COURSE STRUCTURE and SYLLABUS

OF

2 YEAR M.Tech PETROLEUM ENGINEERING

(Approved by 8th Senate On 10.04.2019)

TO BE IMPLEMENTED FROM SESSION

(2019 – 2020)

DEPARTMENT OF PETROLEUM ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY

(INDIAN SCHOOL OF MINES)

DHANBAD 826004

Semester I

Course No.	Course Name	L	T	P	C
Core Courses					
PEC 501	Formation Evaluation and Production Logging (Core Course 1)	3	0	0	9
PEC 502	Advanced Well Testing (Core Course 2)	3	0	0	9
PEC 503	Numerical Methods For Petroleum Engineers (Core Course 3)	3	0	0	9
PET 504	Advanced Production Technologies (Core Course 4)	3	0	0	9
PEC 505	Petroleum Economics, Risk and Uncertainty Management (Core Course 5)	3	0	0	9
Practical Courses					
PEC 506	Practical 1:Reservoir Characterization	0	0	3	3
PEC 507	Practical 2:Term paper/Mini Project	0	0	2	2
			Total Credits		**50**

Semester II

Department Electives (DE): Select Any Three					
Course No.	**Course Name**	**L**	**T**	**P**	**C**
Core Courses					
PEC 508	Petroleum Geomechanics and Hydraulic Fracturing	3	0	0	9
PEC 509	Advanced Drilling Technology	3	0	0	9
Departmental Elective (DE): Select Any One					
PED 501	Reservoir Simulation	3	0	0	9
PED 502	Well Intervention, Workover and Stimulation Techniques	3	0	0	9
Open Electives (OE): Select Any Two					
PEO 501	Fluid Flow Through Porous Media	3	0	0	9
PEO 502	Flow Assurance	3	0	0	9
PEO 503	Unconventional Hydrocarbon Resources	3	0	0	9
PEO 504	Health, Safety & Environment in Petroleum Industry	3	0	0	9
Practical Courses					
PEC 510	Practical 3: Petroleum Instrumentation and Measurements	0	0	3	3
PEC 511	Practical 4: Development of Working Models	0	0	2	2
		Total Credits			**50**

Semester III

Course No.	Course Name	L	T	P	C
PEC 601	Thesis Unit 1	0	0	0	9
PEC 602	Thesis Unit 2	0	0	0	9
PEC 603	Thesis Unit 3	0	0	0	9
PEC 604	Thesis Unit 4	0	0	0	9
			Total Credits		**36**

Semester IV

Course No.	Course Name	L	T	P	C
PEC 605	Thesis Unit 5	0	0	0	9
PEC 606	Thesis Unit 6	0	0	0	9
Department Electives (DE): (Select Any One)					
PED 601	Enhanced Oil and Gas Recovery Methods	3	0	0	9
PED 602	Profile Modification and Water Shut-Off	3	0	0	9
Open Electives (OE): (Select Any One)					
PEO 601	Oil & Gas Processing Plant Design	3	0	0	9
PEO 602	Carbon Capture, Utilization and Sequestration	3	0	0	9
			Total Credits		**36**

SEMESTER I

DEPARTMENT CORE COURSE 1 (DC 1)

Course Name: Formation Evaluation and Production Logging
Course No. : PEC 501 **L-T-P: 3-0-0**

Course Objectives:

1. Advanced study of production and cased-hole logging
2. Log interpretation techniques and determination of reservoir properties

Learning Outcomes:

1. Understanding the principle of different cased hole logging and application
2. Monitoring of reservoir production and problem identification using production log data
3. Using well log to evaluation formation; porosity, permeability & residual oil saturation calculation

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Temperature logging: theory, measurement, interpretation and detection of hydraulic fracture.	4
2.	Radioactive tracer logging: introduction, tracer and velocity-shot log, and two pulse tracer logging. Spinner flowmeter logging: introduction, theory and spinner log interpretation.	5
3.	Single-phase flow profiling by compression of temperature, radioactive tracer and spinner flowmeter logs. Production logging in multiphase flow: operational procedures, fluid Identification log and its qualitative and quantatative interpretation.	5
4.	Production logging and layered system with reference to reservoir engineers' application of production logging. Production logging in horizontal wells.	5
5.	Resistivity through casing: cased-hole formation resistivity tool. Pulsed neutron logging: principle, interpretation and application. Dual water model oil saturation determination and identification of water injection zones. Reservoir time-lapse maps.	5
6.	Inelastic gamma ray logging: carbon-oxygen log, cased-hole wireline formation tester.	5
7.	Downhole casing inspection tools and fluid movement: noise logging & pulse neutron logging and application.	5
8.	New logging techniques, permeability evaluation from well logs data.	5
	Total	**39**

Text Books:

1. Production logging – Theoretical & Interpretive Elements, A. D. Hill, SPE Monograph Series Vol. 14,1990
2. Cased-Hole Log Analysis and Reservoir Performance Monitoring, Richard M. Bateman, Springer, 2015

References:

1. Wireline Formation Testing & Well deliverability, George Slewal, PennWell, 2012
2. Cased- Hole Log Interpretation: Principles and Applications, Schlumberger Ltd,1989

DEPARTMENT CORE COURSE 2 (DC 2)

Course Name: Advanced Well Testing
Course No. : PEC 502 **L-T-P: 3-0-0**

Course Objective:

1. Advanced well testing techniques for reservoir characterization
2. Diagnosis of productivity problems and evaluation of stimulation treatment effectiveness

Learning Outcomes:

1. Understanding different interpretation methodology of various types of well testing
2. Skills for performing diagnostic analysis, history matching, and characterization

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Background of Pressure Transient Analysis**:** radial flow Theory, infinite acting radial flow- *Ei* function solution, principal of superposition, radius of investigation, wellbore storage effects, pressure drawdown and build-up testing,	**4**
2.	Pressure Transient Testing for Gas Wells: Concept of pseudo-pressure and adjusted pressure, pseudo-time and adjusted time, gas well drawdown test – semi-log analysis, log-log analysis, gas well build-up test – semi log analysis, log-log analysis.	**5**
3.	Diagnostic Plots for Vertical Wells: Radial flow – Vertical well IARF, hemi-radial flow, vertical well between intersecting faults, and radial composite reservoir.	**5**
4.	Horizontal wells - early radial flow, hemi-radial flow and pseudo radial flow	**5**
5.	Hydraulically fractured wells – early pseudo radial flow; linear flow – channel reservoirs; spherical flow – limited entry completion, partial penetration; bilinear flow – finite conductivity hydraulic fractures.	**5**
6.	Bounded Reservoir behavior: Closed boundary, linear boundary – no-flow and constant pressure boundary, Circular boundary – closed and constant pressure boundary, Multiple linear boundaries.	**5**
7.	Wellbore phenomena: Constant wellbore storage, variable wellbore storage, Gas phase redistribution, well clean-up and changing skin, Type curve matching.	**5**
8.	Well test interpretation workflow: data preparation, review and quality control, convolution-deconvolution, identification of flow regimes, selection of reservoir model, simulation and history matching of pressure response, and validation of results.	**5**
	Total	**39**

Text Books:

1. Fundamentals of Reservoir Engineering, L.P. Dake, Elsevier, 2010
2. Advanced Reservoir Engineering, Tarek Ahmed, Elsevier, 2004

Reference:

1. Well Testing, John Lee, SPE Text Book Series, Volume 1, 1982.

DEPARTMENT CORE COURSE 3 (DC 3)

Course Name: Numerical Methods for Petroleum Engineers
Course No. : PEC 503 **L-T-P: 3-0-0**

Course Objective:

1. Advanced numerical techniques for petroleum engineering applications.
2. To prepare students for advanced courses in reservoir modelling and simulation

Learning Outcomes:

1. Able to numerically solve linear and non-linear ODEs and PDEs
2. Apply the knowledge for solving complex reservoir simulation problems

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Introduction - tools for numerical analysis (e.g., Matlab, Excel, VBA), debugging and errors handling; fundamental concepts of numerical methods – iteration, convergence, order, stability, Taylor's series, numerical errors and error propagation, and numerical dispersion.	4
2.	Numerical differentiation and integration of functions; interpolation and smoothing; differentiation and integration of discrete data series. linear and pseudo-linear least squares, introduction to regression and curve-fitting.	5
3.	Linear Algebra: vectors, matrices, system of linear equations; direct and iterative methods.	5
4.	Nonlinear algebraic equations – roots of nonlinear equations, maxima and minima of nonlinear functions, local and global extremas. Multivariable methods: root finding and search for extremas. Nonlinear least squares; regression analysis, polynomial curve-fitting.	5
5.	Numerical solution of ODEs and applications; numerical solution of system of ODEs. Numerical inversion of Laplace transforms functions.	5
6.	Numerical solution of elliptic PDEs (e.g., steady-state heat conduction equation) in 2D and 3D using finite difference.	5
7.	Finite element and finite volume methods.	5
8.	Numerical solution of parabolic PDEs such as 1D transient diffusivity equation; numerical solution of steady-state advective-diffusive equation (ADE) in 2D and 3D; numerical solution of transient ADE in 2D and 3D. Explicit and implicit solution, courant number and adaptive time stepping.	5
	Total	**39**

Text Books:

1. Numerical Methods for Engineers, 7th Edition, S.C. Chapra and R.P. Canale, McGraw-Hill Education, New York, NY, 2015.

Reference:

1. Numerical Methods for Engineers, 3rd Edition, S.K. Gupta, New Age International Publishers, New Delhi, India, 2015

DEPARTMENT CORE COURSE 4 (DC 4)

Course Name: Advanced Production Technologies
Course No. : PEC 504 **L-T-P: 3-0-0**

Course Objective:

1. Familiarize students with advanced well problem diagnosis and solutions
2. Predicting future reservoir performance from well performance data interpretation and analysis

Learning Outcome:

1. Understanding of advanced well systems and their application environments
2. Ability to compute the current and future optimized production from wells
3. Ability to diagnose well problems and apply solutions

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Introduction. Advanced well equipment and subsurface well completions	4
2.	Artificial lift equipment, horizontal and multilateral well completion systems.	5
3.	Formation damage, calculation of various skin factors such as perforation skin, partial completion skin, inclined well skin, and horizontal well skin.	5
4.	Details on various IPR, various models of horizontal well productivity index	5
5.	Details on various VLP (Poetmann and Carpenter, Hagedorn and Brown, Beggs & Brill etc.), multiphase flow and flow patterns, and modelling of liquid hold up.	5
6.	Pressure drop and tubing size optimization in horizontal, directional & vertical wells. Liquid loading problem and solution. Choke-performance relationships. Software applications in optimized production.	5
7.	Coupling of well models with reservoir models using material balance for future well performance	5
8.	Advanced diagnostic methods and solutions	5
	Total	**39**

Text Books:

1. Petroleum Production Systems, Economides et al., Prentice Hall, 2012.
2. Production Operations II, Thomas O. Allen and Alan P. Roberts, Pennwell, 2012

DEPARTMENT CORE COURSE 5 (DC 5)

Course Name: Petroleum Economics, Risk and Uncertainty Management
Course No. : PEC 505 **L-T-P: 3-0-0**

Course Objectives:

1. Economic analysis tools and techniques used in the upstream oil and gas business
2. Investment decision making in an uncertain environment

Learning Outcomes:

1. Ability to perform advanced economics analysis for the upstream oil and gas business
2. Evaluate and quantify different risk and uncertainties in oil and gas investment process
3. Ability to make the right investment decision in the presence of risk and risk mitigation

COURSE CONTENT

Unit No.	Topic	Contact Hours
1.	Introduction: nature of the oil and gas business, crude oil pricing and volatility, forward and futures contract for crudes, options and hedging, and inflation.	4
2.	Time value of money, FV and PV, loan amortization and amortization schedule, funds flow and compounding/discounting, cash flow diagram, and spreadsheet applications.	5
3.	CAPEX and OPEX, cost estimates, cost overrun, contingencies, transfer pricing, leasing, severance and ad valorem taxes, estimation bias, depreciation and depletion.	5
4.	International petroleum economics, types of contracts, concessionary versus production sharing contracts, fiscal terms and efficient fiscal regimes, and cost recovery ceiling.	5
5.	Profitability measures (e.g., Payback period, NPV, IRR, PI, UTC, GRR) and investment decision making, service and income-producing investments, and lease versus buy.	5
6..	Optimization and break-even analysis, sensitivity analysis, linear programming and resource assignment challenges.	5
7.	Decision making under certainty, uncertainty and risk, uncertainty in capital investment, decision analysis cycle, applications of decision analysis. Expected values and decision tree, EMV, EPI, and EOL.	5
8.	Value of information, perfect and imperfect information, designing decision trees, solving a decision tree, and risk profiles. Managing attitudes towards risk, expected utility theory, assessing the utility function, risk premium and risk aversion.	5
	Total	**39**

Text Books:

1. Mian, M.A. (2011), Project Economics and Decision Analysis Volume 1: Deterministic Models, 2nd Edition, PennWell Corporation, Tulsa, OK
2. Mian, M.A. (2011), Project Economics and Decision Analysis Volume 2: Probabilistic Models, 2nd Edition, PennWell Corporation, Tulsa, OK.

DEPARTMENT PRACTICAL 1 (DP 1)

Course Name: Reservoir Characterization
Course No. : PEC 506 **L-T-P: 0-0-3**

Any ten out of the following

1. Oil Well Model Optimization: Generation of IPR and VLP
2. Production Tubing Size Optimization
3. Gas Well Optimization: Generation of IPR and VLP
4. Designing of Water Injection Wells
5. Well-Test Data Interpretation for Pressure Build-up Tests
6. Well Test Data Interpretation for Pressure Drawdown Tests
7. Open Hole Log Interpretation
8. Generation of Phase Envelope for a Multiphase/Multicomponent Hydrocarbon Mixture
9. Assisted History Matching (ASHM) and Reservoir Performance Prediction Using Material Balance
10. Compositional Reservoir Simulation
11. Phase-Behaviour of Hydrocarbon Systems
12. Modelling and Optimization of CO_2 Flooding Processes.

SEMESTER II

DEPARTMENT CORE COURSE 6 (DC61)

Course Name: Petroleum Geomechanics & Hydraulic Fracturing
Course No. : PEC 509**8** **L-T-P: 3-0-0**

Course Objective:

1. Fundamentals of geomechanics including stress/strain relationships of rocks and failure criteria
2. Designing, evaluation and optimization of hydraulic fracturing operations

Learning Outcomes:

1. Ability to analyse and interpret poro-thermo-mechanical data of rocks and in-situ stresses
2. Ability to design a 2D fracture and fracture fluids from models, and evaluation of fracturing operations.

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Stress/strain in 2D & 3D, transformation in space, principal and deviatoric stresses and strains, introduction to thermo and poroelasticity.	4
2.	Theory of elasticity & inelasticity, constitutive relationships for rocks. Failure criterion for rocks and rock strengths.	5
3.	Effective stresses: in-situ stresses, measurement techniques for stresses and rock mechanical parameters, and stresses around a wellbore.	5
4.	2D fracture models: PKN and KGD fracture shapes, propagation, widths, lengths and net pressures for Newtonian & non-Newtonian fluids, fluid leak-off efficiency and surface pressures during fracturing. Review of fracture conductivity & equivalent skin factor of fractured vertical wells.	5
5.	Techniques of gathering the rock mechanical and in-situ stress data for modeling fracture propagation. Height migration (deviation from 2D model) and propagation issues.	5
6.	Pseudo-2D and 3D fracture model introduction, heat transfer models, fracture tip effects, and fracture tortuosity.	5
7.	Design of fracture fluids, rheology, and polymer induced damage, pressure drop during pumping volume requirements for both pad and slurry, proppant mixing and injection schedule, and final propped fracture width.	5
8.	Fracture evaluation using pressure diagnostics, well testing and other techniques. Parametric studies for fracture design optimization.	5
	Total	**39**

Text Books:

1. Petroleum Related Rock Mechanics – Drilling Operation and Well Design, Bernt S. Aadnoy & Reza Looyeh, Elsevier, 2019
2. Petroleum Related Rock Mechanics Volume 33, E. Fjaer et al., Elsevier, 1992

References:

1. Petroleum Production Systems, Economides et al., Prentice Hall, 2012
2. Recent Advances in Hydraulic Fracturing, SPE Reprint Series, 1990

DEPARTMENT CORE COURSE 72 (DC 7)

Course Name: Advanced Drilling Technology
Course No. : PEC 509 **L-T-P: 3-0-0**

Course Objectives:

1. Modern drilling technologies including horizontal and high-pressure, high-temperature drilling (HPHT) techniques
2. To apply and/or develop drilling simulators

Learning Outcomes:

1. Ability to predict of the drilling environment (pore and rock breakdown pressures)
2. Ability to design drill-strings, casing strings, well hydraulics, well control and drill bits
3. Ability to design bottom-hole pressure (BHP) for directional wells

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Drilling Integrity: formation pore pressures & prediction methods, formation breakdown & methods to estimate fracture gradient, and rock strength.	**4**
2.	Geo monitoring: geo steering and real-time measurements, and smart well drilling techniques. Drill String Design: design of stabilized string, bending moments, length of drill collars, drill pipe selection and design procedure.	**5**
3.	Casing design: conventional and conditional casing design, casing performance, failures & repair, casing stability and buckling.	**5**
4.	Drilling hydraulics: Rheological models, pipe, annular and jet hydraulics, hydrostatic pressure in liquid and gas wells, swabbing and surge impacts, and borehole cleaning mechanism.	**5**
5.	Well control: secondary control methods.	**5**
6.	Drill bits: rock failure mechanism, bit tooth wear and dullness mechanism, bit bearing and its failures, factors affecting penetration rate. Modeling and optimization of bit selection. Real-time data analysis for bit wear monitoring and prediction.	**5**
7.	High-pressure and high-temperature (HP/HT) drilling technology: application of drilling fluids in HP/HT, managed pressure drilling for HP/HT wells, casing and drill string for HP/HT wells, integrity risk and its surveillance in HP/HT wells.	**5**
8.	Directional drilling: well kick-off and trajectory control, well monitoring and bottom-hole assembly (BHA) modelling to detect doglegs. Horizontal and multilateral wells. Application/ development of drilling simulators.	**5**
	Total	**39**

Text Books:

1. Applied Drilling Engineering, Adam T. Bourgoyne Jr. et al., SPE Text Book Series, 1991
2. Drilling Engineering: A Complete Well Planning and Approach, Neal J. Adams, Pennwell, 1985.

References:

1. Well Control Problems Solutions, Neal J. Adams, Pennwell, 1980
2. Oil Well Drilling Engineering: Principles and Practice, H Rabia, Springer, 1986

DEPARTMENT ELECTIVE 1 (DE 1)

Course Name: Reservoir Simulation
Course No. : PED 501 **L-T-P: 3-0-0**

Course Objectives:

1. Reservoir performance prediction under different operating conditions and parametric sensitivity studies
2. Test the robustness of field development strategies

Learning Outcomes:

1. Ability to select the proper model for simulation study
2. Skills with data preparation, model calibration, interpretation of results and performance prediction

Unit No.	Topic	Contact Hours
1.	Overview: reservoir fluid and rock properties, conservation of mass and momentum - continuity equation, equation of motion, Darcy and non-Darcy flow, and single phase flow equation.	**4**
2.	Black oil reservoir simulation: well representation, numerical solution of single phase flow equation, and multiphase flow simulation.	**5**
3.	Modeling of hydrocarbon phase behavior: hydrocarbon phase behavior, equilibrium flash calculations, equation of state (EOS) models such as Peng-Robinson (PR) and Soave-Redlich-Kwong (SRK) EOS.	**5**
4.	Compositional simulator: compositional mass balance equations, numerical model and discretization, well model, IMPES and AIM formulation, and iterative solution schemes.	**5**
5.	Thermal simulation: conservation equation of flowing component, conservation equation for solid component, conservation equation of energy, thermal conductivity of rock, solution of linear and nonlinear equations, and IMPES and AIM formulation for thermal simulations.	**5**
6.	Unconventional reservoir simulation: formulation of dual porosity/dual permeability equations for matrix and fracture blocks, matrix-fracture interaction and transfer, multiple porosity model for shale reservoirs – multiple interacting continua (MINC) model, stimulated reservoir volume (SRV), and formulation of flow equations for CBM reservoirs (diffusive flow in matrix).	**5**
7.	History Matching (HM): data preparation, HM parameters, and evaluation of HM	**5**
8.	Future performance prediction: prediction process, sensitivity analyses, and validation of model predictions.	**5**
	Total	**39**

Text Books:

1. Basic Applied Reservoir Simulation, Ertekin, T., Abou-Kassem J. H. and King, G.R, SPE Textbook Series Volume 7, 2001.
2. Reservoir Simulation,Mattax, C.C. and Dalton R.L., SPE Monograph Volume 13, 1990

References:

1. Practical Reservoir Simulation, Carlson, M.R, PennWell, 2003.

DEPARTMENT ELECTIVE 2 (DE 2)

Course Name: Well Intervention, Workover and Stimulation Techniques
Course No. : PED 502 **L-T-P: 3-0-0**

Objectives:

1. Understanding of workover and stimulation operations.
2. Workover operation design and field application

Learning Outcomes:

1. Understand different oil and gas well problems and their workover solutions
2. Ability to select appropriate workover and stimulation techniques for improving well production

Course Content

Unit No.	Topic	Contact Hours
1.	Introduction to workover and well stimulation operations: challenges and solutions.	**4**
2.	Workover operations. Workover fluids, fluid loss and formation damage. Scraping, and well circulation.	**5**
3.	Water and gas shut-off and squeeze cementing. Handling of water and gas coning.	**5**
4.	Production packers and packer calculation, and well activation. Repair of wells, and paraffin and scale removal. Planning and evaluation of workover jobs. Corrosion, bacteria & scale control.	**5**
5.	Well treatment: acidizing of oil and gas wells. Hydro-perforation. Hydraulic fracturing. Stimulation designing, proppants and their placement. Thermal stimulation techniques.	**5**
6.	Surface equipment for stimulation and gravel pack jobs. Down-hole heaters. Horizontal well stimulation.	**5**
7.	Sand-control, screens, and gravel packs: design and installation.	**5**
8.	Well intervention: slickline/wireline operations and coil tubing operation.	**5**
	Total	**39**

Text Books:

1. Production Operations I, Thomas O. Allen and Alan P. Roberts, Pennwell, 2012
2. Workover Well Control, Neal J. Adams, Pennwell, 1981.

Reference:

1. Well Design, Drilling and Production, Craft et al., Prentice Hall, 1962.

OPEN ELECTIVE 1(OE 1)

Course Name: Fluid Flow through Porous Media
Course No. : PEO 501 **L-T-P: 3-0-0**

Course Objective:

1. Fundamental aspects of flow and transport processes in porous media
2. Preparing students for reservoir modelling concepts and applications

Learning Outcomes:

1. Able to write mass, momentum and energy conservation equations for flow in porous media
2. Develop skills in modelling single- and multiphase fluid flow in porous media
3. Understand fluid flow in rocks and its applications in reservoir engineering

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Introduction: Importance of studying fluid flow through porous medium, natural vs. synthetic porous media, differences in fluid flow phenomena in porous materials with those in channels/pipes/tubes, pore structure, homogeneous vs heterogeneous porous media, scale-dependence of heterogeneity, and fractals.	4
2.	Properties of Porous Media: porosity and permeability, bundle of capillary tube models of porous medium, porosity-permeability relationships, pore connectivity and parametric functions, data analysis and correlation methods of typical permeability data.	5
3.	Macroscopic transport in porous media: representative elementary volume (REV), volume averaging, applications of volume and surface averaging rules, tortuosity, and macroscopic transport by control volume analysis.	5
4.	Effective properties of porous media: effective medium, determination of effective properties through Monte-Carlo simulations, effective properties of anisotropic porous media, pore connectivity and disorder, introduction to percolation theory.	5
5.	Single-phase flow in porous media: flow potential, incompressible and compressible flow in porous media, Darcy's law and non-Darcy effects, mass, momentum and energy transport equations, Forchheimer's equation and determination of its parameters, and viscous dissipation in porous media flow.	5
6.	Gas transport in tight rocks: gas transport mechanisms through nanopores, flow regimes, Knudsen number and mean flow paths, slip flow, thermal effects, apparent gas permeability, single- and multicomponent gas flow, and effect of pore size distribution on gas transport through porous media.	5
7.	Multi-phase flow in porous media: wettability and threshold potential, capillary pressure and its estimation, capillary pressure function, permeability dependence of capillary pressure and Leverett scaling, relative permeability, steady-state and unsteady-state relative permeability measurements and data interpretation.	5
8.	Mass, momentum, and energy transport in porous Media: molecular diffusion, hydrodynamic dispersion, advective/convective flux functions, coupled transport equations, constitutive relationships, sources and sinks, phase transition and applications.	5
	Total	**39**

Text Book:

1. Civan, F.A, Porous Media Transport Phenomena, Wiley, 2011.
2. Dullien, F.A.L, Porous Media 2nd Edition, Fluid Transport and Pore Structure, Elsevier, 1991.

Reference:

1. Bear, J., Dynamics of Fluids in Porous Media, Dover, 1989

OPEN ELECTIVE 2 (OE 2)

Course Name: Flow Assurance
Course No. : PEO 502 **L-T-P: 3-0-0**

Course Objectives:

1. Understanding flow assurance challenges in hydrocarbon production
2. Diagnosis of flow assurance problems and possible solutions

Learning Outcomes:

1. Apply fluid hydraulics and fluid characterization for addressing flow assurance challenges.
2. Understand and apply advanced techniques for smooth flow operations

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Flow assurance: definition, flow assurance in project life cycle, flow assurance in offshore developments, role of flow assurance, fluid related issues, and pipeline/flowline/tubing design related issues.	4
2.	Application of fluid hydraulics and fluid characterization for addressing flow assurance problems, phase behavior, and operating regions for smooth operations (wax deposition, hydrate formation, and scaling).	5
3.	Flow assurance challenges for gas hydrates, thermodynamics and kinetics of gas hydrates formation and dissociation, prevention and remedies for hydrate formation and agglomeration.	5
4.	Modelling of hydrate formation/inhibition, industry practice: rules of thumb – for hydrate management.	5
5.	Wax and asphaltene as flow assurance problems, determination of wax appearance temperature, impact on production, wax and asphaltenes management, downhole deposition of wax and asphaltenes and their assessment, inhibition and remediation.	5
6.	Modelling and optimization of flow in onshore and offshore pipelines.	5
7.	Scale: mechanism of scale formation, common scaling minerals, scale mitigation and remediation, and scale management.	5
8.	Corrosion : pipeline corrosion examples, corrosion predictions, reducing corrosion, and corrosion monitoring.	5
	Total	**39**

Text Books:

1. Applied Multiphase Flow in Pipes and Flow Assurance: Oil and Gas Production, Elsa M. Al-Safran and James P. Brill, SPE Text Book Series, 2017.
2. Flow Assurance Solids in Oil and Gas Production, Jon Steinar Gudmundsson, CRC Press, 2017.

Reference:

1. Natural Gas Hydrates, John Carroll, Elsevier, 2014

OPEN ELECTIVE 3 (OE 3)

Course Name: Unconventional Hydrocarbon Resources
Course No. : PEO 503 **L-T-P: 3-0-0**

Course Objectives:

1. Introducing students to newer hydrocarbon resources including coalbed methane, methane hydrates, and shale oil/gas
2. Teaching exploitation strategies for these emerging energy resources

Learning Outcomes:

1. Familiar with newer resources for fossil fuel
2. Exposure to contemporary energy recovery processes

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Introduction to unconventional hydrocarbon resources - global and Indian scenarios.	4
2.	Coalbed methane: formation and properties of coalbed methane, generation of coalbed methane and its properties, properties of coal as reservoir rock. Reserve estimation. Thermodynamics of coalbed methane and isotherm studies. Overview of drilling and production systems of coalbed methane wells.	5
3.	Hydro-fracturing of coal seams, treating and disposal of produced water. Testing of coalbed methane wells.	5
4.	Natural gas hydrates: formation, accumulation and properties of gas hydrates. Thermodynamics, kinetics and phase behavior of gas hydrates. Drilling and production systems for gas hydrate wells.	5
5.	Extraction technologies from gas hydrates. Uses and applications of gas hydrates.	5
6.	Shale gas and oil: nature, origin and distribution of shale gas and oil, and characterization of shale for production of shale gas and oil.	5
7.	Extraction methods of shale gas and oil: development of current practices, location and size of production areas. Estimated reserves and economics.	5
8.	Environmental issues in shale gas exploration, markets and global impact on energy scenario, and economic factors controlling shale gas and oil production.	5
	Total	**39**

Text Books:

1. Unconventional Oil and Gas Resources – Exploitation and Development, Y. Zee Ma and Stephen Holdich, CRC Press, 2016.
2. Advanced Reservoir and Production Engineering for Coalbed Methane, Pramod Thakur, Gulf Publishing, 2016.

Reference:

1. Natural Gas Hydrates, John Carroll, Elsevier, 2014

OPEN ELECTIVE 4 (OE 4)

Course Name: Health, Safety & Environment in Petroleum Industry
Course No. : PEO 504 **L-T-P: 3-0-0**

Course Objectives:

1. Introduction to operational and occupational hazards in oil and gas industry
2. Teaching safe practices and environmental sustainability

Learning Outcomes:

1. Safety code of conduct in oil and gas operations
2. Environmental impact assessment and mitigation

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Introduction to health, safety and environmental (HSE) management terms and definitions, importance of HSE management, and HSE performance.	4
2.	HSE regulations and regulatory agencies for oil and gas industry.	5
3.	Environmental issues and management.	5
4.	Air pollution - stack emissions, flaring and fugitive release.	5
5.	Water pollution and wastewater management, and produced water management.	5
6.	Oil spill management.	5
7.	Waste management: drilling waste, rock cutting, oily sludge and others. Environmental management, monitoring, and impact assessment	5
8.	Occupational health and safety management, risk assessment and management: qualitative and quantitative assessments.	5
	Total	**39**

Text Books:

1. Environmental Technology in the Oil Industry by Orszulik, Stefan, Springer, 2007
2. Fire Protection Manual for Hydrocarbon Processing plants ,Charles H. Vervalin, Gulf Pub Co; 1984

Reference:

1. Response to Oil and Chemical Marine Pollution, D. Cormack, Applied Science Pubs, 1983

DEPARTMENT PRACTICAL 3 (DP 3)

Course Name: Petroleum Instrumentation and Measurements
Course No. : PEC 510 **L-T-P: 0-0-3**

Any ten out of the following

1. Study of water flooding and measurement of oil recovery
2. Measurement of interfacial tension between crude oil and water by spinning drop tensiometer
3. Wettability alteration study by surfactant solution.
4. Chemical analysis of oil by GC
5. Functional group analysis of oil by FTIR
6. Measurement of dynamic surface tension: Effect of temperature and salinity
7. Analysis of pressure drop for flow of oil/water through pipeline
8. Studies of pour point depression by pour point depressant
9. Pressure drop analysis of fracturing fluid at different proppant loading
10. Wettability studies using Amott Cell
11. Effect of surfactant on oil-water phase behaviour

SEMESTER IV

DEPARTMENT ELECTIVE 3 (DE 3)

Course Name: Enhanced Oil and Gas Recovery Methods
Course No. : PED 601 **L-T-P: 3-0-0**

Course Objectives:

1. Understanding of in-depth mechanisms of enhanced oil and gas recovery methods
2. Contemporary improved recovery methods including those from unconventional reservoirs

Learning Outcomes:

1. Students will be competent in working on enhanced oil and gas recovery projects
2. Competence in understanding production methods from unconventional reservoirs

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1.	Principles of enhanced oil and gas recovery methods. IOR, EOR& EGR. Screening criteria for EOR methods.	4
2.	Displacement of fluids in reservoir: capillary force; viscous force; phase trapping; mobilization of trapped phases, and alteration of viscous/capillary force ratio.	5
3.	Design aspects of chemical flooding. Case studies of surfactant, alkali, polymer, ASP flooding. WAG process, SWAG process, and Chemical augmented WAG process. Foam flooding.	5
4.	Miscible displacement performance modeling, design procedure and field experiences, CO_2 miscible and immiscible flooding, carbonated water flooding and its design and case studies.	5
5.	Designing of thermal EOR methods. Optimization of operation parameters of in-situ combustion. Thermodynamics of thermal EOR.	5
6.	Nanotechnology in EOR: nanoparticle, nanoemulsion, nano-surfactant and nano-polymer processes.	5
7.	Advanced recovery methods: CBM, shale gas, shale oil, tight sand, oil sand and others.	5
8.	Molecular dynamics simulation approach for EOR. Technical and economic feasibility studies.	5
	Total	**39**

Text Books:

1. Enhanced Oil Recovery, Don W. Green and G. Paul Willhite, SPE Text Book Series, 1998.
2. Fundamentals of Enhanced Oil Recovery, Lake et al., SPE Text Book Series, 2014.

Reference:

1. Enhanced Oil Recovery: Field Planning and Development Strategies, Vladimir Alvarado and Eduardo Manrique, Gulf Publishing, 2010.

DEPARTMENT ELECTIVE 4 (DE 4)

Course Name: Profile Modification and Water Shut-Off
Course No. : PED 602 **L-T-P: 3-0-0**

Course Objectives:

1. Understanding the key aspects of water production problem in oil fields.
2. Techniques to control and mitigate water production problems during production

Learning Outcomes:

1. Ability to learn the root causes of excessive water production in the oilfields
2. Develop skills for the proper diagnosis of different sources of water production in the oilfields
3. Selection of proper methods to prevent water production in the oilfields

Course Content

Unit No.	Topic	Contact Hours
1.	Overview of reservoir conformance problems, reservoir conformance control techniques: profile modification and water shut off.	4
2	Diagnosis of water production problems**:** production logging techniques, use of tracers, production history plots.	5
3.	Mechanical methods of well bore and near well bore water shut off technologies: application of cement squeezes (foamed and acid resistant cements), and zonal isolation with packers.	5
4.	Improving conformance by profile modification/vertical permeability modification: permeability-reducing materials for improving conformance, and types of permeability reducing conformance improvement treatments.	5
5.	Water control in production well: polymer gel placement around the well bore, relative permeability modifiers, and organic and inorganic gels.	5
6.	Selection of candidate wells: selection criteria for profile modification and water shut off job, and selection criteria for injection wells and production wells.	5
7.	Designing gel job for oil field application: chemistry of different types of gelling systems, factors affecting gel slug design, gel volume treatment, and execution of gel job.	5
8.	Selected field-application: examples of conformance improvement techniques.	5
	Total	**39**

Text Books:

1. Well Production Practical Handbook, Henri Cholet, Technips Edition, 2008
2. Reservoir Conformance Improvement by Robert D. Sydansk and Laura Romero-Zerón, SPE Text Book Series, 2011.

OPEN ELECTIVE 5 (OE 5)

Course Name: Oil & Gas Processing Plant Design
Course No. : PEO 601 **L-T-P: 3-0-0**

Course Objectives:

1. Understanding of oil & gas processing operation and equipment.
2. Design and optimization of different oil and gas field operations.

Learning Outcomes:

1. Students will learn different surface operations carried out in the field.
2. Understand and apply optimization techniques for smooth operations.

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1	Oil desalting: operation, variables, and heater treater design.	4
2	Crude & condensate stabilization: LTX stabilization.	5
3	Oil & gas treatment : oil desalter, emulsion treatment theory and practice, emulsifiers & demulsifiers, gravity separation, coalescence, coalescing media, and electrostatic coalescers.	5
4	Treating equipment: pressure vessels - vertical, horizontal, and electrostatic. Process heat duty, sensible heat of natural gas, water, heat transfer from fire-tube. Heat exchangers-types, fluid placement, sizing, and number of tubes.	5
5	Natural gas dehydration: (a) glycol process: operation, effect of variables, dew point depression, and stage calculations. NTU - graphical and analytical methods, absorber sizing, and lean oil absorption.	5
6	Natural gas dehydration (b) solid-bed processes: design & operation, effect of process variables, regeneration and cooling calculations. Hydrocarbon recovery.	5
7	Natural gas sweetening: acid gases, toxicity, pipeline specification. Solid-bed processes: design, operation & effect of variables.	5
8	Natural gas sweetening: adsorbent selection. Multistage separation, Hengsteback's flash calculation, stabilizer design. Amine and other absorptive process details.	5
	Total	**39**

Text Books:

1. Surface Production Operations, Volumes 1&2, Maurice Stewart and Ken Arnold, Elsevier,2007
2. Technology of Artificial Lift Methods, Kermit E. Brown, PennWell Books,1980

OPEN ELECTIVE 6 (OE 6)

Course Name: Carbon Capture, Utilization and Sequestration
Course No. : PEO 602 **L-T-P: 3-0-0**

Course Objectives:

1. The need for carbon capture and sequestration, different methods, application in Hydrocarbon industry
2. Modelling and implementation CO_2 sequestration project

Learning Outcomes:

1. Student will learn the in-depth mechanism of possible CO_2 sequestration methods
2. Different aspect of CO_2 sequestration implementation in EOR projects

COURSE CONTENT:

Unit No.	Topic	Contact Hours
1	Introduction: scope, objectives and necessity of CCUS.	4
2	The contribution of fossil fuels emission to climate change and global warming. concept of carbon credit and carbon footprint.	5
3	Carbon capture techniques: CO_2 emission, scrubbing of CO_2, CO_2 re-cycling.	5
4	CO_2 sequestration: underground storage, potential for geologic storage, and applications in oil and gas industry.	5
5	CO_2 flooding projects and methane recovery projects.	5
6	Strategy for implementing CCUS technologies.	5
7	Modeling of cost and performance of CCUS plants.	5
8	Role and function of IPCC.	5
	Total	**39**

Text Books:

1. Introduction to Carbon Capture and Sequestration, Berend Smit, Imperial college press, 2014
2. Carbon Capture and Storage, Stephen A. Rackley, Elsevier,2017