COURSE STRUCTURE and SYLLABUS

OF

2 YEAR M.Tech. PETROLEUM ENGINEERING

(Approved by 9th Senate On 08.07.2019)

TO BE IMPLEMENTED FROM SESSION

(2019 – 2020)

DEPARTMENT OF PETROLEUM ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY

(INDIAN SCHOOL OF MINES)

DHANBAD 826004

Semester I

Course Desgn	Course No.	Course Name	L	T	P	C
DC2	**PEC503**	Numerical Methods for Petroleum Engineers	3	0	0	9
DC3	**PEC501**	Formation Evaluation and Production Logging	3	0	0	9
DC4	**PEC504**	Advanced Production Technologies	3	0	0	9
DC5	**PEC502**	Advanced Well Testing	3	0	0	9
DC6	**PEC505**	Petroleum Economics, Risk and Uncertainty Management	3	0	0	9
	Practical Courses					
DP1	**PEC506**	Reservoir Characterization	0	0	3	3
DP2	**PEC507**	Term paper/Mini Project	0	0	2	2
				Total Credits		**50**

Semester II

Course Desgn	Course No.	Course Name	L	T	P	C
	Core Courses					
DC7	**PEC508**	Petroleum Geomechanics and Hydraulic Fracturing	3	0	0	9
DC8	**PEC509**	Advanced Drilling Technology	3	0	0	9
	Departmental Elective (DE): Select Any One					
DE1	**PED501**	Reservoir Simulation	3	0	0	9
	PED502	Well Intervention, Workover and Stimulation Techniques	3	0	0	9
	Open Electives (OE): Select Any Two					
OE1	**PEO501**	Fluid Flow Through Porous Media	3	0	0	9
	PEO502	Flow Assurance	3	0	0	9
OE2	**PEO503**	Unconventional Hydrocarbon Resources	3	0	0	9
	PEO504	Health, Safety & Environment in Petroleum Industry	3	0	0	9
	Practical Courses					
DP3	**PEC510**	Petroleum Instrumentation and Measurements	0	0	3	3
DP4	**PEC511**	Development of Working Models	0	0	2	2
				Total Credits		**50**

Semester III

Desgn	Course No.	Course Name	L	T	P	C
DC9	**PEC597**	Thesis Unit 1	0	0	0	9
DC10	**PEC597**	Thesis Unit 2	0	0	0	9
DC11	**PEC597**	Thesis Unit 3	0	0	0	9
DC12	**PEC597**	Thesis Unit 4	0	0	0	9
					Total Credits	**36**

Semester IV

Desgn	Course No.	Course Name	L	T	P	C
DC13	**PEC598**	Thesis Unit 5	0	0	0	9
DC14	**PEC598**	Thesis Unit 6	0	0	0	9
	Department Electives (DE): (Select Any One)					
DE2	**PED 503**	Enhanced Oil and Gas Recovery Methods	3	0	0	9
	PED 504	Profile Modification and Water Shut-Off	3	0	0	9
	Open Electives (OE): (Select Any One)					
OE3	**PEO 505**	Oil & Gas Processing Plant Design	3	0	0	9
	PEO 506	Carbon Capture, Utilization and Sequestration	3	0	0	9
					Total Credits	**36**

SEMESTER I

DEPARTMENT CORE COURSE 1 (DC 1)

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PEC 501**	**Formation Evaluation and Production Logging**	3	0	0	9

Course Objective
The objective of the course is to provide the applied knowledge of production and cased-hole logging methods and interpretation techniques for determination of reservoir properties and production evaluation.
Learning Outcomes
Upon successful completion of this course, students will: • have understanding the principle of different cased hole logging and application • be able to understand monitoring of reservoir production &problem identification using production log data • be able to use well log to evaluation formation; porosity, permeability & residual oil saturation calculation

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Temperature logging: theory, measurement, interpretation and detection of hydraulic fracture	4	It gives an idea about temperature measurement and its use in different application
2	Radioactive tracer logging: introduction, tracer and velocity-shot log, and two pulse tracer logging. Spinner flow meter logging: introduction, theory and spinner log interpretation	5	The measurement of fluid flow inside the well bore and application to solve different problem will be explained to students with the help of different production logging method.
3	Single-phase flow profiling by compression of temperature, radioactive tracer and spinner flow meter logs. Production logging in multiphase flow: operational procedures, fluid Identification log and its qualitative and quantatative interpretation	5	Advanced multiphase flow measurement and data interpretation to model the well bore production will be understood by students.
4	Production logging and layered system with reference to reservoir engineers' application of production logging. Production logging in horizontal wells	5	Use of production logging tool in different specific condition will be explained to students
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	Student will be able to measure the saturation of fluid behind the casing in producing well with the help of different logging methods.
6	Inelastic gamma ray logging: carbon-oxygen log, cased-hole wireline formation tester.	5	Student will learn about new methods in cased hole logging and can interpretate these logs to characterize a number of reservoir properties.
7	Downhole casing inspection tools and fluid movement: noise logging & pulse neutron logging and application.	5	Student will be able to analyse the sound measurement and their interpretation in terms of fluid flow.
8	New logging techniques, permeability evaluation from well logs data.	5	Student will be able to calculate the permeability from well logs by applying different interpretation techniques

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

Course Type	Course Code	Name of Course	L	T	P	Credit
EC	PEC 502	**Advanced Well Testing**	3	0	0	9

Course Objective
The objective of the course is to provide the applied knowledge of well testing techniques for reservoir characterization
Learning Outcomes
Upon successful completion of this course, students will: • be able to interpret the data gathered through production and well testing and characterize the reservoir with proper integration of data. • be able to understand different interpretation methodology of various types of well testing

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Background of Transient Pressure Analysis:** Radial Flow Theory, Infinite Acting Radial flow- Ei function solution, Principal of superposition, Radius of Investigation, Wellbore Storage effects, Pressure Drawdown Testing, Pressure Build-up Testing	4	Understanding of fluid flow through porous media. It provides idea of the different well test techniques for oil reservoirs.
2	**Pressure Transient Testing for Gas Wells:** Concept of pseudo-pressure and adjusted pressure, pseudo-time and adjusted time, Gas Well Drawdown test – semilog analysis, log log analysis, Gas well build-up test – semilog analysis, log log analysis,	5	This unit will help student in understanding the behavior of pressure response in gas well testing.
3	**Diagnostic Plots for Vertical Wells:** Radial flow – Vertical well IARF, hemi-radial flow, vertical well between intersecting faults, and radial composite reservoir.	5	This will help students to learn how to diagnose the flow regimes in reservoir and characterize the reservoir in terms of heterogeneity and boundary effects.
4	**Horizontal wells:** early radial flow, hemi-radial flow and pseudo radial flow	5	This will help students to learn how to diagnose the flow regimes in reservoir and characterize the reservoir in terms of heterogeneity and boundary effects.
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	This will help students to learn how to diagnose the flow regimes in reservoir and characterize the reservoir in terms of heterogeneity and boundary effects.
6	**Bounded Reservoir behaviour:** Closed boundary, linear boundary – no-flow and constant pressure boundary, Circular boundary – closed and constant pressure boundary, Multiple linear boundaries,	5	This will help student in developing the knowledge with the ways to interpret geological boundary effects.
7	**Wellbore phenomena:** Constant wellbore storage, variable wellbore storage, Gas phase redistribution, well clean-up and changing skin, Type curve matching	5	Students will learn about the behavior of pressure response during early time period of a well test.
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, validation of result	5	Students will learn the workflow and steps to interpret a well test.
	Total contact hours:	**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

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PEC503**	**Numerical Methods for Petroleum Engineers**	3	0	0	9

Course Objective
• Advanced numerical techniques for petroleum engineering applications. • To prepare students for advanced courses in reservoir modelling and simulation
Learning Outcomes
Upon successful completion of this course, students will: • Able to numerically solve linear and non-linear algebraic equations, ODEs and PDEs • Apply the knowledge for solving complex reservoir simulation problems.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
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	To learn about the concept and applicability of numerical methods in petroleum engineering and the programming tools that can be used to carry out numerical analysis.
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	To know about the numerical differentiation, integration of functions, regression analysis and curve-fitting
3.	Linear Algebra: vectors, matrices, system of linear equations; direct and iterative methods.	5	To know about the vectors and tensors, and their applications in petroleum Engineering problems
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	To find the principle of finding the roots of non-linear equations, local and global minimum/maximum and best fitted polynomial
5.	Numerical solution of ODEs and applications; numerical solution of system of ODEs. Numerical inversion of Laplace transforms functions.	5	To know the principles of solving system of ODEs and numerical inversion of Laplace transformations
6.	Numerical solution of elliptic PDEs (e.g., steady-state heat conduction equation) in 2D and 3D using finite difference.	5	To know the principles of finite difference technique and solve the steady state heat conduction.
7.	Finite element and finite volume methods.	5	To know the principles of Finite element and finite volume methods
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	To solve linear and non-linear diffusion equations for reservoir simulation numerically.
	Total contact hours:	**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 Books:

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

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PEC 504**	**Advanced Production Technologies**	3	0	0	9

Course Objective
The objective of the course is to familiarize the students with well problem diagnosis and solutions and to predict reservoir performance from well performance data.
Learning Outcomes
Upon successful completion of this course, students will: • Have the ability to diagnose well problems and apply solutions • Have the ability to compute the current and future optimized production from wells • Understand advance well systems and their application environment

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Introduction: Advanced well equipment and subsurface well completions	4	Knowledge of advanced well equipment and subsurface well completions.
2.	Artificial lift equipment, horizontal and multilateral well completion systems.	5	Knowledge of various lift methods, horizontal and multilateral well completion systems.
3.	Formation damage, calculation of various skin factors such as perforation skin, partial completion skin, inclined well skin, and horizontal well skin.	5	Knowledge of various skin factors in wells due to drilling and various completion methods.
4.	Details on various IPR, various models of horizontal well productivity index	5	Knowledge of various IPR correlations applicable to vertical and horizontal wells.
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.	Knowledge of various VLP correlations for vertical and horizontal wells.
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	Ability to design an optimum production system that includes the major components of the production system.
7.	Coupling of well models with reservoir models using material balance for future well performance	5	Ability to forecast the future well performance using both well models and reservoir models with material balance.
8.	Advanced diagnostic methods and solutions	5	Knowledge of various production problems, their diagnostic techniques and solutions.
	Total contact hours:	**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

Reference Books:

1. Artificial Lift Methods, Kermit Brown, Pennwell

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PEC 505**	**Petroleum Economics, Risk and Uncertainty Management**	3	0	0	9

Course Objective
The objective of the course is to provide the concept of economic analysis tools and techniques used in the upstream oil and gas business and also investment decision making in an uncertain environment.
Learning Outcomes
Upon successful completion of this course, students will have the: • Ability to perform advanced economics analysis for the upstream oil and gas business • Evaluate and quantify different risk and uncertainties in oil and gas investment process • Ability to make the right investment decision in the presence of risk and risk mitigation

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
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	Knowledge about oil and gas business, how the oil pricing and its volatility determined. It also helps to understand about different forward and future contract for crudes, hedging and inflation.
2	Time value of money, FV and PV, loan amortization and amortization schedule, funds flow and compounding/discounting, cash flow diagram, and spread sheet applications.	5	Knowledge about concept of Time value of money, FV and PV, loan amortization and amortization
3	CAPEX and OPEX, cost estimates, cost overrun, contingencies, transfer pricing, leasing, severance and ad valorem taxes, estimation bias, depreciation and depletion.	5	Knowledge about CAPEX and OPEX, cost estimates, cost overrun, contingencies, transfer pricing, leasing, severance and ad valorem taxes, estimation bias, depreciation and depletion
4	International petroleum economics, types of contracts, concessionary versus production sharing contracts, fiscal terms and efficient fiscal regimes, and cost recovery ceiling.	5	This unit will help student to understand about petroleum economics, different contracts, fiscal terms and regimes.
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	Knowledge about profitability measures in terms of payback period, NPV, IRR, PI, UTC, and GRR, as well as investment decision making, service and income-producing investments, and lease versus buy.
6	Optimization and break-even analysis, sensitivity analysis, linear programming and resource assignment challenges.	5	Knowledge understand about different analysis (Optimization and break-even analysis, sensitivity analysis, linear programming, etc.) concept in economics
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, EOL.	5	Knowledge of uncertainty concept in economics.
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	Knowledge the concept of risk in economics.
	Total contact hours:	**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**

Course Objective
The objective of the course is to develop knowledge on Reservoir simulation
Learning Outcomes
Upon successful completion of this course, students will: • Have the ability to work on simulation of projects related to oil and gas industry • Have to work individually on optimization of process

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.

PEC 507	Term paper/Mini Project	0	0	2	2

Course Objective

The objective of the course is to develop knowledge on design aspects, planning of projects related to petroleum Industry

Learning Outcomes

Upon successful completion of this course, students will:

- Have the ability to analyze the system design of different projects
- Have to work individually on different projects related to oil and gas industry.

SEMESTER II

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PEC 508**	**Petroleum Geomechanics & Hydraulic Fracturing**	3	0	0	9

Course Objective
The objective of the course is to provide the fundamentals of geomechanics including stress/strain relationships of rocks and failure criteria which goes into designing, evaluating and optimizing hydraulic fracturing operations.
Learning Outcomes
Upon successful completion of this course, students will: • Have the ability to analyze in-situ stresses, and the effects of poro-thermo-mechanical data of rocks. • Have the ability to design a 2D fracture from models, and to evaluate the fracture productivity.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Stress/strain in 2D & 3D, transformation in space, principal and deviatoric stresses and strains, introduction to thermo and poroelasticity.	4	Knowledge of stress and strain in a body in 2D and 3D, principal stresses and the effect of pressure and temperature on stress.
2	Theory of elasticity & inelasticity, constitutive relationships for rocks. Failure criterion for rocks and rock strengths.	5	Knowledge of theory of elasticity and its application to rocks. Ability to predict the failure in rocks based on the failure criterion and the theory of elasticity.
3	Effective stresses: in-situ stresses, measurement techniques for stresses and rock mechanical parameters, and stresses around a wellbore.	5	Knowledge of stresses in-situ, their measurement techniques and mechanical properties. Ability to calculate stress around wellbores.
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	Knowledge of PKN and KGD fracture propagation models. Knowledge of productivity of a fractured well.
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	Ability to gather mechanical and stress data to model fracture propagation for fracture treatment design.
6	Pseudo-2D and 3D fracture model introduction, heat transfer models, fracture tip effects, and fracture tortuosity.	5	Basic knowledge of pseudo-2D and 3D fracture propagation models and other special propagation effects.
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.	4	Basic knowledge on effect of fracturing fluid rheology on fracture treatments. Design of pumping schedule during fracture propagation.
8	Fracture evaluation using pressure diagnostics, well testing and other techniques. Parametric studies for fracture design optimization.	5	Knowledge of fracture conductivity evaluation using well testing and other methods.
	Total contact hours:	**39**	

Text Books:

1. Petroleum 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

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PEC 509**	**Advanced Drilling Technology**	3	0	0	9

Course Objective
Modern drilling technologies including horizontal and high-pressure, high-temperature drilling (HPHT) techniques To apply and/or develop drilling simulators
Learning Outcomes
Upon successful completion of this course, students will: Ability to predict of the drilling environment (pore and rock breakdown pressures) Ability to design drill-strings, casing strings, well hydraulics, well control and drill bits Ability to design bottom-hole pressure (BHP) for directional wells

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Drilling Integrity: formation pore pressures & prediction methods, formation breakdown & methods to estimate fracture gradient, and rock strength.	**4**	Understanding of Formation Pressure and its role in drilling.
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**	This unit will help student in understanding the role of geo-steering and design od drill string.
3	Casing design: conventional and conditional casing design, casing performance, failures & repair, casing stability and buckling.	**5**	This will help is designing of casing as per field conditions.
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**	Proper utilization of hydraulic balance in drilling and combat the bore hole problems.
5	Well control: secondary control methods.	**5**	To understand the proper well control techniques.
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**	This will help student to be familiar with the bit technology and the monitoring the drilling.
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**	To know all about the high pressure and high temperature environment and its impact during the drilling.
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**	Help in understanding the details of directional drilling and the proper monitoring of the wells to avoid the unwanted deflections.
	Total contact hours:	**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
1. Raghu Ramkrishnan and Johannes Gehrke, “Database Management Systems”, TMH.

DEPARTMENT ELECTIVE 1 (DE 1)

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	PED 501	**Reservoir Simulation**	3	0	0	9

Course Objective
Fundamentals aspects of reservoir simulation in different enhanced oil/gas recovery processes.
Learning Outcomes
Upon successful completion of this course, students will have: • Understanding of different simulation models, their theoretical aspects necessary to use in developing algorithms, software for their future research uses.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
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	Understanding properties of reservoir rock and fluid, flow equations require in recovery simulation of reservoir fluid.
2	**Black oil reservoir simulation:** well representation, numerical solution of single phase flow equation, and multiphase flow simulation.	5	Conducting recovery simulation of reservoir fluid by a simple representation of reservoir rock and fluid.
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	Application of cubic EOS and its use in developing EOS model
4	**Compositional simulator:** compositional mass balance equations, numerical model and discretization, well model, IMPES and AIM formulation, and iterative solution schemes.	5	Understanding of theoretical aspects of compositional simulation
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	Understanding of theoretical aspects of thermal simulation
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	Understanding of theoretical aspects of recovery simulation for unconventional sources of hydrocarbons.
7	**History Matching (HM):** data preparation, HM parameters, and evaluation of HM	5	Understanding of the approaches used to enhance the reliability of simulation models.
8	**Future Performance Prediction:** prediction process, sensitivity analyses, and validation of model predictions.	5	Understanding of points to be taken care of while analyzing the future recovery predictions.
	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

Reference:

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

DEPARTMENT ELECTIVE 2 (DE 2)

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PED 502**	**Well Intervention, Workover and Stimulation Techniques**	3	0	0	9

Course Objective
1. Understanding of workover and stimulation operations. 2. Workover operation design and field application
Learning Outcomes
Upon successful completion of this course, students will: • Understand different oil and gas well problems and their workover solutions • Understand how to select appropriate workover and stimulation techniques for improving well production

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to workover and well stimulation operations: challenges and solutions.	4	Understanding of post-completion enhancement of both reservoir and well.
2	Workover operations. Workover fluids, fluid loss and formation damage. Scraping, and well circulation.	5	This unit will help the student to understand the challenges encountered during workover operations and their mitigation.
3	Water and gas shut-off and squeeze cementing. Handling of water and gas coning.	5	The aim behind this unit is to provide a general description of identifying the unwanted water and gas production sources and the common practices for water and gas shutoff
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	This unit will help the students to understand that how packers work, what are the setting mechanism and forces acting on it. This unit also helps the students to know about different problems arising during production and their mitigations.
5	Well treatment: acidizing of oil and gas wells. Hydro-perforation. Hydraulic fracturing. Stimulation designing, proppants and their placement. Thermal stimulation techniques	5	Students should be able to understand how to select stimulation techniques best suited for various formation types and situations.
6	Surface equipment for stimulation and gravel pack jobs. Down-hole heaters. Horizontal well stimulation.	5	Students will able to learn about different surface equipments that are needed during well stimulation and gravel pack job and functions of each equipment.
7	Sand-control, screens, and gravel packs: design and installation.	5	Provide Students with the knowledge, understanding and tools required to design, implement and manage sand control completions.
8	Well intervention: slickline/wireline operations and coil tubing operation.	5	Students will get up-to-date knowledge on wireline equipment, techniques and operations during well completion, servicing, work over and production.
	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 Type	Course Code	Name of Course	L	T	P	Credit
OE	PEO 501	Fluid Flow through Porous Media	3	0	0	9

Course Objective
• Fundamental aspects of flow and transport processes in porous media • Preparing students for reservoir modelling concepts and applications
Learning Outcomes
Upon successful completion of this course, students will: • Able to write mass, momentum and energy conservation equations for flow in porous media • Develop skills in modelling single- and multiphase fluid flow in porous media • Understand fluid flow in rocks and its applications in reservoir engineering

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
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	To learn about the concept and applicability of flow through porous media, particularly in in petroleum reservoir.
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	To know about the fundamental properties of reservoir rock estimation methodology.
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	To know about the macroscopic transport phenomena in porous media
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	To determine the effective properties of porous media, anisotropy and pore connectivity.
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	To know about the various transport equations for the flow of single phase incompressible and slightly compressible fluid through porous media
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	To know about the various transport equations for the flow of single and multicomponent gas flow through porous media
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	To know about the various transport equations for the flow of multi-phase flow through porous media

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	The applications of porous media transport equations for reservoir engineering problems.
	Total contact hours:	**39**	

Text Books:

2. Porous Media Transport Phenomena — Civan, F.A, Wiley, 2011
3. Porous Media: Fluid Transport and Pore Structure — Dullien, F.A.L, 2^{nd} Edition, Elsevier, 1991
4. Flow of Fluids Through Porous materials — Collins, R.E., Reinhold Publishing Corporation , NY, 1961

Reference Books:

1. Dynamics of Fluids in Porous Media — Bear, J., Dover, 1988

OPEN ELECTIVE 2 (OE 2)

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	**PEO 502**	**Flow Assurance**	3	0	0	9

Course Objective
• Understanding flow assurance challenges in hydrocarbon production • Diagnosis of flow assurance problems and possible solutions
Learning Outcomes
Upon successful completion of this course, students will: • Apply fluid hydraulics and fluid characterization for addressing flow assurance challenges. • Understand and apply advanced techniques for smooth flow operations

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
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	Primary knowledge about flow assurance. Learn about role of Flow assurance in Oil and Gas production related Project in different aspects
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	Get idea about the suitable range of Temperature, pressure and other operating variables to avoid flow assurance problems
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	Knowledge on the influential parameters and its range for hydrate formation and dissociate. Know about the preventive measures to prevent hydrate formation and agglomeration
4	Modelling of hydrate formation/inhibition, industry practice: rules of thumb – for hydrate management.	5	Deep knowledge to handle hydrate management. Gain knowledge about the method of handling hydrate in industry in wider range of operating conditions
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	Knowledge on role and impact of wax and Ashphaltenes on the flow assurance problem. Aspects Wax and Ashphaltene management and their differences. Inhibition and remediation methods to handle wax and asphaltenes deposition and their differences.
6	Modelling and optimization of flow in onshore and offshore pipelines.	5	How to model and design flow in onshore and offshore considering all impacts of flow assurance problems. How to optimize the flow to get economic production in offshore and onshore.
7	Scale: mechanism of scale formation, common scaling minerals, scale mitigation and remediation, and scale management.	5	Knowledge of scale depositional problems in oil fields. Its impact on production and reservoir management. Scale prevention, remediation and management
8	Corrosion : pipeline corrosion examples, corrosion predictions, reducing corrosion, and corrosion monitoring.	5	Knowledge of corrosion problems in oil and gas fields and its prediction. Impact on production. Corrosion inhibition, remediation and management. How to monitor corrosion and manage it
	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 Type	Course Code	Name of Course	L	T	P	Credit
OE	PEO 503	**Unconventional Hydrocarbon Resources**	3	0	0	9

Course Objective
• Introducing students to newer hydrocarbon resources including coalbed methane, gas hydrates, and shale oil/gas • Teaching exploitation strategies for these emerging energy resources
Learning Outcomes
• Familiar with newer resources for fossil fuel • Exposure to contemporary energy recovery processes

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to unconventional hydrocarbon resources - global and Indian scenarios.	4	Updating the share of unconventional resources in energy basket
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	students will know how the generation of CBM, identification of sweet spot, finding out volume of gas, and processes of exploitation of CBM
3	Hydro-fracturing of coal seams; Testing of coalbed methane wells; treating and disposal of produced water.	5	How to enhance CBM production through fracturing and assessment of reservoir properties and extent of reservoir. To understand, what to do with the huge volume of produced water.
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	Knowledge about (i) the gas hydrate formation and dissociation through thermodynamic point of view (ii) what are kinds of special precaution need to be taken during drilling and production compared to that of conventional hydrocarbon production
5	Extraction technologies from gas hydrates. Uses and applications of gas hydrates.	5	Overview about the special technologies adopted for gas hydrate exploitation and its application in transportation and energy consumptions.
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	Understanding about the shale as reservoir, its characteristics to restore oil/gas, finding sweet spot.
7	Extraction methods of shale gas and oil: development of current practices, location and size of production areas. Estimated reserves and economics.	5	Developing knowledge about the required characteristics and volume of oil/gas for economic production through available techniques
8	Environmental issues in shale gas exploration, markets and global impact on energy scenario, and economic factors controlling shale gas and oil production.	5	What are facts involved in productions and whether they cause environmental issues during production of shale oil/gas, with special emphasis on the HF job and its impact. Students shall have understanding whether gas from shale can change the energy scenario of country with example of USA shale gas production.
	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.
3. A Guide to Coalbed Methane (i) Operations & (ii) Reservoir Engineering: Gas Research Institute, Chicago, Illinois, U.S.A.
4. Natural Gas Hydrates, John Carroll, Elsevier, 2014

OPEN ELECTIVE 4 (OE 4)

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	**PEO 504**	**Health, Safety & Environment in Petroleum Industry**	3	0	0	9

Course Objective
• Introduction to operational and occupational hazards in oil and gas industry • Teaching safe practices and environmental sustainability
Learning Outcomes
• Safety code of conduct in oil and gas operations • Environmental impact assessment and mitigation

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to health, safety and environmental (HSE) management terms and definitions, importance of HSE management, and HSE performance.	4	Students will learn about how environment and biotic communities is affected by oil industry and possible mitigation.
2	HSE regulations and regulatory agencies for oil and gas industry.	5	Students will learn about legislations formulated from time to time, which are required to be complied with by the E&P operators before, during and after the completion of operations.
3	Environmental issues and management.	5	How to minimize that adverse impacts of oil and gas activity to the environment will be explained to the students.
4	Air pollution - stack emissions, flaring and fugitive release.	5	Students will learn about different harmful gases which releases during E&P activities and how to minimize that emissions.
5	Water pollution and wastewater management, and produced water management.	5	Students will learn about waste water management techniques which ultimately controls the problems of water pollution.
6	Oil spill management.	5	Student will learn about methods to mitigate offshore and onshore oil spill.
7	Waste management: drilling waste, rock cutting, oily sludge and others. Environmental management, monitoring, and impact assessment	5	Students will be able to understand the different process to decrease the toxicity of waste generated by oil and gas drilling and production activities.
8	Occupational health and safety management, risk assessment and management: qualitative and quantitative assessments.	5	We will teach to students the management to plan ahead, not necessarily to avoid the risk, but to be as prepared as possible should the risk become an issue.

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 (DP 3)

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

Course Objective
The objective of the course is to develop knowledge on different Instruments related to petroleum Industry
Learning Outcomes
Upon successful completion of this course, students will: • Able to run different instruments individually • Understand the knowledge of principle of different measurements.

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 Type	Course Code	Name of Course	L	T	P	Credit
DE	PED 503	**Enhanced Oil and Gas Recovery Methods**	3	0	0	9

Course Objective
• Understanding of in-depth mechanisms of enhanced oil and gas recovery methods • Contemporary improved recovery methods including those from unconventional reservoirs
Learning Outcomes
• Students will be competent in working on enhanced oil and gas recovery projects • Competence in understanding production methods from unconventional reservoirs

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Principles of enhanced oil and gas recovery methods. IOR, EOR& EGR. Screening criteria for EOR methods.	4	Why EOR is required. Potential of EOR. Evaluation of reservoir characteristics for suitable EOR.
2	Displacement of fluids in reservoir: capillary force; viscous force; phase trapping; mobilization of trapped phases, and alteration of viscous/capillary force ratio.	5	Knowledge of the fundamentals on various microscopic forces acting during oil recovery.
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	Knowledge of the fundamentals of chemical flooding, alkali and polymer flooding, with the emphasis on the phase behavior and IFT of the fluids and wettability alterations of the porous medium. Present status of chemical flooding and design aspects.
4	Miscible displacement performance modeling, design procedure and field experiences, CO2 miscible and immiscible flooding, carbonated water flooding and its design and case studies.	5	Knowledge of minimum miscibility pressure (MMP); Mechanisms of miscible flooding and design aspects.
5	Designing of thermal EOR methods. Optimization of operation parameters of in-situ combustion. Thermodynamics of thermal EOR.	5	Mechanisms of thermal EOR. Planning and implementation of different thermal methods.
6	Nanotechnology in EOR: nanoparticle, nanoemulsion, nano-surfactant and nano-polymer processes.	5	Advantages and efficiencies of different nanotechnology based EOR methods along with their mechanisms.
7	Advanced recovery methods: CBM, shale gas, shale oil, tight sand, oil sand and others.	5	EOR methods for unconventional oil and gas reservoirs.
8	Molecular dynamics simulation approach for EOR. Technical and economic feasibility studies.	5	Pore scale modeling of fluid flow through reservoir for different EOR methods.

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 Type	Course Code	Name of Course	L	T	P	Credit
DE	**PED 504**	**Profile Modification and Water Shut-Off**	3	0	0	9

Course Objective
The objective of this course is to provide an understanding of the key aspects of water production problem in oil fields and basic knowledge to control these problems & improve the oil recover
Learning Outcomes
Upon successful completion of this course, students will have the: • Ability to learn the root causes of excessive water production in the oilfields • Develop skills for the proper diagnosis of different sources of water production in the oilfields • Selection of proper methods to prevent water production in the oilfields

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Overview of reservoir conformance problems, reservoir conformance control techniques: profile modification and water shut off.	4	This will help students to understand the basic fundamentals of profile modification and water shut off.
2	Diagnosis of water production problems**:** production logging techniques, use of tracers, production history plots.	5	This will help student to learn about the diagnosis of water production problems in the oilfields
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	This will help students to learn about the mechanical methods for the control of water production problems in the oilfields
4.	Improving conformance by profile modification/vertical permeability modification: permeability-reducing materials for improving conformance, and types of permeability reducing conformance improvement treatments.	5	This will help students to learn about the chemical methods for the control of water production problems in the oilfields
5.	Water control in production well: polymer gel placement around the well bore, relative permeability modifiers, and organic and inorganic gels.	5	This will help students to learn about the water control in production wells using gel treatments
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	This will help students to learn about the selection criteria of wells for profile modification and water shut off
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	This will help student to learn about the designing of gel treatment jobs in the oilfields
8.	Selected field-application: examples of conformance improvement techniques.	5	This will help student to learn about the selected field application of conformance improvement technique

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 Type	Course Code	Name of Course	L	T	P	Credit
OE	**PEO505**	**Oil & Gas Processing Plant Design**	**3**	**0**	**0**	**9**

Course Objective

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

Learning Outcomes

Upon successful completion of this course, students will:

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

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Oil desalting: operation, variables, and heater treater design.	4	To learn about main oil & gas processing operations at the surface
2.	Crude & condensate stabilization: LTX stabilization.	5	To know about the oil and condensate stabilization.
3.	Oil & gas treatment: oil desalter, emulsion treatment theory and practice, emulsifiers & demulsifiers, gravity separation, coalescence, coalescing media, and electrostatic coalescers.	5	To know about oil and gas separation process, methodology, and equipment.
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	To know about the oil treating methods at surface, designing of equipment.
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	To understand the principle and process conditions of natural gas purification by dehydration using absorption and adsorption technique and process design
6.	Natural gas dehydration (b) solid-bed processes: design & operation, effect of process variables, regeneration and cooling calculations. Hydrocarbon recovery.	5	To understand the principle and process conditions of natural gas purification by dehydration using absorption and adsorption technique and process design
7.	Natural gas sweetening: acid gases, toxicity, pipeline specification. Solid-bed processes: design, operation & effect of variables.	5	To know the reasons of requirement of gas sweetening, impact of sour gases on process design and operation.
8	Natural gas sweetening: adsorbent selection. Multistage separation, Hengsteback's flash calculation, stabilizer design. Amine and other absorptive process details.	5	To understand the methods of gas sweetening.
	Total contact hours:	**39**	

Text Books:

1. Surface Productions Operations Volume 1 & 2 — Ken Arnold and Maurice Stewart

Reference Books:

1. Process Heat Transfer — D. Q. Kern
2. Unit Operations of Chemical Engineering — McCabe, Warren, Smith, Harriott.

OPEN ELECTIVE 6 (OE 6)

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	**PEO 506**	**Carbon Capture, Utilization and Sequestration**	**3**	**0**	**0**	**9**

Course Objective
• The need for carbon capture and sequestration, different methods, application in Hydrocarbon industry • Modeling and implementation CO2 sequestration project
Learning Outcomes
• Student will learn the in-depth mechanism of possible CO_2 sequestration methods • Different aspect of CO_2 sequestration implementation in EOR projects

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Introduction: scope, objectives and necessity of CCUS.	4	Why to go for CCUS and how to do?
2	The contribution of fossil fuels emission to climate change and global warming. Concept of carbon credit and carbon footprint.	5	Student shall understand how fossil fuels are responsible for climate change and its extent depending on the types of gas emission. They also shall gain the idea about carbon credit and its benefit.
3.	Carbon capture techniques: CO_2 emission, scrubbing of CO_2, CO_2 re-cycling.	5	Students should learn about the processes emitting CO2 and should be able to identify the suitable technology for remedy.
4.	CO_2 sequestration: underground storage, potential for geologic storage, and applications in oil and gas industry.	5	What are available options for geological carbon storage and how the technology could be used for enhancing the hydrocarbon recovery simultaneously at the time of sequestration
5.	CO_2 flooding projects and methane recovery projects.	5	Learning about the mechanism of CO2 injection for recovery the stored methane in Coalbed and oil from conventional reservoirs
6.	Strategy for implementing CCUS technologies.	5	Understanding about the policies taken by various industries and countries.
7.	Modeling of cost and performance of CCUS plants.	5	Cash flow performance involved in CCUS plant
8.	Role and function of IPCC.	5	Understanding about policies, Acts, rules and regulations of IPCC
	Total	**39**	

Reference Books:

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