Structures: Introduction to structural modeling and analysis of jacket structures; Main piled and skirt pile jacket models, In-service analysis for storm wave loads, load-out and launch analysis, sea transportation loads generation and analysis; Seismic analysis fixed offshore structures; Code guidance; Examples problems and case studies, tutorial problems;

Floating Structures: Static and dynamic stability of floating systems; ABS guidelines; Longitudinal strength calculation; Basics of motion analysis of floating structures; Motion analysis of flat bottom barges, heavy lift vessels and other floating systems such as SPAR, Tension leg platforms and semi-submersible; Generation of Response Amplitude Operators (RAOs); Motion analysis of multi-bodies; Heavy lift vessel and crane lifting system; Case studies and tutorial problems;

Mooring System analysis: Basics of mooring systems; Slack and catenary mooring systems; Spread mooring system analysis; Turret mooring system analysis; Case studies and tutorial problems.

OE5546 Underwater Acoustics and instruments

Course Content:

Derivation of the Helmholtz Equation from Fundamentals Concepts such as standing waves, wave interference, and scattering Acoustic Wave interaction at boundaries Propagation Models using ray theory and modes SONARs and Transmission loss models Instrumentation fundamentals Oceanographic instruments Measurement principles and data analysis

Text Books:

1. George V. Frisk "Ocean and Seabed Acoustics A theory of Wave Propagation" published by Prentice Hall
2. Kinsler et.al. "Fundamentals of Acoustics" published by Wiley
3. Beckwith et.al. "Mechanical Measurements" published by Prentice Hall
4. Plenty of reference materials provided by the instructor

Reference Books:

Prerequisite:

Background in vibration or wave propagation preferred but not required

DPE2 – Elective Basket 2

DPE3 – Elective Basket 2

M.TECH SUMMER TRAINING: (COMMON TO BOTH STREAMS)

OE5190 Practical Training

Course Content:

The course is designed for 8 weeks during summer vacation after the first year. First two weeks the students attend lectures presented by NIOT scientists followed by laboratory visits. Students identify a mini project with a division and work on the stated objectives. A schedule trip on board to conduct few experiments are also part of this training. Students complete the Mini Project and present before a team of scientists and faculty of IIT Madras. At the end of the training, the students have to submit a Report followed by Viva Voce evaluation in the department.

TextBooks:
As prescribed by faculty and guide

Reference Books:

As prescribed by faculty and guide

Prerequisite:

SUMMER TRAINING for 45 DAYS

- **INTERNSHIP AT NIOT (INCLUDING SHIP VISIT AND TRAINING IN COMPUTATIONAL SOFTWARE'S) AND INDUSTRY**

SEMESTER #3

OE6007 Pipeline & Riser Engineering

OE6007: PIPELINE & RISER ENGINEERING

Course content:

Introduction to subsea pipelines; Pipeline arrival and discharge conditions; Pipeline hydraulics; Pipeline sizing; Friction loss; Temperature profile; Slug formation and control. Installation of pipelines in shallow and deep water; S and J lay methods; Pipe lay barges and vessels; Pipeline initiation and termination. Pipeline design for stresses in service conditions; Static and dynamic stability; Pipeline flexibility and span analysis; Cathodic protection design. Rigid and flexible risers; Design and installation of risers; Intelligent pigging; Pipeline corrosion monitoring; Pipeline crossings; Bonded and unbonded flexibles

Text Books:

1. Subsea Pipelines and Risers (First Edition) by **Yong Bai and Qiang Bai**, Elsevier, 2005.
2. Offshore Pipelines by **Boyun Guo, Shanhong Song, Jacob Chacko and Ali Ghalambor**, Elsevier, 2005.

Reference Books:

1. Deepwater petroleum exploration and production : A non-technical guide **by William L. Leffler, Richard Pattarozzi, and Gordon Sterling, PennWell**, 2003.
2. Subsea Pipeline Engineering, (2nd Edition) by **Andrew C. Palmer and Roger A. King, PennWell**, 2008.
3. Fundamentals of Marine Riser Mechanics by **Charles P. Sparks, PennWell,** 2007.

Prerequisite:

Consent of teacher

DPE4 – Elective Basket 3

DPE5 – Elective Basket 3

OE6911 MTech Ocean Technology Project - Phase I

Course Content:

Students should be able to find out the appropriate numerical/analytical/ experimental tools required and learn them. The pilot problem as well as the hands-on experience in the tools (analytical, numerical and experimental) should be finalized so as to obtain results from the proposed research.

Text Books:

As prescribed by the faculty guide e.g., existing literature and previously carried out projects

Reference Books:

As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Prerequisite:

SEMESTER #4

OE6912 M Tech Ocean Technology Project - Phase II

Course Content:

Experiments and /or simulations and / or computations related to the project. Analysis of outcomes and presentation of the results from the proposed research. Present any theoretical proofs of any new methods / findings (if applicable).

Text Books:

As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Reference Books:

As prescribed by the faculty guide e.g., existing literature and previously carried out projects.

Prerequisite:

PORTION OF OCEANOGRAPHY

ELECTIVE BASKET 1: FROM THE POOL AND ADVISED BY FA

OE5540 CONCEPTUAL DESIGN OF MARINE STRUCTURES

Course content:

Principles of Working Stress and Load and Resistance Factor Design of steel structures; Allowable stresses and Partial Safety Factors Ship types and classification; cargo ships and passenger ships; estimation of displacement and buoyancy; sizing and structural arrangement; pontoon design; bulkheads and stiffeners; simple stability calculations Design principles of rubble mound structures; cross-section and geometry of breakwater, seawall, groins; sizing of armour layers; Layout and design berthing structures, diaphragm walls and open sea jetty, breasting, and mooring dolphins; Dry Docks, Slipways; Code Provision Concepts and design principles of fixed offshore structures and pile foundations; Design principles of floating structures such as Tension Leg Platforms, semi-submersible, and Spar.

Text Books

1. **Chakrabarti, SK.** 1994. Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0-90545-166-4
2. **Ben C. Gerwick Jr.** 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7
3. **Srinivasan Chandrasekaran, Arvind Kr. Jain, Nasir Shafiq, M. Mubarak A. Wahab.** 2021. Design aids for offshore platforms under special loads, CRC Press, Florida, pp. 280, ISBN: 9781032136844.
4. **Srinivasan Chandrasekaran**. 2020. Offshore Semi-Submersible Platform Engineering, CRC Press, Florida, pp. 240, ISBN: 978-0367673307.
5. **Vallam Sundar, Sannasiraj, SA.** 2019. Coastal Engineering: Theory and Practice, Adv series on Coastal engineering, Vol. 47, World Scientific, Singapore, ISBN: 978-981-3275-90-4
6. **Srinivasan Chandrasekaran**. 2019. Advanced steel design of structures, CRC press, Florida, ISBN: 978-036-72-3290-0
7. **Chen,WF, E.M. Lui.** 1987. Structural stability: Theory and implementation, Elsevier, New York, ISBN: 0-444-01119-6.
8. **Muir Wood, AM and Fleming, CA.** 1981. Coastal hydraulics, 2nd Ed., Palgrave Macmillan, NY, ISBN: 978-033-3261-293
9. **Horikawa, K**. 1978. Coastal Engineering, University of Tokyo Press, Japan.
10. **Alonzon De F. Quinn.** 1972. Design and construction of ports and marine structures, 2nd Ed., McGraw-Hill, USA, ISBN: 978-0070510647
11. **Carl A. Thoresen**. 1988. Port design: Guidelines and recommendations, Tapir, University of California, ISBN: 9788251908399
12. **Gaythwaite, JW.** 1990. Design of marine facilities for berthing, mooring and repair of vessels, Van Nostrand Reinhold, USA, ISBN: 978-0784407264

Reference books:

1. **Chakrabarti, SK.** 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
2. **API-RP 2A. 2000**. Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design, 21st Edition, Errata and Supplement 1, December 2002, Errata and Supplement 2, September 2005, Errata and Supplement 3, October 2007.
3. **Srinivasan Chandrasekaran, and A.K.Jain** 2016. Ocean structures: Construction, Materials and Operations, CRC Press, Florida, ISBN: 978-149-87-9742-9. 3

Prerequisite:

OE6002: INSTALLATION OF OFFSHORE STRUCTURES

Course content:

:Concepts of offshore installations : Fixed and floating structures; Spars and TLP's; Modular topsides and integrated topsides; deck levels and jacket configurations; Spar and TLP hull arrangements; Loadout : Fabrication yard, grillage and foundation conditions; Fabrication sequence of Launch jacket, lift jackets, topsides and modules; Weighing and weight control; Skidded, Trailer and lifted Loadout methods; Transportation : Cargo barges; Launch barges; layout of cargo arrangement; Sea fastening layout and design; Static and dynamic stability of barge; Motion analysis of barge – cargo system; Transportation analysis. Transportation fatigue analysis; Installation Schemes: Lifting and launch schemes for jackets, upending and setting, on bottom stability; Float-over installations; Dynamics of barge – cargo system; Installation aids: Launch cradle design; Buoyancy tank design; Lift points – padeyes and trunnions; spreader frame and spreader bar concepts; Mudmat concepts and design methods; Lifting topside modules and towers; Bumpers and guides; Grouting and leveling of jackets;

Text Books:

1. Handbook of Offshore Engineering by **Subrata K. Chakrabarti,** Elsevier, 2005 2. Construction of Marine and Offshore Structures by Ben C. Gerwick, CRC Press, 2007

Reference Books:

1. Offshore Geotechnical Engineering by **E.T.R. Dean**, Thomas Telford publications, 2010

Prerequisite:

Consent of teacher

EE5130 Digital Signal Processing

Course Content:

(1) Review of Discrete-Time Signals and Systems, LTI systems, convolution, sampling;
(2) Review of Discrete-Time Fourier Transform, Z-Transform, DFT (FFT)and their properties;
(3) LTI systems in the transform domain: poles and zeros, magnitude and phase response, group delay;(
(4) Linear-phase, allpass and minimum-phase systems, spectral factorization;
(5) Introduction to multirate DSP

Text Books:

1. Discrete-Time Signal Processing (3rd ed.) by **A.V. Oppenheim and R.W. Schafer** (Pearson 2010)
2. Digital Signal Processing: A Computer-based Approach (4th ed.) by **S.K. Mitra** (McGraw-Hill 2011)

Reference Books:

None

Prerequisite:

EE5340 Micro Electro Mechanical Systems

Course Content:

Introduction to MEMSSurface micromachining, Oxide anchored Cantilever beam, poly anchored beamsLPCVD poly silicon deposition, doping, oxidationTransport in PolySi, 2 and 3 terminal beamsBulk micromachining; Wet etching –isotropic and anisotropic; Etch stop – Electrochemical etching; Dry etching; BondingComparison of bulk and Surface micromachining: LIGA; SU-8; Moulding processes;Stiction: process, in-use, Measuring stictionPull-in parallel plate capacitorPressure Sensor: piezo-resisitivity, Diffused Si, Poly, porous SiBeams: Structure; force, moments, equation, spring constant; Stress, pull-in, pull-out; resonance freq, etcAccelerometer. Quasi-static, capacitive, equivalent circuit; Analog; Tunnel; Thermal accelerometerRate GyroscopeBiosensor and BioMEMS; Microfluidics; Digital Microfluidics; Ink jet printerOptical MEMS: Displays -DMDs, LGVs, active and passive componentsRF MEMS: switches, active and passive componentsPackaging; ReliabilityScalingOther materials/ actuatorsBy TAsMEMS software training: COMSOL & IntellisuiteSome process technology (Litho, oxidation, etc)

Text Books:

1. Microsystems design, Senturia

Reference Books:

1. Microfabrication, MadouPolycrystalline Si, Ted Kamins

Prerequisite:

COT

ME5101 Advanced Heat & Mass Transfer

Course Content:

Introduction and Review of Heat Transfer FundamentalsConduction Review of One-dimensional Steady state conductionHeat Transfer from Extended SurfacesTwo Dimensional Steady State Conduction in Cartesian and Cylindrical CoordinatesTransient ConductionConvectionVelocity and Thermal Boundary layersLaminar and turbulent boundary layers - Blasius solution, Similarity solutions, Integral technique.Heat transfer correlations for External flowsDeveloped flow inside ducts and pipes- Nusselt number for constant heat flux and constant wall temperature- turbulentflow in pipesNatural convective heat transfer from a heated plateRadiation Basics - black and gray body radiation - radiation in enclosuresFundamentals of condensation and boiling- pool boiling curve- flow boilingBasics of mass transfer- mass averaged and mole averaged velocities and fluxes- Fick's law of diffusion

Text Books:

1. **F.P.Incropera, D.P. Dewitt, T.L Bergman and A.S Lavine**, Principles of Heat and Mass Transfer, John Wiley, Sixth Edition, 2018.
2. **Yunus A Cengel,** Heat Transfer: A Practical Approach, Second Edition, McGraw Hill, 2008.

Reference Books:

1. **A. Bejan,** Heat Transfer John Wiley, 1993.
2. **J.H.Lienhard V and J.H.Lienhard IV A** Heat Transfer Textbook, Fourth Edition, 2011, Dover Publications, New York (free online edition available for download).
3. **J.P.Holman**, Heat Transfer, Eighth Edition, McGraw Hill, 1997
4. Massoud Kaviany, Principles of Heat Transfer, John Wiley, 2002.

Prerequisite:

ME5280 Design Practice Using Cad tools

Course Content:

Introduction to practical design of various mechanical systems such as gearboxes, brakes, Clutch, friction drives, couplings and transmission components. Design considerations and aspects of of design covering conceptual, strength analysis and safety, tolerances and fits, manufacturing, lubrication and assembly.

Text Books:

1. **Shigley, J.E. and Mischke, C.R.,** Mechanical Engineering Design, Fifth Edition, McGraw-Hill International; 1989.
2. **R. L. Norton,** Mechanical Design – An Integrated Approach, Prentice Hall, 1998
3. **G. Lechner and H. Naunheimer** (1999), Automotive Transmissions: Fundamentals, Selection, Design and Application, Springer, Berlin

Reference Books:

1. **P Lynwander** (1983), Gear Drive Systems: Design and Application, Marcel Dekker Inc: New York.
2. **S P Radzevich** (2012), Dudley's Handbook of Practical Gear Design and Manufacture, CRC Press, New York.
3. **D Jelaska** (2012), Gears and Gear Drives, Wiley Publication, Chichester, UK

Prerequisite:

COT

ELECTIVE BASKET 2: FROM THE POOL AND ADVISED BY FA1

OE 6200 DESIGN OF FIXED OFFSHORE STRUCTURES

Course content:

Wind profile; gusting and averaging of wind speed; wind pressure and forces; Wave kinematics; Wave theory selection; drag and inertia regimes; wave and current interaction; Morison equation applied to spatially distributed framed structures; hydrodynamic coefficients and marine growth; Seismic zone in India on land and offshore/coastal area; Recurrence interval and selection of design seismic acceleration; Return period for strength and ductility; Seismic loads; loads due to fire and blast; loads due to ship impact and ice impact; Design principles of jackets and pile foundations; main and skirt pile arrangements; wellhead and process platforms; concepts and geometry; Material selection for different classes of structural members; Structural analysis (linear and nonlinear); Pushover analysis procedure; Tubular Members, Slenderness effects; Column Buckling, Design for Hydrostatic pressure; Design for combined axial and bending stresses; Simple tubular joints, design using allowable loads; design of T, K and Y joints; Parametric equations; stress concentration factors; Design using pseudo static methods; Design of ring stiffened joints; Introduction to fatigue failure; cracking and Paris law; fracture mechanics and material selection for joints; material toughness class; S-N curves and fatigue damage calculations; deterministic and spectral fatigue analysis; Introduction to corrosion; corrosion protection coatings and design of cathodic protection; design of anodes; cathodic protection monitoring system

Text Books

1. **Chakrabarti, SK.** 1994. Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0-90545-166-4
2. **Chakrabarti, SK.** 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
3. **Chen,WF, E.M. Lui.** 1987. Structural stability: Theory and implementation, Elsevier, New York, ISBN: 0-444-01119-6.
4. **Ben C. Gerwick Jr.** 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7
5. **UEG Offshore Research.** 1985. Design of Tubular Joints for offshore structures, Vol. 1-3, UEG Publications, ISBN: 978-086-0172-314
6. **Bjorn Skallerud and Jorgen Amdahl.** 2002. Nonlinear analysis of offshore structures, Research Studies Press, Baldock, ISBN: 978-086-3802-584
7. **Srinivasan Chandrasekaran, Gaurav Srivastava.** 2022. Fire-resistant design of structures, CRC Press, FLORIDA, USA, ISBN: 978-103-2358-116

Reference books:

1. **API-RP 2A. 2000.** Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design, 21st Edition, Errata and Supplement 1, December 2002, Errata and Supplement 2, September 2005, Errata and Supplement 3, October 2007.
2. **FABIG. 1992.** Interim Guidance Notes for the design of and protection of topside structures against explosion and fire, FABIG Technical Notes, Ascot, UK.
3. **AWS D1.1. 2000.** Structural welding code- Steel, American Welding Society, FL, USA, pp. 449.
4. **DNV-RP-401. 2010.** Cathodic protection design, Det Norske Veritas, Norway.
5. **Chandima Ratnayake, RM and Samindi Samarakoon, SM.** 2017. Modeling and Simulation techniques in structural engineering: Structural Integrity Assessment and Control of Ageing Onshore and Offshore Structures, IGI Global publishers, USA, pp. 445-476.
6. **N-006. 2009.** Assessment of structural integrity for existing offshore load bearing structures, 1st Ed., NORSOK Standards, Norway.
7. **DNV Report 95-3203. 1996.** Guidelines for offshore structural reliability analysis: Application to Jacket Platforms, Det Norske Veritas, Norway.

Prerequisite: NIL

OE6001: MATERIALS AND FABRICATION OF SHIP AND OFFSHORE STRUCTURES

Course content:

Steel manufacturing processes; Tempered and quenched steel; Thermo-Mechanically Controlled Process (TMCP); Low carbon steel, high strength alloys, duplex and super duplex steels; ASTM / API steel products, chemical composition, carbon equivalent, mechanical properties, through thickness requirements, weldability, supplementary requirements, low temperature service, Charpy V-notch test and energy requirements, properties of steel at elevated temperature; Steel requirements for ship classification to IRS/ABS/DNV/BV etc. Functionally Graded Materials for corrosion resistance-applications to pipelines and risers. American Welding Society (AWS) guidelines, standard prequalified welds, Welding processes; SMAW and FCAW process; full penetration / fillet welds, heat affected zone (HAZ), Welding electrodes; Hydrogen induced cracking; Crack Tip Opening Displacement (CTOD) tests, fabrication tolerances, residual stresses; inspection and quality control requirements; NDT of welds; Ultrasonic tests; Magnetic particle inspection; X-rays methods; Jacket fabrication sequence; Quality Assurance Program; Rolling and fabrication of tubular; TKY joints, typical jacket fabrication and rollup procedure, frame rolling up and assembly; loadout arrangement; skidways; launch ways; quayside requirement; Ship fabrication arrangement; Dry docks; slipways; modular fabrication; assembly; longitudinal and transverse bulk heads; stiffeners and deck frame; machinery and outfitting; launching and testing.

Text Books:

1. **Ben C. Gerwick Jr.** 2007. Construction of Marine and Offshore Structures, CRC Press, USA, ISBN: 978-042-91-2502-7
2. **Srinivasan Chandrasekaran, Arvind Kr. Jain, Nasir Shafiq, M. Mubarak A. Wahab.** 2021. Design aids for offshore platforms under special loads, CRC Press, Florida, pp. 280, ISBN: 9781032136844.
3. **Srinivasan Chandrasekaran.** 2019. Advanced steel design of structures, CRC press, Florida, ISBN: 978-036-72-3290-0
4. **Srinivasan Chandrasekaran.** 2020. Design of Marine Risers with Functionally Graded Materials, Woodhead Publishing, Elsevier, pp. 200, ISBN: 978-0128235379
5. **UEG Offshore Research.** 1985. Design of Tubular Joints for offshore structures, Vol. 1-3, UEG Publications, ISBN: 978-086-0172-314

Reference books:

1. **AWS D1.1. 2000.** Structural welding code- Steel, American Welding Society, FL, USA, pp. 449.
2. **DNV-RP-401. 2010.** Cathodic protection design, Det Norske Veritas, Norway.
3. **Chandima Ratnayake, RM and Samindi Samarakoon, SM**. 2017. Modeling and Simulation techniques in structural engineering: Structural Integrity Assessment and Control of Ageing Onshore and Offshore Structures, IGI Global publishers, USA, pp. 445-476.

Prerequisite:

NIL

OE5400: PORT AND HARBOUR STRUCTURES

Course content:

Vessel types, types of harbour, types of breakwaters and berthing structures. Port planning, navigation channel, turning circle and berth pockets, dredging methodology, Estimation of loads, Analysis, design and construction of Berthing Structures and Breakwaters. Bathymetry survey and soil investigation, return period for operational and extreme waves, fixing crest level of breakwater and deck level of berth Structural and foundation design of concrete and steel piles and concrete Diaphragm Walls and steel sheet pile walls. Limit state design, crack width calculations and deflection limits. Codal Requirements Slipways, marine travel lift, ship lift, Offshore terminals and Islands Types of mechanical handling and conveying systems Types of fenders and Mooring Facilities. Integrity analysis of berthing structures. Low strain and High strain integrity tests. UPV and HCP tests. Retrofitting of port structures, corrosion of steel piles and protection methods Case studies of breakwater failures and other types of structures.

Text Books:

1. Design and Construction of Port and Marine Structures by A. D. Quinn, McGraw-Hill Book Company

Reference Books:

1. Port Design – Guidelines and recommendations by C. A. Thoresen, Tapir Publications
2. Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels by J. W. Gaythwaite, Van Nostrand;
3. Handbook of Offshore Engineering by S.K. Chakrabarti, Elseviers, 2005.

Prerequisite:

COT for Non-OE students

EE5177 Machine Learning for Computer Vision

Course Content:

1. Probability: Common probability distributions such as Gaussian, Bernoulli, Dirichlet, etc.. Fitting probability models.
2. Machine Learning models and inference:Regression models such as linear regression, Bayesian regression, nonlinear regression, sparse linear regression.Classification models such as logistic regression, support vector machine, relevance vector machine, classification tree.
3. Graphical models:Directed and undirected graphical models; models for trees; Markov random fields; Conditional Markov fields.
4. Image pre-processing:Per-pixel transformation; interest point detection and description; dimensionality reduction.
5. Multi-view geometry:Pinhole camera; single view geometry; Projective transformation; Stereo and epipolar geometry; Multi-view reconstruction6. Models for vision:Models for shape; Models for style and identity; temporal models; models for visual words

TextBooks:

1. Computer Vision: Models, Learning and Inference, Simon J. D. Prince, Cambridge University Press, 2012.

ReferenceBooks:

1. Pattern Recognition and Machine Learning, C. M. Bishop, Springer, 2006.
2. Pattern Classification, R. O. Duda, P. E. Hart and D. G. Stork, Wiley 2000.
3. Computer Vision: A Modern Approch, D. A. Forsyth and J. Ponce, Pearson, 2003.
4. Computer Vision Algorithms and Applications, R. Szelisky, Springer, 2011.
5. Multi View Geometry in Computer Vision, R. Hartley and A. Zisserman, Cambridge University Press, 2004.

Prerequisite:

EE3110 or equivalent and CoT

EE6403 Transducers

Course Content:

Transducers and their characteristics: Definition of terminologies – Generalized performance characteristics – range – resolution – linearity – overload factor – accuracy – precision – static and dynamic – rise time – fall time – settling time– slew rate – frequency response – bandwidth – modelling – Classification – ingress protection – vibration isolation – passive – active.Resistive Transducers: Resistance potentiometer – noise – resolution – signal conditioning – strain gauges – associated electrical circuitry – temperature compensation – load cells – torque and pressure measurement using strain gauges –resistive temperature device (RTD) – three-lead arrangement – thermistors – linearization - hot-wire anemometers – time constant improvement – measurement of direction of flow – peizo resistive transducers.5 Experiments on signal conditioning applied to transducersInductive Transducers: Self-inductance transducers – transverse armature and plunger type – sensitivity and linearity – signal conditioning circuits – choice of components – linear variable differential transducer (LVDT) – lead and lag compensation.Capacitive Transducers: Single – push-pull – angle transducer – humidity sensor – parasitic effects – solutions – signal conditioning circuits.Miscellaneous transducers: Peizo electric – signal conditioning – thermo couples – theory – mass-spring accelerometer – force-balance.Applications of transducers: Measurement of displacement (linear and angular) – velocity – acceleration – force – torque – pressure – flow – temperature.

Text Books:

1. **H. K. Neubert**, 'Instrument Transducers-An introduction to their performance and design' Oxford University press, Oxford, Second edition-2003.

Reference Books:

1. **E. O. Doeblin** 'Measurement Systems – Application and Design' McGraw - Hill Publications, Fifth Edition, 2004.

Prerequisite:

NIL

ME5105 Applied Thermodynamics

Course Content:

(1) Second Law Analysis1.1 Review of entropy1.2 Second law analysis for a control volume1.3 Irreversibility and availability 1.4 Exergy balance equation and Exergy analysis

(2) Thermodynamic relations for homogeneous phase 2.1 Maxwell relations, Relations involving enthalpy, internal energy and entropy2.2 Equilibrium between two-phases of a pure substance2.3 Clausius- Clapeyron equation

(3) Review of Ideal Gas, Ideal gas mixtures and mixing rules3.1 Real gas behavior 3.2 Real gas equations of state3.3 Property relations for mixtures and Psychrometry

(4) Combustion4.1 Combustion reactions - Stoichiometry 4.2 First law analysis, Heat calculations, Adiabatic flame temperature

(5) Chemical Equilibrium5.1 Chemical potential5.2 Second law analysis of reacting systems5.3 Chemical equilibrium5.4 Free energies5.5 Equilibrium flame temperature 5.6 Equilibrium products of combustion

(6) Gas Dynamics6.1 Basic ideas in compressible flow 6.2 Normal shocks 6.3 Flow of perfect gases through nozzles 6.4 Flow of wet steam – Supersaturation, Wilson line and condensation shock

TextBooks:

1. Moran, M. J. and Shapiro, H. N. Fundamentals of Engineering Thermodynamics, 5th edition, 203, John Wiley Sons
2. Sonntag, R. E, Borgnakke, C and Van Wylen, G. J. and., 1976, Fundamentals of Classical Thermodynamics, Wiley Eastern Ltd.
3. Jones, J. B. and Hawkins, G. A., 1986, Engineering Thermodynamics, John Wiley Sons4. Nag, P.K, 1986, Engineering Thermodynamics, Tata McGraw-Hill Publishing Co, Ltd5. Fundamentals of Gas Dynamics by V Babu, 2nd edition, Athena Publishers, 2015

Reference Books:

NIL

Prerequisite:

NIL

ME5205 Theory of Vibration

Course Content:

Building Vibration Models - Assumptions and approximations; Practical case study - deriving theequations of motion; highlight need for single degree-of-freedom (SDOF) modelsSDOF Models - Free vibration without and with damping; viscous and other damping types; Forcedvibration - harmonic force, rotating unbalance/base excitation, vibration isolation; periodic forcing and concept of frequency response function (FRF); General Excitation - Impulse response, Step and pulse type forces, shock response spectrumMulti degree-of-freedom (MDOF) Models - Deriving equations of motion for complex models; Concept of mode shapes and associated mathematical properties; Use of modal superposition to obtain forced vibration response; Concept of proportional or Rayleigh damping; More on FRFs and their uses; Vibration absorber application Continuous system Models - Equations of motion for transverse vibration of strings, torsional vibration of shafts, axial and beam bending vibrations; forced vibration of continuous systems using modalSuperposition; Approximation methods – Rayleigh-Ritz and Galerkin based solutions.

Text Books:

1. **W. T. Thomson, M. D. Dahleh and C. Padmanabhan,** 2008, Theory of Vibration with Applications, Pearson Education India: New Delhi.
2. **L. Meirovitch**, 2001, Elements of Vibration Analysis, Tata McGraw-Hill: New Delhi.
3. **S. S. Rao,** 2003, Mechanical Vibrations, 4th Edition, and Pearson India: New Delhi.

Reference Books:

1. **B. Balachandran, E. B. Magrab**, 2009, Fundamentals of Vibrations} Cengage Engineering: New Delhi.
2. **V. Ramamurti**, 2012, Mechanical Vibration Practice and Noise Control, Narosa: New Delhi.

Prerequisite:

COT

Elective Basket 3 : From The Pool and Advised by FA

OE5300 Advanced Dynamics of Floating Bodies

Course Content:

Review of Linear equations of motion; Oscillations of floating bodies – Concepts of small bodies and large bodies- Morisons for wave –current interactions- Added mass and Moment of Inertia and hydrodynamic damping, Exciting forces and moments due to waves - Froude Krylov theory Diffraction - MacCamy and Fuchs solution - Radiation Theory -General motion analysis of floating bodies - Time and frequency domain approaches – Response amplitude operators -strip theory for slender bodies with forward speed- Symmetric and unsymmetric coupled motions Directional spectra for waves - 3 D waves and responses Random response theory – Random response of linear systems under wave loading – response statistics – time frequency and probabilistic approach Introduction to multi-body structure - Two floating structures formulation

Text Books:

1. **Chakrabarti, SK.** 1994. Hydrodynamics of Offshore Structures, WIT Press, Southampton, UK. ISBN: 978-0-90545-166-4
2. **Turget Sarpkaya and Michael Isaacson.** 1981. Mechanics of wave forces on offshore structures, Van Nostrand Reinhold Company, USA, ISBN: 978-044-22-5402-5

Reference Books:

1. **Chakrabarti, SK**. 2005. Handbook of Offshore Engineering, Elsevier, ISBN: 978-008-05-2381-1
2. **Michael E. McCormick.** 2010. Ocean Engineering Mechanics with Applications Cambridge University Press, pp. 580, ISBN: 978-052-1859-523

Prerequisite:

NIL

OE5560: DREDGING AND RECLAMATION

Course content:

Introduction to Dredging and dredging equipment; Need for reclamation; Introduction to Engineering aspects of Dredging and Reclamation. Marine investigations for Dredging and Reclamation – Standards, Requirements and Methods: Hydrographic survey; Geophysical – sidescan, sub-bottom, seabed refraction investigations; Geotechnical investigations; Sea bed and water sample analysis. Use of Marine investigations in Capital and Maintenance Dredging, and reclamation. Characterization of Soils and Rocks; PIANC guidelines (Report No. WG 144) and other international practices; Interpretation of marine investigation data in the context of characterization of soils for dredging. Methods of estimation of Dredging Production; Estimation cutter power. Dredging equipment selection; cutting tools and power estimation; pumps and capacity; dredging tolerances and dredging methods in river, open sea and inland water bodies; dredging near existing structures; Dredge spoil disposal; spoil dumping ground selection; methods of transportation of dredged spoil. Reclamation schemes; Burrow pit materials from land; dyke formation and peripheral shore protection; near shore and island reclamation; use of dredged materials for reclamation; direct dumping methods; rainbow discharge; pumping via pipelines; booster stations; layered soil dumping; suitability of materials for reclamation; Methods of ground improvement in reclamation; vibro-compaction etc. Estimation of cost; rate analysis for dredging; Cost standards (CIRIA C684); Dredging management to protect the environment; risks and cost escalation in dredging; siltation issues; dispersion of silt; silt curtains and containment booms.

Text Books:

1. **Vlasblom, WJ.** 2007. Dredging equipment and technology, University lecture notes, Delft University of Technology, Delft, The Netherlands.
2. **Sape A Miedema.** 2019. The Delft Sand, Clay and Rock, Cutting Model, TU Delft Open, ISBN: 978-946-3661-324
3. **Bray, N and COHEN, M (Ed.).** 2010. Dredging for development, Sixth Ed., Int. Association of Dredging Companies, The Netherlands and Int. Association of Ports and Harbors, Japan, ISBN: 978-9-07525-416-7
4. **Bray, RN., Bates, AD and Land, JM.** 1996. Dredging: A Handbook for Engineers, Butterworth Heinemann, London, UK, ISBN: 978-0-34054-524-9
5. **Vallam Sundar and Sannasiraj, SA.** 2019. Coastal Engineering: Theory and Practice, Adv series on Coastal engineering, Vol. 47, World Scientific, Singapore, ISBN: 978-981-3275-90-4

Reference Books:

1. **IADC.** 2018. Dredging for sustainable infrastructure, Int. Association of Dredging companies, The Netherlands.
2. **Offshore Shipping Online,** 2009. Dredgers of the world, 7th Ed., Offshore Energy Newsletter, The Netherlands.
3. **Bray, RN.** 2009. A guide to cost standards of dredging equipment C684, Construction Industry Research and Information Association (CIRIA), ISBN: 978-0-86017-684-8

Prerequisite:

OE5450 Numerical Techniques in Ocean Hydrodynamics

Course content:

Revisit Fluid Dynamics fundamentals. Numerical solution of Diffusion, Advection and Burgers' equations. Requirements of numerical solutions - Lax theorem; linear stability analysis. Introduction to CFD concepts: Pressure elimination, Pressure correction and Split algorithms; modeling of turbulence; introduction to LES, DES and DNS. Computations in solution of PDEs, Pressure elimination and Pressure correction. Introduction to computations using unstructured meshes. Introduction to Numerical Marine Hydrodynamics: Partial differential equations of inviscid hydrodynamics; Code development and computations of hydrodynamics of wave-structure interaction for fixed and floating bodies using BIEM, BEM and FEM techniques; Application of Fast methods; Time domain computation - non-linear velocity potential and acceleration potential approaches. Free surface computation in viscous models - VOF and Levelset. Computation of the motions of ships in waves. Forward speed problem and computation. Integral boundary layer equations and numerical solutions. Introduction to Parallel Machines and High Performance Computing.

Text Books:

1. **Anderson, D.** Computational Fluid Dynamics, McGraw Hill International Editions, 1995.

Reference books:

1. **Tannehill, C., Anderson, D and Pletcher, R.** Computational Fluid Mechanics and Heat Transfer, 1997.
2. **Newman, JN.** Marine Hydrodynamics, MIT Press, Cambridge, MA, 1977.
3. Journal and thesis publications and prescribed by teacher.

Prerequisite:

NIL

OE5201 Modelling and Analysis of Electric Machines

No Data

EE5411 Synthesis of Control Systems

Course Content:

Overview of the course: review of modelling and analysis of control systems, introduction to design, types of specifications, transform-based and state-space approaches.Compensation in time domain with specifications on settling time, peak overshoot etc., the root locus approach, design of a compensator using the root locus, notion of dominant poles, circuit representations. Compensation by frequency response methods with specications on gain margin and phase margin, design of a compensator using Bode plots.Synthesis of PID controllers: design of a controller for a known plant, design of a PID controller when plant model is unknown,Ziegler-Nichols tuning rules and related derivations. Two-degrees-of-freedom (2-DOF) control systems: introduction to 2-DOF control, design of 2-DOF controllers for disturbance rejection along with specifications on overshoot for setpoint trackingInternal stability and design of stabilizing controllers: pole-zero cancellation and issues, parametrization of stabilizing controllers, Youla parameter. State space-based synthesis: Design of a state-feedback controller using pole placement, Ackermanns formula, introduction to optimal control.

Text Books:

1. **K. Ogata,** Modern Control Engineering, Pearson, 2015

Reference Books:

1. **J.C. Doyle, B.A. Francis and A.R. Tannenbaum**, Feedback Control Theory, Dover, 2009
2. **K.J. Astrom and R.M. Murray**, Feedback Systems, Overseas Press, 2011
3. **L. Qiu and K. Zhou**, Introduction to Feedback Control, Pearson Education, 2010

Prerequisite:

Control Engineering

ME5303 Cad in Manufacturing

Course Content:

Geometric Modeling – wireframe modelling, surface and solid modelling; use of solid models in CAD/CAM – automated process planning; automated cutting tool path planning; slicing of CAD models for rapid prototyping; mesh generation and use in manufacturing process development.

Text Books:

1. Integrating Advanced Computer-Aided Design, Manufacturing and Numerical Control, by Xun Xu Computer-Aided Manufacturing by T-C Chang, R. A. Wysk and H-P Wang

Reference Books:

1. Delaunay mesh generation, by Siu-Wing Cheng, Tamal Krishna Dey and Jonathan Richard Shewchuk

Prerequisite:

NIL

ME7120 Sensors for intelligent Manufacturing and Condition Monitoring

NO DATA

Master of Technology
In
PE Curriculum

Curriculum and Course Contents
(Applicable from 2023 Batch)

Indian institute of Technology Madras
Chennai 600 036

M.Tech in PE Curriculum

Semester #1

No.	Subject	L	T	E	A	O	Credits
PE6030	Reservoir Engineering	3	0	0	0	6	9
PE6050	Exploration and formation Evaluation of Oil and Gas Reservoirs	3	0	0	0	6	9
PE5050	Offshore Drilling and Production Practices	3	0	0	0	6	9
PE5040	Surface Facility for Oil and Gas Handling	3	0	0	0	6	9
DPE1	Department Elective 1	3	0	0	0	6	9
total							45

Semester #2

No.	Subject	L	T	E	A	O	Credits
PE6031	Reservoir Simulation	3	0	0	0	6	9
PE6040	Advanced Seismic Data analysis and interpretation	3	0	0	0	6	9
PE6312	Enhanced Oil Recovery	3	0	0	0	6	9
DPE2	Department Elective 2	3	0	0	0	6	9
DPE3	Department Elective 3	3	0	0	0	6	9
DPE4	Department Elective 4	3	0	0	0	6	9
total							54

Summer

No.	Subject	L	T	E	A	O	Credits
PE6201	M.Tech Petroleum Engineering Project – Phase I	0	0	0	0	20	20
Total							20

Semester # 3

No.	Subject	L	T	E	A	O	Credits
PE6202	M.Tech Petroleum Engineering Project – Phase II	0	0	0	0	40	40
Total							40

Semester # 4

No.	Subject	L	T	E	A	O	Credits
PE6203	M.Tech Petroleum Engineering Project – Phase III	0	0	0	0	40	40
Total							40

Total Credits - 199

List of Electives for Petroleum Engineering

PE6060	Offshore Oil and Gas Production Systems
PE6317	Applied Hydrodynamics in Petroleum Exploration and Production
PE6313	Applied Scientific Computing in Ocean and Petroleum Engineering
PE6010	Petroleum Geology
PE6314	Drilling Fluid Design and analysis
PE5010	Petroleum Geomechanics
PE5020	Environmental Impacts of Petroleum Exploration and Production
PE 5030	Artificial Life Technology for Oil and Gas Production
PE6320	Sub Sea Engineering for Oil and Gas Fields
PE6180	Natural Gas Engineering
PE6090	HSE Management in Petroleum & offshore Engineering
OE5450	Numerical Techniques in Ocean Hydrodynamics
OE5012	Deep Sea Technology
OE6020	Meshfree Methods applied to Hydrodynamics
OE5650	Marine Corrosion Engineering
CH5023	Unconventional Oil and Gas Resources
CH5030	Transport Phenomena
AM5530	Advanced Fluid Mechanics
AM5630	Foundation of Computational Fluid Dynamics
AS5420	Introduction to CFD
AS5460	Finite Volume Methods for Hyperbolic PDES
CE5460	Ground Water Engineering
CH6060	Numerical Tech for Engineers
MA5890	Numerical Linear algebra
MA6270	Numerical Solutions of Partial Differential Equations
MA6460	Computational Fluid Dynamics
ME6000	Computational Methods in Engineering
ME7790	Heat and Fluid Flow in Porous Media
ME6000	Computational Methods in Engineering
ME7121	Heat and Mass Transfer in Porous Media

Curriculum - M.Tech in PE Curriculum

SEMESTER #1

PE6030 Reservoir Engineering

Course Content:

Introduction to Reservoir Engineering; Petroleum Reservoir System; Petroleum Reserves; Reservoir Pressure and Temperature; Reservoir Fluids Composition; Phase Behavior of Hydrocarbons; Properties of Reservoir Liquids; Fundamental Properties of Reservoir Rocks; Reservoir Drive Mechanisms; Single and Multi-Phase Fluid Flow Through Porous Media; Material Balance Equation; Basic Water-Drive and Immiscible Displacement theories. Laboratory Demonstration of Porosity and Permeability Measurements Using Helium Porosimeter and Liquid Permeameter.

Text Books:

1. **Lyons, W. C.** Standard Handbook of Petroleum and Natural Gas Engineering. Gulf Professional Publishing (6th Edition), 1076 Pages, 1996
2. **Craft, B. C., M. Hawkins., and R. E. Terry.** applied Petroleum Reservoir Engineering (2nd Edition), Prentice Hall, 464 Pages.,1991
3. **Lake, L. W.** (1989). Enhanced Oil Recovery, Prentice Hall, Englewood Cliffs., 1989.
4. **Amyx, J. W., D. M. Bass., and R. L. Whiting.** Petroleum Reservoir Engineering – Physical Properties. Mcgraw-Hill inc.,1960.
5. **Marle, C. M.** Multiphase Flow in Porous Media. Gulf Publishing Company,1981.

Reference Books:

1. **Dake, L. P** Fundamentals of Reservoir Engineering (Developments in Petroleum Science), Elsevier, ISSN: 0376-7361 (Series), 2001
2. **Towler, B. F.** Fundamental Principles of Reservoir Engineering. Textbook Vol. 8, Society of Petroleum Engineers, 232 Pages. ISBN: 978-1-55563-092-8,2002
3. **Ewing, R.E.** the Mathematics of Reservoir Simulation. Society for industrial Mathematics, 198 Pages,1987.
4. **Ahmed, T.** Reservoir Engineering Handbook. Gulf Professional Publishers, (3rd Edition), 1376 Pages,2006
5. **Goodman, R. E.** introduction to Rock Mechanics, Second Edition, John Wiley & Sons.
6. **Jaegar, J., N. G. Cook., and R. Zimmerman** Fundamentals of Rock Mechanics, Fourth Edition, Blackwell Publishing,2007

Prerequisite:

NIL

PE6050 Exploration and formation Evaluation of Oil and Gas Reservoirs

Course Content:

Gravity, introduction to Geophysical Methods, the Role of Non-Seismic Methods in the E& P Business, Gravity Surveying, Determination of Contour Map anomalies, Calculation of Gravity Responses, Determination of Gravity Resolution of Bodies, anticlines and Faults, Depth Estimation Methods: Half-Width, Gradient-Amplitude, Exercises on Paper and Using Computer Software Magnetics and Electrical Methods, introduction to Magnetic and Electrical Methods, Gravity and Magnetic Signatures,(Poisson's) Relationship Between Gravity and Magnetic Responses, Electrical Measurement Methods, Calculations of Resistivity Profiles, Effective Resistivity, Exercises on Paper and Using Computer Software Electrical and Electro-Magnetic (EM) Methods, EM: Diffusion Or Wave-Propagation ? Land EM: TEM Surveying, Magneto Tellurics (Mt): Measurements & Modelling, Marine EM:CSEM (Controlled Source Electromagnetics) Measurements, Calculations of E Refraction, Mt Resolution, EM Skin Depth & Velocity, Exercises on Paper and Using Computer Software CSEM Modeling and inversion, EM Terminology, Exercises: CSEM Scripps Modelling: 3 Layers Exercises: CSEM Scripps Modelling: 5 Layers, CSEM & Mt: Scripps Occam inversion, Time-Lapse Gravity & Electrical Methods, Joint inversion CSEM & Mt, Joint inversion TE & TM Joint inversion TDEM (Time Domain EM), Mt Sub-Surface Correlation and Mapping from Log Data. Delineation of Fractures from Logs. Production Logging. Well Logging for Metallic and Non-Metallic Minerals: Radioactive and Nonradioactive Evaporates, Coal, Sulphur. Borehole Geophysics for Groundwater Exploration., Effective Pay Thickness of an aquifer. Saline Water-Fresh Water interface from Log Data., Determination of Groundwater Flow Direction By Logs. theoretical Computations of Normal and Lateral Log Responses. Identification and Delineation of Sub-Surface formations from Well Log Data. Calculation of Reservoir Parameters: formation Factor, Porosity, Permeability, Resistivity, Water and Hydrocarbon Saturations, and Movable Oil. Subsurface Correlation of formations and interpretation of Field Data.

Text Books:

1. **Kearey, P., Brooks, M., & Hill, I.** an introduction to Geophysical Exploration. John Wiley & Sons, 2013
2. **Telford, William Murray, Lloyd P. Geldart, and Robert E. Sheriff**. applied Geophysics. Vol. 1. Cambridge University Press, 1990.

Reference Books:

1. **D.P Helander** 'Fundamentals of formation Evaluation'
2. **Dewan.J.T** 'Essentials of Modern Open-Hole Log interpretation' Pen Well Books, 1983.

Prerequisite:

Nil

PE5050 Offshore Drilling and Production Practices

Course Content:

Ocean Environment for installation, Operation and Survival Condition; Exploratory, Production, Storage and Transportation, Platform installation and Positioning, Subsea Preparation. Deep-Water Platforms: FPSO, Semisubmersible, TLP and Spar with Case Studies including Transportation By Tankers and Pipelines. Difference Between onshore Drilling and offshore Drilling. Unconventional and Conventional Resources and Environmental Effects, Digital Oil Field, Oil Processing Facilities and Gas Processing Facilities: Upstream Well Planning, Risers for Shallow and Deep-Water Platforms, Corrosion inhibition in Pipelines, Case Studies on offshore Drilling Worldwide, Oil Spill and Safety Measures. anchors: Pile, Suction, torpedo, Dead Weight, Mushroom Etc. Calm, SPM, Mooring Dolphins and Booms, Selection Criteria, Moorings with and Without Buoys, Mooring alternatives- Dynamic Positioning Systems (DPS), Remotely Operated Vehicles (ROV) and Its Types. Viv in offshore Pipelines, Umbilical's and Risers, and Its Mitigation Measures.

Text Books:

1. **Subrata K. Chakrabarti,** Handbook of Offshore Engineering, Volume 1 and 2, Elsevier, 2005.
2. **Gregory Tsinker,** Marine Structure Engineering: Specialized applications, Springer, 1995.

Reference Books:

1. **James G Speight,** Handbook of offshore Oil and Gas Operations. Elsevier, 2011.
2. **Laik Sukumar,** Offshore Petroleum Drilling and Production. CRC Press, 2018.
3. **Huacan Fang and Menglan Duan,** Offshore Operation Facilities: Equipment and Procedures, Gulf Professional Publishing, 2014.
4. **Håvard Devold,** Oil and Gas Production Handbook. an introduction to Oil and Gas Production, Transport, Refining and Petrochemical industry. 2013.

Prerequisite:

NIL

PE5040 Surface Facilities for Oil and Gas Handling

Course Content:

Two and Three Phase Separators, Emulsion Treatment theory and Practice, Emulsifiers & Demulsifies, Coalescence, Coalescing Media, Electrostatic Coalescers. Natural Gas Dehydration, Glycol Process: Effect of Variables, Natural Gas Sweetening: Effect of Variables. Evaporative Emissions, Storage Tanks, Strategic Storage. • Mechanism of Heat Transfer, Process Heat Duty, Sensible Heat of Natural Gas, Water, Heat Transfer from a Fire-Tube, Heat Exchangers- Types, Sizing, Number of Tubes. • Pressure Vessel Design, Wall Thickness and Stress, Corrosion allowance. Pressure Relief and Safety System, Valves, Fittings and Piping's. Material Considerations. • Natural Gas Handling Compressors- Reciprocating, Centrifugal and Other Types. Surge Control, Process Parameters, Compressor Selection Calculations. Pumps on the Surface Facilities, Selections. • Prime Movers: internal Combustion Engines, Fuel, Gas Turbine Engines, Construction and Mechanism of the Engines, Pollutions

Text Books:

1. **Maurice Stewart, Ken arnold,** Surface Production Operations (Vol I & II), Gulf Professional Publishing.2007.
2. **Maurice Stewart,** Surface Production Operations (Vol III & IV), Gulf Professional Publishing. 2018.

Reference Books:

1. **William C. Lyons, Gary J Plisga, BS**, Standard Handbook of Petroleum and Natural Gas Engineering, Gulf Professional Publishing.2004, Book ISBN: 978-0750677851
2. **Larry W. Lake,** Petroleum Engineering Handbook, Editor-In-Chief, SPE Publication, Vol-III, 2007.
3. **A P.Szilas,** Production and Transportation of Oil and Gas, Part B, Elsevier, 1986.

Prerequisite:

NIL

DPE1 – Department Elective 1

SEMESTER #2

PE6031 Reservoir Simulation

Course Content:

Derivation of Partial Differential Equations Governing Single and Multi-Phase Fluid Flow Through Petroleum Reservoirs; Conceptual, Mathematical and Numerical Modelling Principles; introduction to Elliptic, Parabolic and Hyperbolic Partial Differential Equations; introduction to Finite Difference Techniques; introducing Numerical Modelling Concepts on thermal/Microbial Enhanced Oil Recovery Techniques; Fluid Flow Through Fractured/Shale-Gas/Coal-Bed-Methane Reservoirs Using Dual-Porosity approach

Text Books:

1. **Zhangxin Chen**. Reservoir Simulation: Mathematical Techniques in Oil Recovery, Society for industrial and applied Mathematics, 2008.
2. **Abou-Kassem, J. H., Farouq Ali, S. M., and Islam, M. R.** Petroleum Reservoir Simulation: a Basic approach, Gulf Publishing Company, 2006.
3. **Fanchi John R**. Principles of applied Reservoir Simulation, Gulf Professional Publishing, 2005.
4. **Carlson, M. R.,** Practical Reservoir Simulation: Using, assessing, and Developing Results, Pennwell Books, 2003.

Reference Books:

1. **Mattax, C.C. and Kyte, R.L.** Reservoir Simulation, Monograph Series, SPE, Richardson, Tx., 1990.
2. **Ertekin, abou-Kassem and King.** Basic applied Reservoir Simulation, SPE Textbook 7, 2001.
3. **Mattax, C. C. and Dalton, R. L.** Reservoir Simulation, Spe Monograph, 1990.
4. **Armin Iske, and Trygve Randen** (Editors). Mathematical Methods and Modelling in Hydrocarbon Exploration and Production, Part III. Springer, 2004

Prerequisite:

Reservoir Engineering

PE6040 Advanced Seismic Data analysis and interpretation

Course Content:

Introduction to Elasticity theory Wave Equation, Plane and Spherical Wave Solutions, Seismic Waves, Marine 3-D Data acquisition Marine Shear Wave acquisition, 3-D Land acquisition, Normal-Moveout Calculations, Dip, Cross-Dip, and angle of approach, Depth and Dip Calculations Using Velocity Functions, Weathering Corrections and Dip/Depth Calculations, Field Techniques, Seismic Data Processing – Fourier Transforms, Convolution, and Correlation, Deconvolution and Frequency Filtering, automatic Statics Determination, Velocity analysis, Preservation of amplitude information, Migration Methods, DMO and Prestack Migration Maximum Porosity Versus Depth, Relation Between Lithology and Seismic Velocities, Porosities, Velocities, and Densities of Rocks Velocities in Limestone and Sandstone, Dependence of Velocity-Depth Curves on Geology, Determining Lithology from Well-Velocity Surveys, Reflectivity Versus Water Saturation, Effect of Overpressure, Effects of Weathered Layer (LVL) and Permafrost Stacking Velocity Versus Rms and average Velocities, Well-Velocity Survey, Effect of Timing Errors on Stacking Velocity, Depth, and Dip. Estimating Lithology from Stacking Velocity, Velocity Versus Depth from Sonobuoy Data, influence of Direction on Velocity analyses, Reflection Field Methods, Reflection-Point Smear for Dipping Reflectors, attenuation of air Waves, Maximum array Length for Given apparent Velocity, Noise Tests, Selecting Optimum Field Methods, Optimizing Field Layouts, Selecting Survey Parameters, interpreting Up hole Surveys, Weathering and Elevation (Near-Surface) Corrections, Determining Static Corrections from First Breaks Seismic Data Processing, Fourier Series, Fourier Transforms of the Unit Impulse and Boxcar, alias Filters, Calculating Cross correlation and autocorrelation, Convolution and Correlation Calculations, Deconvolution Methods, inverse Filter to Remove Ghosting; Recursive Filtering, Ghosting as a Notch Filter, autocorrelation, apparent-Velocity (F -K) Filtering, Kirchhoff Migration, Effects of Normal-Moveout (NMO) Removal Specialize Techniques, Exploration With S Waves, Channel Waves, Vertical Seismic Profiling, Seismic tomography, Borehole Studies, Passive Methods, Geostatistical Methods

Text Books:

1. **Sheriff R.E. and Geldart L.P., Tulsa, Oklahoma,** Exploration Seismology, 2nd Edition, Cambridge University Press, Cambridge, 1995. Payton C.E., Seismic Stratigraphy – applications to Hydrocarbon Exploration, Memoir of the American association of Petroleum Geologists 26, Tulsa, Oklahoma, 1977. Yilmaz O., Seismic Data analysis: Processing inversion and interpretation of Seismic Data (Vols. 1&2), Society of Exploration Geophysicists, 2001.

Reference Books:

1. **Hardage B.A., Seismic Stratigraphy,** Elsevier, amsterdam, 1987. Bullen K.E. and Bolt B.A., an introduction to the theory of Seismology, Cambridge University Press, 1985. Bath M., introduction to Seismology, Birkhauser Verlag, Basel, 1973. Coffeen J.A., interpreting Seismic Data, Penn Well, 1984.

Prerequisite:

NIL

PE6312 Enhanced Oil Recovery

Course Content:

General EOR: Displacement Fundamentals, Reservoir Engineering Concepts for EOR, Factors affecting Oil Recovery, Comparative Performance of Different EOR Methods, Screening Criteria and Technical Constraints. Water Flooding Fundamentals. Fractional Flow theory, applications of Fractional Flow in Oil Recovery Calculations, Homogeneous Reservoirs: Buckley leverett. onedimensional Displacement, Layered Reservoirs: Styles, Dykstra ¬Parsons and Johnson Methods. Improved Water-Flooding Processes: Miscible Processes: General Overview of Solvent Methods, Phase Behavior Fundamentals from: Pressure/Temperature and Pressure/Composition Diagrams, Quantitative Representation of Phase Equilibria Processes. Chemical and Polymer Flooding: Polymer Flooding, Rheology of Polymer Solutions, Polymer adsorption and Retention, Micellar¬-Polymer or Micro-Emulsion Flooding, Properties of Surfactants and Co-Surfactants, Surfactantbrineoil Phase Behavior, Performance Evaluation. Low Salinity Water Flooding. Nanotechnology for EOR. thermal Processes: Steam injection Processes, Cyclic and Continuous Steam injection, thermal Properties of Fluids and Solids, Steam Properties: Flow Rate and Quality Measurements. Temperature Effect on Reservoir and Fluid Properties, Viscosity Reduction, thermal Expansion, Oil Characterization for thermal Reservoir Simulation, Evaluation of Heat Losses, Prediction of Steam Flood Performance, Cyclic Steam Performance: Marx Langenheim Model, Steam Flood Performance: Gomaa's Method. Microbial EOR: Well Bore Clean Up, Well Stimulation and Enhanced Water Floods Using Microbes. Environmental and Economics aspects of EOR Methods.

Text Books:

1. **Lake, L.** Enhanced Oil Recovery, Pennwell Publishing Company,1991
2. **Donaldson, E. C., Chilngarian G. V., and T. F. Yen.** Enhanced Oil Recovery-I, Elsevier Publications,1985
3. **Latil, M.** Enhanced Oil Recovery, Gulf Publications,1980
4. **Green, D.W. and G. P. Willhite.** Enhanced Oil Recovery, SPE,2003

Reference Books:

1. **Carcoana, A.** applied Enhanced Oil Recovery, Prentice Hall, 1992
2. **James, G.** Enhanced Recovery Methods for Heavy Oil and Tar Sands, Gulf Publishing Company,2009.
3. **Donaldson, E. C., Chilngarian G. V., and T. F. Yen**. Enhanced Oil Recovery II: Processes and Operations. Elsevier Publications,1989.
4. **Ramirez, W. F.** application of Optimal Control theory to Enhanced Oil Recovery, Elsevier Publications,1987

Prerequisite:

Reservoir Engineering.

DPE 2 – DEPARTMENT ELECTIVE 2

DPE 3 – DEPARTMENT ELECTIVE 3

DPE 4 – DEPARTMENT ELECTIVE 4

Summer

PE6201 MTECH PETROLEUM ENGINEERING PROJECT - PHASE I

Course Content:

Students Should Be able to Find Out the appropriate Numerical/Analytical/ Experimental tools Required and Learn them.

Text Books:

1. As Prescribed by the Faculty Guide E.G., Existing Literature and Previously Carried Out Projects.

Reference Books:

1. As Prescribed by the Faculty Guide E.G., Existing Literature and Previously Carried Out Projects.

Prerequisite:

NIL

Semester #3

PE6202 MTECH PETROLEUM ENGINEERING PROJECT - PHASE II

Course Content:

In the Second Half, the initial Results and the Pilot Problem as Well as the Hands-On Experience in the tools (Analytical, Numerical and Experimental) Should Be Finalized So as to Obtain Results from the Proposed Research.

Text Books:

1. As Prescribed by the Faculty Guide E.G., Existing Literature and Previously Carried Out Projects.

Reference Books:

1. As Prescribed by the Faculty Guide E.G., Existing Literature and Previously Carried Out Projects.

Prerequisite:

NIL

Semester #4

PE6203 MTECH PETROLEUM ENGINEERING PROJECT - PHASE III

Course Content:

Experiments and /Or Simulations and / Or Computations Related to the Project. analysis of Outcomes and Presentation of the Results from the Proposed Research. Present any theoretical Proofs of any New Methods / Findings (If applicable).

Text Books:

1. As Prescribed by the Faculty Guide E.G., Existing Literature and Previously Carried Out Projects.

Reference Books:

1. As Prescribed by the Faculty Guide E.G., Existing Literature and Previously Carried Out Projects.

Prerequisite:

NIL

List of Electives for Petroleum Engineering

PE6060 OFFSHORE OIL AND GAS PRODUCTION SYSTEMS

No Data

PE6317 APPLIED HYDRODYNAMICS IN PETROLEUM EXPLORATION AND PRODUCTION

No Data

PE6313 APPLIED SCIENTIFIC COMPUTING IN OCEAN AND PETROLEUM ENGINEERING

No Data

PE6010 PETROLEUM GEOLOGY

Course Content:

NIL

Text Books:

1. **Levorsen A.I.**, Geology of Petroleum, W.H. Freeman & Co, Gordonsville, Virginia, U.S.A., 1967.
2. **Tissot B.P. and Welte D.H.,** Petroleum formation and Occurrence, Springer, Berlin, 1984.

Reference Books:

NIL

Prerequisite:

NIL

PE6314 DRILLING FLUID DESIGN AND ANALYSIS

NO DATA

PE5010 PETROLEUM GEOMECHANICS

Course Content:

Stress fields, poromechanics, rock mechanics, rock strength Stress Patterns, The Principal Stresses, Stress Variations, Calculation of Overburden Stress, Stress Orientations and Relative Magnitudes, Absolute Stress Magnitudes in Sedimentary Basins, Depletion and Stress paths, Predicting Porosity and Permeability Changes, Stress Rotations Associated with Depletion, Elasticity, Elastic Moduli and Seismic Wave Velocity, Elastic Anisotropy, Poroelasticity and Effective Stress, Poroelasticity and Dispersion, Thermoporoelasticity, Failure Criteria, Strength and Pore Pressure, Rock Strength from Geophysical Logs, Rock Strength Anisotropy, Hydraulic Fracture, Estimating Rock Strength from Geophysical Logs Faults and Fractures, Wellbore stability Opening Mode Fractures and Shear Faults, Observations of Fractures and Faults at Depth, Fracture Mechanics in Metals & Non-metals, Computational Fracture Mechanics, Drilling-Induced Tensile fractures, Basic Concepts of Critically Stressed Faults, Observations and Modeling of Fault Damage Zones, Sealing and Leaking Faults, Dynamic Hydrocarbon Migration, Fractured Reservoirs and Permeability Anisotropy, Compressional Wellbore Failure, Wellbore Breakouts, Basic Principles of Deviated Wellbore, Tensile Fractures and Borehole Breakouts in Deviated Wells, Estimating Stress from Failure of Deviated Wells, A Criterion for Wellbore Stability, Wellbore ballooning, Case Studies Geomechanics of shale gas and tight oil production Opportunities of Shale Gas Production, Horizontal Drilling and Multi-stage Hydraulic Fracturing, Physical Properties of Shale Gas Reservoir Rocks, Microseismic Events and Reservoir Stimulation, Microseismic Events and Production, Stimulation of Fracture Networks, Shale and Permeability Sorption, Long Period Long Duration Seismic Events, Geomechanical Constraints on Fracture Networks, Horizontal Drilling and Multi-Stage Hydraulic Fracturing, Environmental Protection Improved reservoir characterization Geostatistics, Modeling and Analysis 2 - Applications and Uncertainty is the second course in the series, Geostatistics, Modeling and Analysis 1 - Data Structures and Theory. It introduces practical applications of geostatistics in the geosciences and explains the associated statistical uncertainty of the results. It covres areas such as uncertainty and probability, visualization and spatial analysis, practical data management, and where possible this is explained through worked examples Induced and triggered seismicity Injection-Induced Earthquakes, Triggered Slip on Basement Faults, Predicting Slip on Potentially Active Faults, Case Studies - Practical: Assignments and hands-on experience with live projects

Text Books:

1. **Berkhout, A. J.** Applied seismic wave theory, 1987.
2. **Fjar, E., Holt, R. M., Raaen, A. M., Risnes, R., & Horsrud, P**. Petroleum related rock mechanics (Vol. 53). Elsevier. ,2008
3. **Meyers, M. A., & Chawla, K. K.** Mechanical behavior of materials (Vol. 2, pp. 420-425). Cambridge: Cambridge University Press,2009

Reference Books:

1. Zoback, Mark D. Reservoir Geomechanics. Cambridge University Press,2010

Prerequisite:

Consent of teacher

PE5020 ENVIRONMENTAL IMPACTS OF PETROLEUM EXPLORATION AND PRODUCTION

Course Content:

Offshore Oil Spill: accidental and Operational Oil Pollution; Marine Pollution Sources from Ships, Vessel-Source and offshore Petroleum Extraction; Fate of Oil Spills; Natural Weathering Processes acting on Spilled Oil including Evaporation, Spreading, Dispersion, Water-In-Emulsion, Dissolution, Oxidation, Biodegradation and Sedimentation; Movement of Oil Slicks; Oil Spill Response Methods That include Passive Oil Removal, Manual Oil Removal, Mechanical Oil Removal, Chemical Oil Removal, Bioremediation, thermal Remediation, in-Situ/Controlled Burning; Equipment Used for Cleanup Operations including Boom and Skimmer; Case Studies of Major Marine Oil Spills; State of the art on offshore Oil Spill Modelling. onshore Oil Spill: Sources of onshore Oil Spill; Lnapl Transport Parameters; Lnapl Transport Through Vadose and Saturated Zones; Lnapl Migration at the Field Scale; Lnapl Migration in Fractured Media; Fate of Lnapls in the Subsurface including Volatilization, Dissolution, Sorption and Biodegradation; Lnapl Site Characterization; Estimating apparent Lnapl Thickness; Remediation Techniques including Excavation, Recovery Wells, Soil-Vapor Extraction, air Sparing and Bioremediation; Case Studies of Major onshore Oil Spills; Lnapl Modeling. Environmental Impacts from Conventional Oil and Gas Fields: Sources of Spilled Hydrocarbon accumulations in the Vicinity of Conventional Oil and Gas Fields; Contamination of Groundwater aquifers By Over-Pressuring the annulus; Drilling Fluids and Technologies; Drilling Fluids Related Environmental Issues and Regulations; Drilling Waste Reduction Techniques; Waste Disposal Issues; Environmental Friendly Drilling Fluid Technologies; advanced Drilling Waste Management Technologies. Environmental Impacts from Unconventional Oil and Gas Fields: Geological Principles of Fracking and Shale Gas Extraction; Hydraulic Fracturing Fluids including Proppants, Gelling agents, Friction Reducers, Cross-Linkers, Breakers, acids and Bases, Biocides, Scale and Corrosion inhibitors, Clay Stabilizers, and Surfactants; Flowback and Produced Water That includes Production Chemicals, Dissolved Minerals, Metals, Dissolved and Dispersed Oil Components and Produced Solids; Releases, Effects and Remediation of Oil and Gas Production Wastewater; Pollution Prevention Techniques.

Text Books:

1. **Doerffer, J. W.** Oil Spill Response in the Marine Environment, Elsevier Publications, 392 Pages.,1992
2. **Davidson, W.F., K. Lee.,** and a. Cogswell. Oil Spill Response: a Global Perspective, Springer Publications, 345 Pages.,2008
3. **Craft, B. C., M. Hawkins., and R. E. Terry.** applied Petroleum Reservoir Engineering (2nd Edition), Prentice Hall, 464 Pages.,1991
4. **Yu-Shu Wu.** Multiphase Fluid Flow in Porous and Fractured Reservoirs. Gulf Professional Publishing, 418 Pages.,2016

Reference Books:

1. **Veil, J. a., and M. D. Dusseault**. Evaluation of Slurry injection Technology for Management of Drilling Wastes, U. S. Department of Energy,2003 Http://Www.Evs.Anl.Gov/Pub/Doc/Si-Tech-Report-1584.Pdf.
2. **Gupta, D. V. S., and B. T. Hlidek.** Frac Fluid Recycling and Water Conservation: a Case History, Spe Hydraulic Fracturing Technology Conference, Woodlands, Texas, Usa, January 19-21.,2009
3. Us Environmental Protection agency. Hydraulic Fracturing. (Us Environmental Protection agency, Washington, Dc), 2011 Http://Water.Epa.Gov/Type/Groundwater/Uic/Class2/Hydraulicfracturing/.
4. Kerr Ra Natural Gas from Shale Bursts onto the Scene. Science, 328:1624-1626.,2010.

Prerequisite:

NIL

PE5030 - ARTIFICIAL LIFT TECHNOLOGIES FOR OIL AND GAS PRODUCTION

Course Content:

Oil and Gas Fluid Properties and Units, Wellbore Flow Fundamentals, Density and Viscosity Correlations, inflow Performance Relationships, Multiphase Flow, Sanding, Overview of artificial Lifts, Selection Criteria of artificial Lift Systems, Multi-Criteria Decision Making. • SRP (Or Beam Pump) Systems, Surface and Subsurface Equipment, Power Requirements, Pump Fill age and Dynamometer, Rod Design and Selection, Design Calculations. • Progressive Cavity Pumps System, Surface and Subsurface Equipment, Stage Calculations, Viscosity Effect, Elastomeric and Metallic PCP Concept, Power Requirement, Design Calculations. • Electric Submersible Pumps, Design of Surface and Subsurface Equipment, Protector, Motor, Cable, Stage Calculations, Design Calculations. • Gas Lift System,Valves, Valve Opening Sequence, Surface Unit, Compressor, Plunger Lift, Design Calculations. Hydraulic Jet Pump, Hydraulic Engine Pump, Surface Pumping Unit, Design Calculations.

Text Books:

1. **B. Guo, W.C. Lyons and a. Galambhor,** Petroleum Production Engineering, Elsevier, 2007.
2. **Kermit Brown,** the Technology of artificial Lift Methods, Pennwell Books, 1984.

Reference Books:

1. **Gabor Tacacs,** Electrical Submersible Pumps Manual: Design, Operations, and Maintenance, Elsevier, 2009.
2. **Henri Cholet, Tecnip,**Progressing Cavity Pumps, 1997.
3. **Gabor Tacacs,** Gas Lift Manual Elsevier, 2009. 2005, Pennwell Book.

Prerequisite:

Consent of Teacher

PE6320 – SUB SEA ENGINEERING FOR OIL AND GAS FIELDS

No Data

PE6180 – NATURAL GAS ENGINEERING

Course Content:

Text Books:

NIL

Reference Books:

1. **Beggs, D, H**, Gas Production Operations. Edition Technip. 1984
2. **Chaudhary, Amanat U,** Gas well Testing Handbook, Elsevier, 2003
3. **Lee, J, Wattenbarger, R. A.,** "Gas Reservoir Engineering", Society of Petroleum Engineers, TX, USA, 1996.
4. **Ikoku, Chi,** "Natural Gas Production Engineering", John Wiley and Sons, 1984.
5. **Kumar Sanjay,** "Gas Production Engineering", Gulf Professional Publishing, TX, USA, 1987.
6. **Mokhatab, s, Poe, W A and Speight, J G,** Handbook of Natural Gas Transmission and Processing, Gulf Professional Publishing, 2006.

Prerequisite:

NIL

PE6090 HSE MANAGEMENT IN PETROLEUM & OFFSHORE ENGINEERING

No Data

OE5120 GEO-MECHANICS OF OFFSHORE OIL AND GAS

No Data

OE5450 NUMERICAL TECHNIQUES IN OCEAN HYDRODYNAMICS

Course Content:

Revisit Fluid Dynamics Fundamentals. Numerical Solution of Diffusion, advection and Burgers' Equations. Requirements of Numerical Solutions - Lax theorem; Linear Stability analysis. introduction to CFD Concepts: Pressure Elimination, Pressure Correction and Split algorithms; Modeling of Turbulence; introduction to Les, DES and DNS. Computations in Solution of PDES, Pressure Elimination and Pressure Correction. introduction to Computations Using Unstructured Meshes. introduction to Numerical Marine Hydrodynamics: Partial Differential Equations of inviscid Hydrodynamics; Code Development and Computations of Hydrodynamics of Wave-Structure interaction for Fixed and Floating Bodies Using BIEM, BEM and Fem Techniques; application of Fast Methods; Time Domain Computation - Non-Linear Velocity Potential and acceleration Potential approaches. Free Surface Computation in Viscous Models - VOF and Level set. Computation of the Motions of Ships in Waves. forward Speed Problem and Computation. integral Boundary Layer Equations and Numerical Solutions. introduction to Parallel Machines and high Performance Computing.

Text Books:

1. **Anderson, D.** Computational Fluid Dynamics, Mcgraw Hill international Editions, 1995.

Reference Books:

1. **Tannehill, C., anderson, D and Pletcher, R**. Computational Fluid Mechanics and Heat Transfer, 1997.
2. **Newman,** Jn. Marine Hydrodynamics, Mit Press, Cambridge, Ma, 1977.
3. Journal and thesis Publications and Prescribed by Teacher.

Prerequisite:

NIL

OE5012 DEEP SEA TECHNOLOGY

Course Content:

Introduction about Ocean Survey: Bathymetry, Seismic and Side Scan, Robotics With auvs and Remotely-Controlled Diving Robots. introduction about the Physical Environment (I.E. Winds, Surface Gravity Water Waves and Currents) for Oceans; introduction to Deep-Sea Resource Exploration Systems; introduction to Different Types of Deepwater Production Systems (I.E. Semi-Submersible, Fpsos, Spar, Subsea Systems and Drill Ships, Etc.); Morrison, Froude-Krylov and Diffraction theory for force Estimation, Issues in Deep Water Riser Mechanics; Dynamic Position System; and Umbilical - Design and Development. Operation, Maintenance and Repair; Flow assurance Challenges Like Hydrate formation, Corrosion, Sand Control, Erosion, Meg injection, Subsea Control System; Marine Growth Prevention Techniques; Paints, Rovs and Sliding Marine Growth Preventer in Splash Zone.; Underwater Welding, Rov inspection, Health Monitoring, Measurement of Marine Growth Case Studies on Few Deepwater E&P Systems in india and abroad; Technology Demonstration Project: at the End, a Student Or a Group of Students Will Need to Do a Project That Will Show at the Conceptual Level the application of a Selected Technological Idea/Concept to Problems of interest in Deep Sea. Tutorials: the assignments Will Focus on Hands-On Exercises and application of Case Studies

Text Books:

1. **Roy Burcher and Louis J. Rydill** Concepts in Submarine Design, Cambridge University Press, USA.
2. **Norman Friedman**, Submarine Design and Development, Naval institute Press, USA,1984.
3. **R. Sharma** Deep-Sea Mining: Resource Potential, Technical and Environmental Considerations, Springer, Germany,2017
4. **Kevin T.** Pickering and Richard N. Hiscott Deep Marine Systems: Processes, Deposits, Environments, Tectonics and Sedimentation, AGU, USA,2015

Reference Books:

1. **E. Eugene allmendinger**, Submersible Vehicle Systems Design, Sname, USA., 1990
2. **Günther Clauss, Eike Lehmann, Carsten Östergaard, M. J. Shields** Offshore Structures: Volume I: Conceptual Design and Hydromechanics (Volume 1), Springer, Germany. 2013
3. **Günther Clauss, Eike Lehmann, Carsten Östergaard, M. J. Shields** Offshore Structures: Volume Ii Strength and Safety for Structural Design, Springer, Germany, 2013
4. **C. M. Wang and B. T. Wang** Large Floating Structures: Technological advances, Springer, Germany, 2014.
5. **Mohamed El-Reedy**, Offshore Structures: Design, Construction and Maintenance, Gulf Professional Publishing, USA,2012
6. **Mohamed El-Reedy** Marine Structural Design Calculations, Butterworth-Heinemann, UK. 2014
7. **Thomas Worzyk,** Submarine Power Cables: Design, installation, Repair, Environmental aspects, Springer, Germany,2012.

Prerequisite:

Consent of Teacher

OE6020 MESHFREE METHODS APPLIED TO HYDRODYNAMICS

Course Content:

Numerical Modelling; Basics of Fluid Mechanics; Ns – Eulerian and Lagrangian formulations; Free Surface and Body Boundary Conditions; Time Split algorithms; Strong and Weak forms; Weighted Residual Methods. Overview of Mesh Based Methods and Meshfree Methods; Basic Techniques; Categories of Meshfree Methods; Shape Function Constructions – Issues; SPH; Point interpolations; Moving Least Square Method; Shepard Functions; Error Estimations; Support Domain and influence Domain; Weight Functions; Meshfree integrations; Computational Cost; Conservation and Convergence. Meshfree Methods Based on Global Weak form – EFG; Meshfree Methods Based on Local Weak form – MLPG; Smoothed Particle Hydrodynamics; Moving Particle Semi-Implicit Method; Essential Boundary Conditions – Issues; Turbulence – Sub-Particle Scale; Meshfree Methods applied to Fluid Dynamics Problem; Matrix formulations and Solution Methods in Meshfree Methods; application to Floating Bodies, Coastal Engineering.

Text Books:

1. **G.R. Liu**, **Taylor and Francis,** “Mesh Free Methods: Moving Beyond the Finite Element Method”, CRC Press, US,2006.

Reference Books:

1. **J. Anderson,** “Computational Fluid Dynamics: the Basics With applications”, Mcgraw-Hill, USA,1995.
2. **Li H and Mulay Ss, Taylor and Francis** “Meshless Methods and their Numerical Properties”, CRC Press, , US,2013.
3. **S.N. atluri,** “The Meshless Method (MLPG) for Domain and Bie Discretizations”, Tech Science Press,2004.
4. **G.R. Liu and M.B. Liu,** “Smoothed Particle Hydrodynamics”, World Scientific, Singapore. (Also available as E-Book), 2003.

Prerequisite:

Consent of Teacher

OE5650 MARINE CORROSION ENGINEERING

Course Content:

Definitions of Corrosion, Classification, forms and Causes of Corrosion. Electrochemical aspects, thermodynamics of Corrosion, Emf and Galvanic Series, Nernst Equation, Pourbaix Diagram. Electrode Kinetics and Polarization Phenomena, Exchange Current Density, Mixed Potential theory, Polarization Techniques to Measure Corrosion Rates, Corrosion Rate Measurement Techniques (Dc & ac Methods). Corrosion in Marine Environment, Principal and Mechanism, Properties of Seawater, Corrosion Under Immersed Condition, Bimetallic and Metallic Corrosion, Fouling, Pitting, intergranular Corrosion, Velocity Effects, Erosion Corrosion. Corrosion of offshore Structures for Oil and Gas, Pipelines and Risers, Downhole Corrosion, External Coatings for Submarine Pipelines and Risers. Biological aspects of Corrosion, Microbial induced Corrosion (Mic), Environments and Microbiology, Corrosion By aerobic and anaerobic Bacteria, Depolarization theory, Case Studies, Biofouling. Failure analyses, Prevention of Mic, Corrosion of Concrete, Metallurgical Factors influencing Corrosion. Corrosion Prevention and Control, Design, Coatings and inhibition, Protective Coating for Ships, Underwater antifouling Paint, Cathodic and anodic Protection, Sacrificial anode, Impressed Current anode, Stray Current Corrosion, Corrosion Resistant alloys, Corrosion Testing and Monitoring, Material Choice, Cleaning of Steelwork, acid Pickling, Dry-Blast and Wet-Blast Cleaning.

Text Books:

1. **R. Singh.** Corrosion Control for offshore Structures. Gulf Professional Publishing, 2014.
2. **K. a. Chandler**. Marine and offshore Corrosion, Butterworth, 1985.

Reference Books:

1. **P. R. Roberge.** Handbook of Corrosion Engineering. Mc Graw Hill, 1999.
2. **M. E. Parker, E. G. Peattie**. Pipeline Corrosion and Cathodic Protection. 3rd Edition, Gulf Professional Publishing, 1999.
3. **J. C. Scully**. the Fundamentals of Corrosion. 3rd Edition, Pergamon Press, 1990.
4. **R. W. Revie** (Editor), Uhlig's Corrosion Handbook. 3rd Edition, John Wiley & Sons, inc., 2011.
5. **R. W. Revie** (Editor), Corrosion and Corrosion Control. 4th Edition, John Wiley & Sons, inc., 2008.
6. **W. H. Hartt, F. Presuel-Moreno.** Marine Corrosion, Lecture Notes. Department of Ocean Engineering, Florida atlantic University, Usa, 2016.
7. **Schweitzer, P.E.,** (Editor). Corrosion Engineering Handbook. New York: Marcel Dekker inc., 1996.
8. **C. Hellio, D. Yebra** (Editors). advances in Marine antifouling Coatings and Technologies. Woodhead Publishing, 2009.
9. **D.A. Jones.** Principles and Prevention of Corrosion. 2nd Edition, Prentice Hall Company, New Jersey, 1996.

Prerequisite:

Consent of Teacher

CH5023: UNCONVENTIONAL OIL AND GAS RESOURCES

Course Content:

Weightage for each topic is given in terms of % 15% - Introduction to conventional oil and gas reservoirs, petroleum systems, concepts of reservoir engineering, phase behavior, production methods, EOR. 15% - Heavy oil and oil sands, occurrences, resources, reservoir characteristics, properties of heavy oil and oil sands, drilling and completion methods, production of heavy oil and oil sands, mining, in situ combustion, steam flooding, production issues, reservoir management, flow assurance, transportation methods, upgradation, refining. 25% - Shale oil and gas, origin, reservoir properties, drilling and completion, horizontal well technology, hydraulic fracturing, reservoir management, produced water treatment methods, environmental issues, emerging trends and technologies. 15% - Coalbed methane (CBM), CBM properties, production methods, methods of drilling, completing, and stimulating CBM wells, hydrologic issues and water production, coal seam gas development, in situ gasification, coal conversion. 30% - Gas hydrates, origin, properties and classification of hydrate reservoirs, molecular structure of hydrate, hydrate formation and dissociation process, phase behavior, kinetics, characterization methods, thermodynamic models, flow assurance issues and hydrate prevention, hydrate promoters and inhibitors, production methods.

Text Books:

1. **Carcoana, A.** (1992) Applied Enhanced Oil Recovery, **Prentice Hall. Sloan, D and Koh, C** (2008) Clathrate Hydrates of Natural Gases, 3rd Edition. CRC Press.

Reference Books:

1. Unconventional Oil and Gas Resources Handbook. (2016) **Ma Z Y, Holditch S A (Eds).**Gulf Professional Publishing. **James, G.** (2009) Enhanced Recovery Methods for Heavy Oil and Tar Sands, Gulf Publishing Company. **Chaudhary, A U.** (2003) Gas Well Testing Handbook, Gulf Professional Publishing, Elsevier Dayal, **A. M., Mani, D.** (2017) Shale Gas: Exploration and Environmental and Economic Impacts, Elsevier

Prerequisite:

None

CH5030: TRANSPORT PHENOMENA

Course Content:

Phenomenological description of the continuum approach; transport properties; constitutive relations; conservation laws of mass, momentum, and energy; applications of the conservation laws; unidirectional flow problems; scaling analysis; irrotational flow; boundary layers; forced convection heat and mass transfer in confined and unconfined flows; introduction to transport in turbulent flows

Text Books:

William M Deen, 'Analysis of Transport Phenomena', New York, Oxford University Press.

Reference Books:

Byron, Bird, Warran E. Stewart and Edwin N. Lightfoot, `Transport Phenomena', New York, Wiley.

Prerequisite:

NIL

AM5530: ADVANCED FLUID MECHANICS

Course Content:

Introduction basic equations of motion of fluid flow Equation ofcontinuity NavierStokes equations Euler's equations Bernoulli'sequation Idean fluid flow Flow past circular cylinder with and withoutcirculation Aerofoil viscous fluid flow exact solutions of NavierStokesequations prandtl's boundary layer equations Blasius solution Approximatemethods Transition and turbulent flows Flow through pipe sand flow past a flat plate Turbulent boundary layer One and two dimensional compressible flows Compressible viscous flows Compressible boundary layers.

Text Books:

1. **G. K. Batchelor**, “An Introduction To Fluid Mechanics”

Reference Books:

1. **Frank M. White**, “Viscous Fluid Flow” •
2. **G. K. Batchelor**, “An Introduction To Fluid Mechanics”
3. **John C. Tannehill, Dale Anderson & R.H. Pletcher**, “Computational Fluid Mechanics And Heat Transfer”
4. **John D. Anderson Jr.**, “Modern Compressible Flow”
5. **H. Schlichting & K. Gersten**, “Boundary Layer Theory”

Prerequisite:

AM5630: FOUNDATION OF COMPUTATIONAL FLUID DYNAMICS

NO DATA

AS5420: INTRODUCTION TO CFD

NO DATA

AS5460: FINITE VOLUME METHODS FOR HYPERBOLIC PDES

Course Content:

Classification of PDEs – elliptic, hyperbolic and parabolic; discrete representation of PDE using Finite difference Method: accuracy, consistency and stability of discretized PDE; dissipation and dispersion errors, stability analysis using von Neumann and matrix methods; finite volume method: basic concept; Linear model equation: 1-D (wave) advection equation – exact solution, notion of wave speed and characteristic, numerical solution using FDM and FVM; upwinding methods Non-linear model equation: Burgers' equation – numerical solution to Burgers' equation; Godunov's scheme; shocks and centered expansions; shock speed System of linear equations: linear acoustics equations (1D), wave speeds / Eigen values and Eigen vectors, characteristic variables, Riemann problem and its solution, upwinding methods for system of equations; System of non-linear equations: Euler equations, conservation and quasi-linear form, flux Jacobian matrix, Eigen values and Eigen vectors, characteristic variables; Flux reconstruction methods for the Euler equation: flux- vector splitting schemes – van Leer, AUSM and LDFSS schemes; flux difference splitting scheme: Roe's method; Higher order interface state reconstruction: MUSCL scheme with limiters; Higher order time integration: Runge-Kutta methods;

TextBooks:

None.

ReferenceBooks:

1. **LeVeque, Randall J.** Finite volume methods for hyperbolic problems. Vol. 31. Cambridge university press, 2002.
2. **Pletcher, Richard H., John C. Tannehill,** and Dale Anderson. Computational fluid mechanics and heat transfer. CRC Press, 2012.
3. **Hirsch, Charles**. Numerical computation of internal and external flows: The fundamentals of computational fluid dynamics. Butterworth-Heinemann, 2007.
4. **Laney, Culbert B**. Computational gas dynamics. Cambridge university press, 1998.

Prerequisite:

CE5460: GROUND WATER ENGINEERING

Course Content:

1) Introduction: Role of groundwater in the hydrologic cycle, ground water origin, distribution, porosity, classification of sediments, hydrogeology of aquifers, soil moisture contents.
2) Properties of aquifers: Energy distribution in porous media, Darcy's law, hydraulic conductivity, hydraulic gradients, aquifer types (confined, unconfined, leaky and karst), homogeneity, isotropy, conductivity tensor (for 2D and 3D flow), specific yield, specific storage, storativity.
3) Principles of groundwater flow: Components of hydraulic head, specific discharge, flow equations in confined, unconfined, and leaky confined aquifers, Dupuit assumptions, unsteady flow, groundwater flux and velocity, flow net
4) Well Hydraulics: steady and unsteady radial flows in aquifers (confined, unconfined and leaky), drawdown computation, slug test, pump test, multiple well systems, partially penetrating wells, characteristic well losses, specific capacity.
5) Soil moisture and recharge: Unsaturated soil moisture, soil water characteristic curve, Richard's equation, infiltration and recharge.
6) Surface and Subsurface investigations of Groundwater: Geologic methods, remote sensing, geophysical exploration, electrical resistivity and seismic refraction, gravity, and magnetic methods; test drilling, various logging techniques including geophysical and resistivity methods.
7) Water wells: methods of construction, completion and development, yield tests, protection, and rehabilitation of wells
8) Quality of groundwater: measures of quality, groundwater samples, physical, chemical, and biological analyses, water quality criteria, and salinity.
9) Pollution of groundwater: sources and causes, distribution, attenuation, evaluation and monitoring, remediation.
10) Management of Groundwater: concepts of basin management, groundwater basin investigations, conjunctive use, mathematical modelling, examples.
11) Artificial recharge of groundwater: concepts, recharge methods, recharge mounds, induced recharge.
12) Saline water intrusion in aquifers: occurrence, shape and structure of the interface, up-coning, control of saline water intrusion.

Text Books:

1) Applied hydrogeology, **C. W.Fetter** (January 2014), Fourth edition, Pearson Education India, ISBN-10: 9789332535114; ISBN-13:978-9332535114

Reference Books:

1) Ground water hydrology, **David K. Todd, and Larry W. Mays** (February 2011), Third edition, Wiley India Pvt. Ltd, ISBN-10:9788126530038, ISBN-13:978-8126530038
2) Hydraulics of groundwater, **Jacob Bear** (December 2013), McGraw Hill Education, ISBN-10:9332901910, ISBN-13:978-9332901919

Prerequisite:

NIL

CH6060: NUMERICAL TECH FOR ENGINEERS

Course Content:

Steady state Processes: Vector space, Algebraic systems, Linear system and solution: Direct and iterative processes, Non linear systems: Iterative processes Unsteady state processes: Initial value problem and solution: Implicit and explicit methods, time integration methods, boundary value problems, shooting method, finite difference method, finite volume method and finite element method

Text Books:

1. **S. K. Gupta**, ``Numerical methods for Engineers', New Age Publisher, 1995.

Reference Books:

1. **M.L. James, G.M. Smith and J.C. Wolford**, "Applied Numerical Methods for Digital Computation", Harper 7n Row Publishers,1985.
2. **H.S. Mickley, T.S. Sherwood and C.E. Reed**, "Applied Mathematics in Chemical Engineering", McGrawHill, 1957.

Prerequisite:

NIL

MA5890: NUMERICAL LINEAR ALGEBRA

Course Content:

Floating point arithmetic (1 lecture), stability of algorithms (2 lectures), conditioning of a problem (2 lectures), perturbation analysis (2 lectures), algorithmic complexity (1 lecture), Matrix decomposition including LU, Cholesky, QR, SVD, etc. (12 lectures), Iterative techniques mainly focussing on Krylov subspace methods including Lanczos, Arnoldi, Conjugate Gradient, GMRES, etc. (12 lectures), Preconditioning (2 lectures), structured matrix computations (4 lectures), designing matrix algorithms on modern computer architectures (3 lectures).

Text Books:

1. **James W. Demmel,** Applied Numerical Linear Algebra, Publisher : Society for Industrial and Applied Mathematics, Year : 1997
2. **N. Trefethen & David Bau III**, Numerical Linear Algebra, Publisher : Society for Industrial and Applied Mathematics, Year : 1997

Reference Books:

1. **Biswa Nath Datta**, Numerical Linear Algebra and applications, 2nd Edition, Publisher : Society for Industrial and Applied Mathematics, Year : 2010

Prerequisite:

Linear Algebra at undergraduate level

MA6270: NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS

Course Content:

Parabolic Equations: explicit and implicit finite difference approximations to one - dimensional heat equation, Alternating Direction Implicit (ADI) method, Hyperbolic Equation: Characteristic method, finite difference solution of second order wave equation, Elliptic equations: finite difference method in polar coordinates, techniques near curved boundaries, improvement of accuracy, methods to accelerate the convergence, Convergence, consistency and stability analysis, Finite element method: types of integral formulations, one and two dimensional elements, Galerkin formulation, application to Dirichlet and Neumann problems.

Text Books:

1. **G D Smith**, Numerical solution of partial differential equations:Finite difference methods, Oxford University press, 1977.
2. **G. Evans, J. Blackledge, P. Yardley**, Numerical Methods for PartialDifferential Equations, 2nd edition, Springer, 2001.

Reference Books:

1. **S. Larsson, V. Thomee**, Partial Differential Equations withNumerical Methods, Springer, 2003.
2. **K. Eriksson, D. Estep, P. Hansbo, C. Johnson**, ComputationalDifferential Equations, Cambridge Univ. Press, 1996.
3. **H. P. Langtangen,** Computational Partial Differential Equations,Numerical Methods and Diffpack Programming, 2nd edition,Springer, 2003.
4. **D. Braess** Finite Elements, 2nd edition, Cambridge Univ. Press,2001.
5. **C. Johnson**, Numerical Solution of Partial Differential Equations bythe Finite Element Method, Cambridge Univ. Press, 1987.

Prerequisite:

NIL

MA6460: COMPUTATION FLUID DYNAMICS

Course Content:

Review of the governing equations of Incompressible viscous flows, Stream function -vorticity approach, upwind schemes, Primitive variables, Staggered grid, Artificial compressibility, pressure correction and vortex methods; Compressible inviscid flows, central schemes with combined and independent space time discretisation, Compressible viscous flows, Explicit, implicit and PISO methods; Grid generation: Structured and unstructured grid generation methods; Finite volume method: Finite volume method to convection-diffusion equations.

Text Books:

1. **P Wessling**, Principles of Computational Fluid Dynamics, Springer,1991.
2. John D Anderson, Jr., Computational Fluid Dynamics, The Basicswith Applications, McGrawHill,1995.

Reference Books:

1. **T J Chung**, Computational Fluid Dynamics, Cambridge, 2002.
2. **C A J Fletcher**, Computational Techniques for Fluid Dynamics, Volumes I & II, Springer Verlag,1988.
3. **C Hirsch**, Numerical Computation of Internal and External Flows, Volume I & II, Wiley, 1991.
4. **J C Tannehill, D A Anderson and R H Pletcher**, Computational Fluid Mechanics and Heat Transfer, McGrawHill,1984.
5. **H K Versteeg and W Malalasekera**, An Introduction to Computational Fluid Dynamics, The Finite Volume Method, Addison Wesley, 1996.

Prerequisite:

NIL

ME6000: COMPUTATIONAL METHODS IN ENGINEERING

NO DATA

ME7790: HEAT AND FLUID FLOW IN POROUS MEDIA

Course Content:

Analytical concepts fundamental for the effective modeling of morphology of porous media Heat and Mass diffusion in fully saturated porous medium systems, Local thermal equilibrium and Effective Stagnant Conductivity Models, Introduction to non-linear heat diffusion equation and applications Momentum transport through single-phase saturated porous media, Permeability, Form-coefficient: their measurement and mathematical modeling Flow Models: From Darcy to Turbulence. Forced Convection: First and Second Law of Thermodynamics applied to convection in saturated porous media, Scale analysis, Confined Flow, Transient effects, Convection with variable viscosity. Natural Convection: external flows over vertical and horizontal plate, similarity solution, transient case: integral method, internal flows: Horton-Rogers-Lap wood problem, constant temperature and heat flux cases with Darcy flow, Transient Effects, Method of asymptotes Introduction to analysis and design of Porous Medium Enhanced Heat Exchangers, compact heat exchangers as porous media Introduction to Radiation in saturated porous media: Porous continuum treatment, Scattering, Volume averaging for Independent Scattering, Experimental determination of Radiative properties

Text Books:

1. Transport Phenomena in Micro-scale and Porous Media, by **Josè L. Lage, Marcel Dekker, NY**, expected pub: May 2004
2. Principles of Heat Transfer in Porous Media, by **Massoud Kaviany,** 2nd Ed., Springer-Verlag, New York, 1999
3. Convection in Porous Media, by **Donald A. Nield & Adrian Bejan**, 2nd Ed., Springer-Verlag, 1999.

Reference Books:

None

Prerequisite:

COT

ME6000: COMPUTATIONAL METHODS IN ENGINEERING

NO DATA

ME7121: HEAT AND MASS TRANSFER IN POROUS MEDIA

NO DATA