

M.Tech in Offshore Structural Engineering

SEMESTER I

No.	Subject	L	T	P	C
OE5030	Wave Hydrodynamics	3	0	0	3
OE6200	Design of Offshore Structures	3	0	0	3
OE5070	Statics and Dynamics of Marine Vehicles	3	0	0	3
OE6001	Materials and Fabrication of Offshore Structures	3	0	0	3
OE6003	Analysis of Offshore Structures	3	0	0	3
DPE1	Department Elective I	3	0	0	3
OE5130	Laboratory I	0	0	3	2
	TOTAL	18	0	3	20

SEMESTER II

No.	Subject	L	T	P	C
OE5230	Foundations for Offshore Structures	3	0	0	3
OE5200	Dynamics of Ocean Structures	3	0	0	3
OE6002	Installation of Offshore Structures	3	0	0	3
OE6004	Numerical Modeling of Offshore Structures	2	0	3	4
DPE2	Department Elective II	3	0	0	3
DPE3	Department Elective III	3	0	0	3
OE5140	Lab II	0	0	3	2
	TOTAL	17	0	6	21

SEMESTER III

No.	Subject	L	T	P	C
OE6005	Practical Training#				2
OE6900*	Thesis Project (Part I)				8
	TOTAL				10

Practical training for 4 weeks will be conducted during summer vacation at the end of second semester.

SEMESTER IV

No.	Subject	L	T	P	C
OE6900	Thesis Project (Part II)				20
	TOTAL				20

* Grade assigned in fourth Semester.

Total = 20 + 21 + 2 + 20 = 63.

List of Electives

Course No.	Subject	L	T	P	C
OE5110	Experimental Methods & Measurements	3	0	0	3
OE5300	Dynamics of Floating Bodies	3	0	0	3
OE5320	Nonlinear Problems in Ocean Engineering	3	0	0	3
OE5330	Advanced Marine Structures	3	0	0	3
OE5400	Port and Harbour Structures	3	0	0	3
OE5450	Numerical Techniques in Ocean Hydrodynamics	3	1	0	4
OE5500	FEM applied to Ocean Engineering	3	0	0	3
OE6500	Marine Corrosion & Control	3	0	0	3
OE6960	Wave Simulation Measurement & Analysis	2	0	3	4
PE6090	HSE Management in Petroleum and Offshore Engineering	3	0	0	3
PE6320	Subsea Engineering for Oil and Gas Fields	3	0	0	3

Any other elective approved by Faculty Advisor - IIT Madras.

Course Contents

OE6001 Materials and Fabrication of Offshore Structures 3 0 0 3

COT

Structural Steel : 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;

Welding and Fabrication : Rolling and fabrication of tubular and TKY joints, typical jacket fabrication and rollup procedure, 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;

Corrosion and Control : Corrosion Mechanism; Types of corrosion; Seawater corrosion; corrosion allowance, cathodic protection design, impressed current method, sacrificial anodes design, protective coatings, splash zone protection, cathodic protection monitoring system.

Concrete / composites : Underwater concrete, mix design, quick setting compounds, high strength grout, fiber reinforced plastics, special composite materials for under water repairs.

Underwater repair : Underwater welding, repair schemes for tubular members, grouted sleeve connections, stressed – grouted connections for tubular joints.

OE6002 Installation of Offshore Structures

3 0 0 3

COT

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;

Pile Driving and Monitoring : Pile driveability; Pile stickup design; main and skirt piles concepts; Vertical and batter piles; Dynamics of vertical piles; Pile driving stresses; Pile driving monitoring system; Pile capacity prediction from driving records.

OE6003 Analysis of Offshore Structures

3 0 0 3

COT

Static Structural Analysis : Introduction to structural modeling and analysis of jacket structures; Static and buckling analysis using matrix methods; formulation; treatment of hydrodynamic loading; Estimation of wave and current loading on framed structures; maximum base shear and overturning methods; Cyclic loads for fatigue analysis; Pile – soil interaction and nonlinear analysis.

Dynamic Structural analysis: Dynamic analysis of framed structures; Mode shapes and Eigen frequency analysis; Wave response; dynamic wave response; frequency and time domain analysis of risers and pipelines.

Spectral Analysis methods: Wave spectral density; Spectra for long term and short term wave loading; cyclic stresses and fatigue analysis; Spectral fatigue analysis; Earthquake loads; Response spectra method; Earthquake analysis.

Ultimate Strength analysis : Introduction to ultimate strength of tubular members; Ship impact and denting of tubular; Collapse analysis jacket structures; Push-over analysis and reserve strength ratio of jacket structures; Analysis of structures subjected to high temperature.

OE6004 Numerical Modeling of offshore Structures

2 0 3 4

COT

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.

OE5030 Wave Hydrodynamics

3 0 0 3

Basic Fluid Mechanics : Conservation of mass and momentum, Euler Equation, Bernoulli's equation, potential flow, stream function.

Waves : Classification of water waves - Two dimensional wave equation and wave characteristics - wave theories - Small amplitude waves - Finite amplitude waves - Stokian, Solitary and Conical wave theories - Water particle kinematics - wave energy, power - wave

deformation - Reflection, Refraction, Diffraction Breaking of waves - Wave Forecasting Methods - Spectral description of Ocean Waves - Design wave.

Currents : Classification - Behaviour - Design Criteria, Scour and other effects of currents.

Forces : Wave forces - Morison equation - wave loads on vertical, inclined and horizontal cylinders. Diffraction theory - wave slamming and slapping - wave impact pressures and forces on Coastal Structures - Breakwaters - Seawalls - Model Experiments.

OE6200 Design of Offshore Structures

3 0 0 3
C O T

Loads on offshore structures

Wind Loads; Wave and Current Loads; Calculation based on Maximum base Shear and Overturning Moments; Design Wave heights and Spectral Definition; Hydrodynamic Coefficients and Marine Growth; Fatigue Load Definition and Joint Probability distribution; Seismic Loads;

Concepts of Fixed Platform Jacket and Deck

Jacket concepts, redundant framing arrangement; Launch and Lift jackets; Simple Deck configurations for Lift and float-over installations; In-service and Pre-service Loads and analysis

Steel Tubular Member Design

Principles of WSD and LRFD; Allowable stresses and Partial Safety Factors; Tubular Members, Slenderness effects; Column Buckling, Design for combined axial and bending stresses (API RP 2A guidelines);

Tubular Joint Design for Static and Cyclic Loads

Simple tubular joints, design using allowable loads; stress concentration factors; S-N curves and fatigue damage calculations

Submarine Pipelines and Risers

Route selection and Diameter / wall thickness calculations; Pipeline stability, free span calculations; Concrete coated pipelines and pipe-in-pipe insulated pipelines; Design using DNV 81 code;

Design against Accidental Loads (Fire, Blast and Collision)

Behaviour of steel at elevated temperature; Fire Rating for Hydrocarbon fire; Design of structures for high temperature; Blast Mitigation-Blast walls; Collision of Boats and energy absorption; Platform survival capacity and Plastic design methods

OE5070 Statics and Dynamics of Marine Vehicles

3 0 0 3

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.

Oscillations of floating bodies - equations of motion - added mass and moment of inertia, damping coefficients - exciting forces and moments due to waves, effect of forward speed -

heave, pitch and roll oscillations - strip theory for ship like forms - prediction of motion in irregular seas - method of model tests.

OE5110 Experimental Methods and Measurements **3 0 0 3**
C O T

Dimensional Analysis with special reference to Model Studies in Hydrodynamic and coastal Engineering problems. Design of Models and Fabrication. Hydrodynamic test facilities, Wave makers, Wave absorbers 2-D and 3-D Wave generation.

Static and Dynamic load application methods with reference to model and prototype testing transducers and Instrumentation for Measurement of Force, Pressure, Strain, Displacement, Vibration and Flow. Data Acquisition Systems.

Measurement Techniques for Drag and Inertia Forces, Cavitation, Water Entry and Exit problems.

Wave, Current and Tide Data collection methods

Field Instrumentation for Geotechnical Engineering

Monitoring of Marine Structural Systems, Non Destructive Testing Techniques and evaluation.

OE5130 Laboratory - I **0 0 3 2**

Identification and classifications of marine minerals and rocks of the oceanic crust, Tests for determination of geotechnical properties of marine deposits, Marine Geo-physical exploration. Use of various transducers, pickups for static and dynamic measurements in Ocean Structures. Non-destructive testing, Data transmission and analysis using DACS.

OE5230 Foundation for Offshore Structures **3 0 0 3**

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 stick up, 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, over-turning stability, short term and long term settlements, factor of safety; Bucket foundation; Suction anchors; Gravity foundation.

OE5200 Dynamics of Ocean Structures **3 0 0 3**
C O T

Free and forced vibrations of 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.

OE5140 Laboratory II

0 0 3 2

Measurement of regular and random wave. Analysis computation of water particle kinematics. Measurement of reflectivity and Transmissivity. Wave Force measurements on cylinder, simulation of standard wave spectra. Wave current – structure interaction studies.

OE5300 Dynamics of Floating Bodies

3 0 0 3

Equations of motion for SDOF systems, time and frequency domain solutions - oscillations of floating bodies, added mass and moment of inertia, and hydrodynamic damping - Exciting forces and moments due to waves - Strip theory for slender bodies - Symmetric & unsymmetric coupled motions - Effect of forward speed-3D effects - Dynamic effects - Roll and pitch damping devices - probabilistic approach- Introduction to random response theory - Random response of linear systems under wave loading, directional spectra for waves Probabilistic design criteria - General motion analysis of floating bodies, time and frequency domain approaches.

OE5320 Non Linear Problems in Ocean Engineering

3 0 0 3

Conservative and nonconservative systems, Quadratic and cubic nonlinearities, Nonlinear damping, Forced oscillations, Sub and Superharmonic responses, Parametrically excited systems, Chaotic motion, System identification.

Nonlinear wave theories and wave loading, Nonlinear models of compliant platforms and soil-structure interaction, Risers and moorings, Nonlinear wave loading on large floating systems, Slow drift oscillation, Random response and statistical analysis.

OE5330 Advanced Marine Structures

3 0 0 3

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.

OE5400 Port and Harbour Structures**3 0 0 3**

C O T

Estimation of loads, Analysis, design and construction of Port Structures - Breakwaters, Jetties, Wharves, Quays, Diaphragm Walls, Slipways, Docks. Offshore terminals and islands - fenders and Mooring Facilities.

Limit state and working stress method of design, crack width calculations. Integrity analysis of berthing structures. Case studies of breakwater failures and other types of structures. Partial safety Factors. Codal Requirements.

OE5450 Numerical Techniques in Ocean Hydrodynamics 3 0 0 3

Introduction to numerical methods: Interpolation, differentiation, integration, systems of linear equations. Revisit Fluid Dynamics fundamentals. Solution of differential equations by numerical integration. Introduction to CFD concepts.

Introduction to Numerical Marine Hydrodynamics; Partial differential equations of inviscid hydrodynamics; FD, FE & BI techniques. Application of Fast Fourier Transforms. Numerical representation of sea waves. Computation of the motions of ships in waves. Integral boundary layer equations and numerical solutions.

Numerical methods in 2D & 3D Ocean Circulation: GFD fundamentals (rotation and stratification); Introduction to 2D & 3D Equations of Motion. Application of CFD concepts to the Equations of Motion. Introduction to Unstructured meshes.

Introduction to Parallel Machines and High Performance Computing.

OE5500 FEM Applied to Ocean Engineering**3 0 0 3**

C O T

Introduction - Different approaches to finite element formulation - Different types of elements and interpolation functions, Language & Hermite 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.

OE6500 Marine Corrosion and Control**3 0 0 3**

C O T

System involved in marine corrosion, principle and mechanism, different forms of corrosion - The nature and diagnosis of marine corrosion, classification of typical marine environment - factors in corrosion failures (material environment and design) - Environmental factors influencing the corrosion process (metals and concrete) mathematical modeling for prediction of corrosion rate.

Stress corrosion and corrosion fatigue behaviour of materials in Marine environment - Marine Corrosion testing and monitoring - Material choice - and control of corrosion (cathodic protection). Installation of different types of anodes in offshore platforms. Anticipation painting scheme. Underwater welding - Biofouling.

OE6960 Wave simulation, measurement and analysis 2 0 3 4

Introduction to random waves – statistical & spectral 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.

Wavelet transforms and principal component analysis.

Multi-Directional waves – simulation and analysis using Fourier Method, MLM & MEM – single point measurement and array of gauges; Reflection, refraction and diffraction of directional waves.

Data buoys types – directional wave measurement.

Radar – LIDAR & SAR techniques of directional wave measurement.

Wave Modelling: Third generation Wind-Wave modeling for wave hind-casting and forecasting.

Nearshore wave propagation in phase-averaging and phase-resolving modes using industry

Softwares; Wave tracing; Computational evaluation of diffracted wave on large bodies using industry software; Boussinesq approximation.

PE 6090 HSE Management in Petroleum and Offshore Engineering 3 0 0 3

Introduction to safety, health and environmental management – Basic terms and their definitions – Importance of safety – safety assurance and assessment – safety in design and operation – organizing for safety

Hazard classification and assessment – hazard evaluation and hazard control

Environmental issues and Management – atmospheric pollution – flaring and fugitive release – water pollution – drilling waste, produced water, oil spills, cooling water, processed water – soil waste – rock cutting, oil sludge, drilling soil waste, production waste – Environmental monitoring – environmental impact and decommissioning – environmental management

Accidents modeling – release modeling – fire and explosion modeling – toxic release and dispersion modeling – accident investigation and reporting – concepts of HAZOP and PHA

Safety measures in design and process operations – inerting, explosion, fire prevention, sprinkler systems

Risk assessment and management – Risk picture – definition and characteristics – risk acceptance criteria – quantified risk assessment – hazard assessment – fatality risk assessment – Marine systems risk modeling – risk management principles and methods and concepts optimization for offshore petroleum industry

Analysis of case studies from offshore and petroleum industry

PE6320 Sub Sea Engineering for Oil and Gas 3 0 0 3

Introduction to field development concepts; Surface and subsea systems; Dry and wet tree concepts; Subsea development field architecture; Subsea manifold; Jumpers, umbilicals and risers; Flexible and deep water risers; Steel catenary risers; Rigid and flexible pipelines; Underwater production systems

Floating production systems; Storage and transfer systems; Deep water structural systems for exploration, drilling and production; interaction of pipelines and risers with the structural systems

Introduction to subsea pipelines; Pipeline arrival and discharge conditions; Pipeline hydraulics; Steady state and transient analysis; pipeline sizing; Friction loss; Temperature profile; Slug formation and control; Pipeline design for stresses and stability; Pipeline flexibility and span analysis; Cathodic protection design

Pipeline and riser installation methods; Pipeline dewatering and startup; Intelligent pigging; Pipeline corrosion monitoring; Pipeline crossings; Bonded and unbonded flexibles.

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