INDIAN INSTITUTE OF PETROLEUM AND ENERGY
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B.TECH THIRD YEAR SYLLABUS PETROLEUM ENGINEERING 2021 Batch

5th SEMESTER

Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Industrial Psychology & Professional Ethics	2	0	0	2	
2	Advanced Reservoir Engineering	3	1	0	4	
3	Hydrocarbon Production Engineering II	3	1	0	4	
4	Advanced Drilling Technology	3	0	0	3	
5	Object Oriented Programming	2	0	3	4	
6	Drilling & Fracturing Lab	0	0	3	2	
7	Transport in Porous Media	3	0	0	3	
	Total	**16**	**2**	**6**	**22**	

6th SEMESTER

Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Oil and Gas Well Testing	3	0	0	3	
2	Offshore and Deep sea Technology	3	0	0	3	
3	Enhanced Oil Recovery	3	0	0	3	
4	Pipeline Engineering	3	0	0	3	
5	Elective I	3	0	0	3	
6	Economics	2	0	0	2	
7	Reservoir Engineering Lab	0	0	3	2	
8	Production Engineering Lab	0	0	3	2	
	Total	**17**	**0**	**6**	**21**	

5th SEMESTER

Course Type	Course Code	Name of Course	L	T	P	Credit
	BS 30001	Industrial psychology & Professional Ethics	2	0	0	2

Unit No.	Topics to be Covered
1.	Understanding human experience and behavior: Definition, schools, methods, branches and application of Psychology for Engineers. • Basic Psychological Processes: • Intelligence, Thinking, Attention, Learning. • Motivation and Emotion: Theories, Motivating people at Workplace.
2.	Personality: Definition, Approaches and Theories. Psychological Disorders, Mental health and Workplace. Psychological Problems of Everyday Life: Stress and coping.
3.	Introduction to Psychometric and types of tests. Attitude and work behavior, Group dynamics, Intergroup relations, conflict resolution. Industrial Psychology and Organizational Behaviour: Concepts, Hawthorne Studies, Application, Personnel Selection, Job satisfaction.
4.	Leadership and Management. Professional Ethics. (includes code of conduct)

Text Books:

1. Baron, R.A. (2001). Psychology. Prentice-Hall of India Private Limited.
2. Blum, M.L. and Naylor, J.C. (1984) Industrial Psychology. New Delhi. CBS Publishers and Distributors.

References:

1. C. T. Morgan, R. A. King, J. R. Weiss and J. Schopler. (1986). Introduction to Psychology.7th ed. McGraw Hill.
2. Newstrom, J.W. & Davis, K. (2002). Organizational Behaviour- Human Behaviour at Work. New Delhi. Tata McGraw-Hill Pub. Co. Ltd.
   Schultz, D. P., & Schultz, E. S. (2008). Psychology and Work today. Newyork. Mac Milan publishing company.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	PE 30011	Advanced Reservoir Engineering	3	1	0	4

Course Objective

The course Advanced Reservoir Engineering is designed to help the students to develop a complete understanding of the characteristics of Drive mechanisms; Steady, pseudo-steady and Unsteady fluid flow behaviour through porous media and various water influx models to estimate water encroachment into a reservoir. The course also introduces the concept of Water flooding with emphasis on displacement efficiencies, flooding pattern and role of reservoir geology in the design and operation of water floods.

Learning Outcomes

1. To develop Critical-thinking and problem-solving approach.
2. Understanding of basic oil & gas reservoir characteristics, Drive mechanisms and pressure behaviour in a steady, pseudo-steady and unsteady state reservoir.
3. Ability to design water flooding project for optimum recovery.
4. Water influx models and its uses to analyse water influx behaviour into reservoir.

Unit No.	Topics to be Covered	Learning Outcome
1.	Reservoir drive mechanisms: solution gas drive, gas cap drive, natural water drive, compaction drive and pore compressibility.	Understanding of reservoir drive mechanism and production behavior of oil & Gas reservoir. Material balance equation for different oil reservoirs and dry gas reservoirs.
2.	Water flooding: microscopic efficiency of immiscible displacement, macroscopic displacement efficiency of linear waterflood, fractional flow and frontal advancement, immiscible displacement in two dimensions, displacement pattern and sweep efficiency, waterflood design, role of reservoir geology in the design and operation of water floods, introduction to EOR.	Microscopic efficiency, Areal sweep efficiency and Vertical sweep efficiency for a displacement process. Fractional flow, Buckley Leverett frontal advancement and immiscible displacement in 2D for water flood design. Selection of flood pattern. Role of reservoir geology in the design and operation of water flood project.
3.	Radial steady state and transient flow, linearization of equations for small and constant compressibility; well in flow equation; steady state and pseudo steady state solutions.	Fluid flow behavior through porous media Solution of diffusivity equation for steady, pseudo-steady and transient state and their significance.

4.	Natural water influx, application of water influx theory in history matching, steam soaking.	Estimation of water encroachment into reservoir using different water influx models.

Text Books:

1. Fundamentals of Reservoir Engineering by LP Dake.
2. Fundamental Principles of Reservoir Engineering by Brian F Towler.
3. Reservoir Engineering Handbook by Tarek Ahmed.
4. Waterflooding by G Paul Willhite.

References:

1. Applied Petroleum Reservoir Engineering by BC Craft and M Hawkins.
2. Petroleum Reservoir Rock and Fluid Properties by Abhijit Y Dandekar.
3. The reservoir Engineering aspects of Waterflooding by Forrest F Craig(Jr).

Course Type	Course Code	Name of Course	L	T	P	Credit
UG	PE 30006	Hydrocarbon Production Engineering-II	3	1	0	4

Course Objective

To provide basic understanding and problem solving approach related to various artificial lift techniques, well stimulation, and sand production control techniques.

Learning Outcomes

- Knowledge of various artificial lift techniques, installation, design and troubleshooting.
- Formation damage mechanism and operations leading to formation damage, design and implementation acidization and hydraulic fracturing treatment operations.

Unit No.	Topics to be Covered	Learning Outcome
1.	Artificial lift; ESP, SRPs, PCP	Concepts, design and components of SRP, ESP, PCP, and Plunger lift. Ability to design and select the lift technique as per suitable field parameters. Identification of operational problems associated with lift techniques.
2.	Gas lift: well construction, design, performance curve; pump assisted lift.	Design of continuous and intermittent gas lift system. Concepts and calculations involved in Valve mechanics.
3.	Formation damage: mechanisms, skin factors.	Operations leading to formation damage. Formation damage mechanism and identification.

4.	Matrix acidizing: transport of acid to mineral surface; reaction stoichiometry and kinetics; sandstone and carbonate acidizing; acid selection; models; wormhole formation, growth, and propagation model for carbonate acidizing; treatment design - volume, injection rate, placement and diversion, additives; acid fracturing.	Mechanism involved in sandstone and carbonate matrix acidizing. Design concepts related to matrix acidizing and acid fracturing.
5.	Hydraulic fracturing: fracture geometry and design; fractured well performance in conventional low permeability, unconventional tight-sand, and shale reservoirs.	Significance of hydraulic fracturing and treatment design. Knowledge of various fracturing fluids and additives Fractured well performance. Calculation of treatment parameters.
6.	Surface flow testing, Sand flow in well bore and management: cavity, gravel pack, and frac pack completions.	Identification methods and various reasons for sand flow from the well. Knowledge of various sand control techniques and mechanisms.

Text Book:

1. Hall / Pearson Education India 2012.Economides M.J., Hill A.D., Economides C.E., Zhu D., Petroleum Production Systems, Prentice.

Reference:

1. Clegg J.D. (ed), Petroleum Engineering Handbook Vol. IV, Production Operations Engineering, SPE 2007.
2. Allen T.O. and Roberts A.P., Production operation, Well Completions, Workover, and Stimulation Volume 1 and 2, OGCI Publication 1994.
3. L Kalfayan. Production Enhancement with Acid Stimulation. PenWell Corporation 2008.
4. Kermit Brown. The Technology of Artificial Lift Methods. 1980. PennWell Books.

Course Type	Course Code	Name of Course	L	T	P	Credit
Theory	PE 30007	Advanced Drilling Technology	3	0	0	3

Course Objective

The objective of the course is to impart detailed knowledge of directional drilling and its components; monitoring tools and corrective measures for deflected well trajectory. The course also aims to analyse hydraulics design, identify directional well profile and perform downhole survey calculations.

Learning Outcomes

- Broad understanding of directional drilling tools and techniques.
- Identify and differentiate among different well profiles as well as implement suitable drilling systems.
- Describe the components of onshore and offshore drilling platforms.
- Expertise to interpret and correct directional and horizontal wells.

Unit No.	Topics to be Covered	Learning Outcome
1.	**Directional drilling basics:** Evolution in the industry, Drilling mud and considerations, Application and need, Azimuth.	Understanding the need and scenario for directional drilling.
2.	**Deflection tools and techniques:** Stabilizers and roll reamers, Rotary assemblies, Types of deflecting tools.	Knowledge of well deflection tools and components.
3.	**Well profile:** Influencing Factors, Type I, II and II wells.	Identify test suitable well profile, perform well trajectory calculations.
4.	**Downhole survey and correction:** Measurement and logging while drilling, Telemetry system, down hole motors, power calculation, steerable system, geo-steering.	Describe tools and methods to survey well path during directional drilling.
5.	**Offshore drilling:** Developmental drilling platforms/units - Fixed, mobile and subsea systems.	Identify and recognize the different equipments in offshore drilling.

6.	**Drill rig system and hydraulics design:** Components, Direct and reverse circulation, Rotary equipment, design of block and tackle system, draw works drum; top drive drilling. Rheological models, Surface connection losses, Pressure loss calculations in pipe and annuli, Bit hydraulics.	Explain the different components of drilling rig Determine pressure losses in laminar and turbulent flow regime Optimization of bit hydraulics programme.
7.	**Highly inclined and horizontal wells:** Considerations, Efficacy and well-path control techniques.	Examine suitable conditions for highly inclined wells Describe horizontal well drill techniques.
8.	**Air & Gas Drilling Technology in Underbalanced condition:** Planning steps, Feasibility, Coiled tubing versus extended reach drilling, Surface and Downhole equipments, Compressors, Nitrogen generators, Specialized Downhole Equipment, Gaseous fluid systems.	Identify the feasibility and application constraints of Underbalanced drilling Explain air and gas drilling components and equipments.
9.	**Introduction to software's:** Drilling simulator framework, Hardware-in-loop simulator, industry tools.	Define software framework and types used in industry.

Text Book:

1. Directional Drilling: T.A. Inglis.
2. Drilling Engineering-Principles and Practice: H. Rabia.
3. Applied Drilling Engineering: Bourgoyne Jr. et al.

Reference:

1. Offshore Petroleum Drilling and Production: Sukumar Laik.
2. Drilling Engineering: Professors, Heriot-Watt University.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	BS20004	Object Oriented Programming	2	0	3	4

Course Objective

Introduce students to:

- Fundamentals of object-oriented concepts, OO programming, and database concepts.
- Model real world problems with Object Oriented constructs and solve them.

Learning Outcomes

Students will be able to:

- Analyse a given problem and model it using objects, inheritance, and other OO constructs
- Implement a given OO model using the Python language.

Unit No.	Topics to be Covered	Learning Outcome
1.	Fundamental concepts of object oriented programming: Introduction to the principles of object- oriented programming (classes, objects, messages, encapsulation, inheritance, polymorphism, exception handling, and object-oriented containers)	Students will understand: the need for OOP, how the OO constructs help to decompose the complex problems.
2.	Object design implementation in a programming language, e.g., C++ or java or Python. (Currently, Python is used.).	Familiarize with Python basics, built-in data structures, functions, etc. Implement object oriented concepts using Python.
3.	Object oriented database systems: Object oriented data model, query languages, storage organization and indexing techniques; object relational databases.	Familiarize with modelling data, creating Python application to interact with a database.

Text Books:

1. Grady Booch, Object Oriented Analysis and Design, Addison-Wesley.
2. Programming Python: Powerful Object-Oriented Programming (4th Edition), Author: Mark Lutz, O'Reilly

References:

1. Bertrand Meyer, Object Oriented Software Construction, Prentice-Hall.

2. Grady Booch, James Rumbaugh and Ivar Jacobson, Unified Modeling Language Guide, Addison-Wesley Erich Gamma et al., Design Patterns: Elements of Reusable OO Software, Addison-Wesley.

Course Type	Course Code	Name of Course	L	T	P	Credit
UG	PE 30004	Drilling & Fracturing Lab	0	0	3	2

Course Objective

- On hand training to determine various drilling fluid properties and cement slurry design.
- On hand training to estimate mechanical properties of rock.

Learning Outcomes

- Understanding of the API recommended methods to determine various drilling fluid properties.
- Ability to develop and design a drilling fluid system and cement slurry.
- Knowledge of conducting various laboratory tests related to rock mechanics.

Unit No.	Topics to be Covered	Learning Outcome
1.	Formulation of mud and fracturing fluid; characterization of mud and fracturing fluid through viscometry and rheometry.	Development and design of drilling and fracturing fluids.
2.	Fluid loss tests for mud and cement.	Determination of filtration characteristics of drilling fluid.
3.	Routine measurements of density, viscosity, sand content.	Knowledge of sand content density, viscosity determination as per API recommended procedure.
4.	Thickening time measurements, atmospheric consistometer for cement.	Design and analysis of cement slurry.
6.	Proppant transport.	Design of fracturing fluid for efficient proppant transport.
7.	Stress-strain measurements.	Determination of Compressive strength, tensile strength, point load index.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	PE20004	Transport in Porous Media	3	0	0	3

Course Objective

The objective of this course is to impart knowledge on the concepts that governs the flow and transport processes in porous media. Also, this course aims to introduce about the basic concepts and techniques that are involved in computational modelling of flow and transport processes in porous media.

Learning Outcomes

Upon successful completion of this course, students will:

- have a detailed understanding on the fundamental concepts that defines porous media and its properties.
- have developed conceptual and theoretical knowledge on single phase and multiphase fluid flow process in porous media.
- have acquired conceptual and theoretical knowledge on solute and heat transport processes that occurs in porous media.
- be introduced to different computational modelling techniques used to simulate flow and transport processes in porous media.

Unit No.	Topics to be Covered	Learning Outcome
1.	**Properties of Porous Media**: Industrial application of porous media; pore structure; volume averaging and Representative Elementary Volume (REV); single and multiple continuum; porosity, tortuosity, permeability, Kozeny-Carmen equation; Mercury porosimetry, helium pycnometry, BET analysis.	Students will learn fundamental concepts involved in defining porous media as a single and multiple continuums. Will learn about different properties of porous media and evaluation of it by experimental methods.
2.	**Fluid flow in porous media**: Continuity/mass balance equation for porous media; momentum equation – Darcy equation, Darcy-Brinkman equation, Darcy-Forchheimer equation. Steady state fluid flow in porous media; transient single phase fluid flow equation in porous media.	Students will learn: about physical meaning of continuity and different momentum equations and its suitability; to derive single phase fluid flow equation by coupling continuity and momentum equations.

3.	**Multiphase fluid flow in porous media:** Relative permeability, wettability, capillary pressure, IFT, multiphase fluid flow equation in porous media.	Students will learn about fundamental concepts involved in multiphase flow in porous media, and will also learn to derive the equations for multiphase fluid flow in porous media.
4.	**Transport in porous media:** Transport of solute in porous media by advection and diffusion process; sorption; straining; coupled advection-dispersion-reactive transport processes in porous media and its governing equation; Tracer analysis. Heat transport in porous media by conduction, convection, and radiation processes; Energy balance equation. Introduction to solute and heat transport in fractured porous media.	Students will develop a broad understanding on the different solute and heat transport processes that occurs in porous media. Students will learn to mathematically represent the solute and heat transport process in porous media through PDE's along with boundary conditions. Students will be introduced to transport process in fractured porous media.
5.	**Computational modeling of flow and transport in porous media**: Introduction to numerical modelling by finite difference discretization and Lattice Boltzmann model. IMPES method for simulating multiphase flow; Methodology for simulating coupled flow and transport process in porous media.	Students will be introduced to modelling and simulation of flow and transport process in porous media by different computational techniques. Students will learn about the methodology to numerically solve: multiphase flow equations; and coupled flow & transport processes in porous media.

Text Book:

1. Dynamics of Fluids in Porous Media: Jacob Bear
2. Porous media Transport Phenomena: Faruk Civian
3. Modeling Phenomena of Flow and Transport in Porous Media: Jacob Bear

References:

1. Essential of Heat and Fluid Flow in Porous Media: Arunn Narasimhan
2. Modelling and Applications of Transport Phenomena in Porous Media: Jacob Bear and J-M. Buchlin

6th SEMESTER

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	PE 30012	Oil and Gas Well Testing	3	0	0	3

Course Objective

The course is designed to give the students an overview of basic Oil & Gas well testing for reservoir characterisation.

Learning Outcomes

1. To develop Critical-thinking and problem-solving approach.
2. Understanding of the oil and gas well testing technology and its significance in identifying well flow issues and reservoir properties.
3. Understanding of different interpretation methodology of various types of well testing.

Unit	Topics to be Covered	Learning Outcome
1.	Introduction to well testing; constant terminal rate solution; superposition theorem; pressure build-up analysis; draw down tests; effects of partial well completion, after flow analysis, Wellbore effect.	Objectives of oil and gas Well Testing Measurement of Reservoir Properties by Pressure Transient Tests. Interpretation of well test data. Important of Type Curves in interpretation of Well test data.
2.	Radial flow of real gas; gaswell testing; non-Darcy flow, multi rate testing, pressure build-up analysis in solution gas drive reservoirs.	Non-Darcy gas flow behavior. Gas well testing to characterize dry gas reservoir properties.
3.	Well Test analysis by Type Curve.	Important of Type Curves in interpretation of Well test data.
	Multirate test, Multiwell test, Injection Well Testing, Pressure Derivative Method, Drill Stem Test (DST).	Different well testing methods to characterize reservoir properties.

Text Books:

1. Well Testing by John Lee. Fundamentals of Reservoir Engineering by LP Dake.
2. Reservoir Engineering Handbook by Tarek Ahmed.
3. Applied Petroleum Reservoir Engineering by BC Craft and M Hawkins.

References:

1. Advances in Well Test Analysis by Robert C Earlougher (Jr).
2. Pressure buildup and flow tests in wells by CS Mathews and DG Russel.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	PE 40005	Offshore and Deep Sea Technology	3	0	0	3

Course Objective

The objective of the course is to introduce the students to the challenging area of petroleum industry and make them understand different offshore platforms used for drilling and production; their stability criteria and station keeping methods. The aim of this course is also to provide a clear understanding of the difference between offshore and onshore operations w.r.t. drilling, completion and production operations with the help of case studies.

Learning Outcomes

On successful completion of the course, the student shall be able to:

(a) explain the offshore sea environment and stability of offshore structures,

(b) explain applications and limitations of the various fixed and floating offshore drilling/production structures,

(c) explain offshore drilling, challenges and technologies,

(d) explain offshore production processing, transportation and storage and deep sea technologies,

(e) Explain well abandonment methods and environmental concerns and emerging technologies,

(f) Solve practical case studies.

Unit No.	Topics to be Covered	Learning Outcome
1.	**Introduction:** Offshore oil and gas operations and ocean environment. Sea floor marine soils, Geotechnical aspects. Various forces acting on offshore structure; Stability of offshore structure.	Explain the offshore sea environment and stability of offshore structures.
2.	**OffshorePlatforms:** Offshore fixed platforms, mobile units, Station keeping methods like mooring & dynamic positioning system.	Explain applications and limitations of the various fixed and floating offshore drilling/production structures.
3.	**Offshore Drilling and Well Completion:** Difference in drilling from land, from fixed platform, Jackup, ships and semi submersibles. Use of conductors and risers. Deep sea drilling. Well completion. Deep water applications of subsea	Explain offshore drilling, challenges and technologies.

	technology: drilling rig, well construction issues, cementations, casing and mud design, mud window for vertical / horizontal drilling, gas hydrates.	
4.	**Offshore Production and sub-sea technologies** Offshore production: Oil processing platforms, water injection platforms, storage, SPM and SBM transportation and utilities. Deep water production system: Subsea transducers / sensors, control module, Wellheads and manifolds phase separators.	Explain offshore production processing, transportation and storage and deep sea technologies.
5.	Well abandonment, environmental concerns, Emerging deep water technologies, equipment and systems, remote operation vessels, safety of divers.	Explain well abandonment methods and environmental concerns and emerging technologies.
6.	**Case studies** Selection of offshore platform, mooring system, production facilities based on given conditions.	Solve practical case studies.

Text Books:

1. S. Laik "Offshore Petroleum Drilling and Production" CRC Press, Taylor and Francis.
2. Yong Bai, Qiang Bai, Subsea Engineering Handbook. Gulf Professional Publishing (2012).
3. James Speight, Handbook of Offshore Oil and Gas Operations. Gulf Professional Publishing (2014).
4. Yong Bai, Qiang Bai, Subsea Pipelines and Risers. Elsevier Science (2005).
5. Andrew Clennel Palmer, Roger A. King, Subsea Pipeline Engineering. PennWell Books (2008).
6. Subrata Chakrabarti, Handbook of Offshore Engineering, Volume I and II. Elsevier Science (2005).

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	PE40003	Enhanced Oil Recovery	3	0	0	3

Course Objective

The objective of this course is to impart knowledge about different EOR techniques and its underlying mechanism on enhancing the oil recovery. This course also aims to provide knowledge on how to field implement and evaluate the performance of different EOR techniques.

Learning Outcomes

Upon successful completion of this course, students will:

- Understand the importance of EOR, learn when to apply EOR, learn about different EOR types and its functions and learn about the different indicators/measures used to evaluate the EOR performance.
- Learn about chemicals/agents used for different EOR techniques and its functions in enhancing oil recovery.
- Learn about the underlying mechanisms that causes oil recovery in different EOR techniques.
- Learn about the field implementation and performance evaluation of different EOR techniques.

Unit No.	Topics to be Covered	Learning Outcome
1.	**Fundamentals of EOR:** Global and domestic necessity for EOR; India's EOR policy; microscopic and macroscopic displacement of fluids in reservoir; mobilization of trapped oil; mobility control; EOR performance indicators - Capillary Number, mobility ratio, breakthrough from fractional flow curves, wettability alteration from relative permeability curves; recovery factor – volumetric displacement and microscopic displacement efficiency; overview of waterflooding process; different EOR methods and its functions; EOR screening.	Students will understand why EOR is required & India's effort to promote EOR. Students will learn on: when to apply EOR in the field; what different EOR techniques are applied; what different indicators/measures are used to evaluate the EOR performance; and how EOR screening is performed.

2.	**Chemical EOR Methods – I:** ***Surfactant flooding EOR***: Oil recovery mechanism by surfactants, surfactant types & its functions; CMC; microemulsion – types & its phase behavior; field implementation of surfactant flooding EOR; performance evaluation and screening of surfactants. ***Polymer flooding EOR***: Oil recovery mechanism by polymers; mobility control; polymer types & its behavior under reservoir conditions; field implementation of polymer flooding EOR; performance evaluation and screening of polymers for EOR. ***Alkaline-Surfactant-Polymer (ASP) flooding EOR***: Role of alkaline in oil recovery; oil recovery mechanism and field implementation of ASP flooding EOR; performance evaluation of ASP EOR.	Students will learn in detail about the underlying oil recovery mechanisms involved in surfactant, polymer and ASP flooding EOR techniques. Students will have understanding on different surfactants, polymers and alkali used in respective EOR techniques and its function in enhancing the oil recovery. Students will also learn about how EOR techniques such as surfactant, polymer and ASP flooding EOR are implemented in the field and how its performance are evaluated. .
3.	**Chemical EOR Methods – II:** ***Low salinity water flooding (LSWF) EOR*:** Oil recovery mechanisms – Double layer expansion, MIE process, pH alteration, fines migration, etc.; evaluation of wettability alteration from rel. permeability curves; field implementation; challenges in LSWF EOR. ***Microbial EOR (MEOR):*** Different types of microbes and bioproducts and its role in oil recovery; MEOR types and its oil recovery mechanism; field implementation and performance evaluation of MEOR; Merits and challenges in implementing MEOR. ***Hybrid EOR techniques***: Oil recovery mechanism of Low salinity surfactant flooding, Low salinity polymer flooding.	About low salinity water flooding (LSWF), microbial and hybrid EOR techniques, students will learn: Underlying concepts and mechanisms that causes the enhancement in oil recovery. How those EOR techniques are implemented in field and how its recovery performance is evaluated. Current merits and challenges of those EOR techniques, which helps them to identify solutions for those challenges in the future.
4.	**Gas EOR Methods & CO_2 Sequestration:** Gases used for EOR; Gas EOR types; MMP; immiscible gas flooding EOR; miscible flooding EOR – first contact miscibility and multiple contact miscibility – vaporization, condensation and combined drive mechanism; ternary phase diagrams for immiscible and miscible gas flooding EOR mechanisms. Field implementation and oil recovery mechanism	Students will learn about: Different gases that are conventionally used for EOR; How gases enhance the oil recovery by miscibilization and immiscibilization process; how miscibilization of injected gas with the reservoir oil happens in first and during multiple-contacts between gas and oil; how oil composition ternary phase

	of: continuous gas injection, CO2 flooding, WAG, SWAG, SSWAG EOR process. Necessity for CO_2 sequestration; CO_2 sequestration in aquifers and oil reservoirs; CO_2 trapping mechanisms – Structural, hydrodynamic, residual, dissolution and mineral trappings. Challenges in CO_2 sequestration.	diagram evolves during first and multiple contact miscibility. Different gas EOR methods implemented in the field and its governing mechanism on enhancing the oil recovery. CO_2 sequestration and different geo-trapping mechanisms by which CO_2 is sequestrated in the subsurface.
5.	**Thermal EOR Methods:** Types of thermal EOR and its oil recovery mechanism, advantages and constraints – Hot water flooding, steam flooding, cyclic steam flooding or huff & puff steam flooding, steam assisted gravity drainage, in-situ combustion oil recovery technique.	Students will learn about the field implementation, merits and constraints of different thermal EOR methods such as Hot water flooding, steam flooding, cyclic steam flooding or huff & puff steam flooding, steam assisted gravity drainage, in-situ combustion oil recovery technique.

Text Books:

1. Enhanced Oil Recovery. SPE (2018): Don W. Green and G. Paul Willhite
2. Fundamentals of Enhanced Oil Recovery. SPE (2015): Larry W. Lake, Russell Johns, Bill Rossen, Gary Pope.
3. Fundamental of enhanced oil and gas recovery from conventional and unconventional reservoirs (2018):Alireza Bahadori

Reference:

1. Enhanced oil recovery, I: Fundamentals and analysis: E.C. Donaldson, G.V. Chilingarian, T.F. Yen
2. Enhanced oil recovery, II: Processes and operations: E.C. Donaldson, G.V. Chilingarian , T.F. Yen

Course Type	Course Code	Name of Course	L	T	P	Credit
Theory	PE 30008	Pipeline Engineering	3	0	0	3

Course Objective

The objective of the course is to provide the basic knowledge of the pipe line components and operations required for transportation of hydrocarbons. It also imparts an understanding of pipeline design, construction, and monitoring to in addition to different safety requirements.

Learning Outcomes

Unit No.	Topics to be Covered	Learning Outcome
1.	**Introduction:** Pipelines, Components, Risers, Pigging, Flow-meters, Responsibilities of Pipeline Engineer; Pipeline vs. other forms of transportation.	Explaining the basic components and design considerations of a pipeline.
2.	**Multiphase flow dynamics:** Types of flow, Liquid and gas flow through a pipeline, Pressure drop equations. Slugging, Hydrate, Wax and Scale Depositions	Describe and analyze the dynamic flow behavior of fluids.
3.	**Pipe losses, Stress analysis and Manufacturing considerations:** Darcy Weisbach flow equations, Shear on Pipe wall, methods of pipe manufacture.	Determine pipe stresses, calculate pipe frictional losses, Consider pipe manufacturing constraints.
4.	**Pipeline Construction and Engineering – Offshore and Onshore Systems:** Planning steps, Pipe bending, Trenchless Technology, Pipe laying methods, Pump operation and associated problems, Pumps, compressor stations. Underwater welding, Pipe failure due to Sagging and Overbending.	Describe methods to plan, bend and lay pipelines, Understand the importance of pump/compressor operations.
5.	**Ensuring Protection against Abrasion, Freezing and Corrosion:** Design considerations, Pipe lining and coating, Insulation tools, Corrosion protection, Sacrificial and Impressed current system.	Recognize and identify methods to protect pipeline against abrasion, freezing and corrosion.
6.	**Pre-commissioning and commissioning:** Pipeline Flushing, Hydrostatic pressure-testing,	Explain the different steps involved in pre-

	Pipeline purging, Drying at the Commissioning stage.	commissioning and commissioning stages.
7.	**Pipeline Monitoring and Maintenance:** Automatic control system, Integrity monitoring, Leak detection, Corrosion detection, Integrity Management Program, Risk Based Management, Maintenance – Routine, Renovation, Crude Conditioning.	Depict and analyze the various tools to ensure fluid flow performance of pipelines.
8.	**Pipeline Economics and Industry standards/codes:** Cost structure, Economic diameter of a pipeline, Industry standards and codes, Non-technical aspects of pipeline design.	Knowledge about pipeline economics, codes and standards in the industry.
9.	**Pipeline Network analysis and software tools:** Conditions for a Good Pipeline Distribution system, Hardy Cross method, List of software tools and their key attributes.	Define pipe network analysis and identify software's

Text Book:

1. Pipeline Engineering: Henry Liu.
2. Mohitpour M., Golshan H., Murray A., Pipeline Design & Construction: A Practical Approach, ASME 2007.
3. Guo B, Song S, Ghalambor A., Lin T., Chacko J, Offshore pipelines, Gulf Professional Publishing 2005.

Reference:

1. A Quick Guide to Pipeline Engineering: D. Alkazraji.
2. Piping and Pipeline Engineering: George A. Antaki.

Course Type	Course Code	Name of Course	L	T	P	Credit
	BS 30003	Economics	2	0	0	2

Unit No.	Topics to be Covered
1.	Introduction, Demand and Supply Analysis, Production and Cost, Price Output Determination, Capital Market and Investment Decisions, Outline of Welfare Economics, Resource Accounting and Sustainability, Income Determination and Fluctuations, Trade, Aid and Development. Economic Systems & Indian Economic Policies.
2.	Geopolitics and world petroleum market; role of OPEC, national oil companies and bilateral contracts; Fundamentals of petroleum business – strategic issues. Dynamics of petroleum pricing; Financial measures and profitability analysis; Risk, uncertainty, and decision analysis; Implications of fiscal and trade policies and regulations for petroleum industry.

Text Books:

1. Contemporary Engineering Economics, by, Chan S. park, Prentice Hall of India (PHI), 3rd Edition.
2. Petroleum Economics and Engineering, by, Abdel Aal, Bakr, and, Al-Sahlavi, 2nd edition.
3. Economics of worldwide Petroleum Production, by, Richard D. Seba, 3rd Edition.

References:

1. Principles of Economics, by, Samuleson and Nordhaus.
2. Principles of Economics, by, N. G. Mankiw.
3. Engineering Economics, by, R. Paneerselvam, PHI.
4. Petroleum Economics, by, Masseron Jean, 4th edition.

Course Type	Course Code	Name of Course	L	T	P	Credit
UG (Core)	PE30009	Reservoir Engineering Lab	0	0	3	2

Course Objective

On hand training to determine reservoir rock and fluid properties along with crude oil characterisation.

Learning Outcomes

- Understanding of the methods of determining various rock and fluid properties.
- Ability to design and develop compatible fluid system for reservoir.

Unit No.	Topics to be Covered	Learning Outcome
1	Core permeability studies using gas permeameter and liquid permeameter.	• Permeability of core sample using Gas and Liquid permeameter. • Klinkenberg effect demonstration.
2	Determination of the effective porosity of core sample by saturation method.	• Porosity of the core sample by fluid saturation and helium porosimeter.
3	Analysis of BHP Chart.	• BHP chart to analyze DST pressure-time plot.
4	Determination of the surface tension and contact angle of liquid hydrocarbon systems.	• Surface tension, IFT and contact angle determination of liquid hydrocarbon systems. • Rock wettability determination.
5	Characterization of crude oil through viscometry.	• Crude oil viscosity determination.
6	Coring from the rock; study of thin section under microscope with digital camera and automatic point counter.	• Demonstration of texture and structure of reservoir rock.
7	Core flooding, and measurement of relative permeability.	• Relative permeability determination for two phase fluid flow system.

Course Type	Course Code	Name of Course	L	T	P	Credit
Lab	PE 40002	Production Engineering Lab	0	0	3	2

Course Objective

The objective of this lab course is to provide hands on practice on the surface production operation related to processing of properties of produced fluid (oil, brine and gas) and to simulate their flow through pipeline and separators. This course also aim to characterize the fluid properties of synthesized EOR fluids and simulate their behavior through core flooding experiment.

Learning Outcomes

Upon successful completion of this course, students should be able to:

(a) Analyze the physical properties of produced crude oil, brine, gas.

(b) Simulate the two phase flow process through pipeline.

(c) Characterize EOR fluids for their wettability, contact angle, surface tension and interfacial tension.

(d) Simulate Additional Oil recovery process using polymer/ surfactant fluids.

Unit No.	Topics to be Covered	Learning Outcome
1.	Determination of TDS and Conductivity of Produced Water.	To Analyze the physical properties of produced brine.
2.	Determination of pH of brine sample pH meter.	To Analyze the physical properties of produced brine.
3.	Determine of water content of crude oil sample using Karl-Fischer measurement.	To Analyze the water content of produced oil.
4.	Determination of the calorific value of gaseous fuel using Junker gas calorimeter.	To analyze the heating value of gaseous fuel.
5.	Determination of Dew Point Temperature of the Natural Gas.	To Analyze the water content of produced natural gas.
6.	Determination of Total Acid Number of given crude oil.	To Characterize the crude oil for suitable EOR method selection.
7.	Determination of the Surface/Interfacial Tension and	To Characterize EOR fluids for their wettability, contact angle, surface tension and

	Contact Angle using Imaging Method.	interfacial tension.
8.	To study the rheological behavior of hydrocarbon and EOR fluids.	To analyze the hydrocarbon and EOR fluids.
9.	To study the pressure drop in two phase flow and observe the two phase flow patterns through transparent acrylic pipe.	To simulate the two phase flow process through pipeline.
10.	Determination of the BS&W content present in the given crude oil sample using centrifugation.	To quantify the sediments and water content in crude oil sample.
11.	To perform Polymer/surfactant flooding using core flooding experiment.	To Simulate Additional Oil recovery using EOR fluids.
12	Horizontal and Cyclone type separator	To perform phase separation in transparent acyclic setup
13	Orifice and Turbine meter	Measurement of gas flow rate using Orifice and Turbine meter
14	Sulfure quantification in Gas	To determine sulfur content in gas
15	Formation damage and matrix acidizing	Formation damage and matrix acidizing
16	Rock-fluid interaction in rotating disc apparatus	Rock-fluid interaction in rotating disc apparatus
17	True Boiling Point curve for crude oil	True Boiling Point curve for crude oil
18	Bernoulli s experiment	Flow through square and circular pipes; horizontal nozzles; pipe fittings; V-notch, packed bed; Venturi meter, orifice meter; rotameter; pitot tube; Pipe flow Viscometer; Characteristics of centrifugal pump.
19	Design studies on valves, pipe fittings and piping network.	Design studies on valves, pipe fittings and piping network.
20	Mechanical design of pressure vessel, flange, reinforcement for opening, support.	Mechanical design of pressure vessel, flange, reinforcement for opening, support.

Reference Material:

1. Lab Manual, IIPE Visakhapatnam

ELECTIVE- I	
Elective - I	1. Petroleum Exploration 2. Bio Energy 3. Waste WaterManagement 4. Management Techniques for Industrial Sector 5. Principles of Energy Conversion

Course Type	Course Code	Name of Course	L	T	P	Credit
ELECTIVE-I	PE 30013	**Petroleum Explorations**	3	0	0	3
Principles and methods of geological and geochemical exploration, pathfinders and trace elements in rocks and soils. Primary and secondary dispersion patterns, geochemical anomalies and their interpretation Geophysical Explorations: Gravity method; Magnetic method; Electrical Methods; Seismic Methods: Field procedure, Data acquisition, Data processing, Data processing sequence, Advanced processing, Data processing using software; Interpretation of images, Detection of hydrocarbons.						

Books:

Course Type	Course Code	Name of Course	L	T	P	Credit
ELECTIVE-I	PE 30014	Bio Energy	3	0	0	3

Course Objective

1. The course will instruct students the science and technology of biofuels and bioenergy.
2. It will give an overview of biomass feedstock and its availability, various technological practices in the generation of biofuels and bioenergy.

Learning Outcomes

1. Students will learn about the benefits of various feedstocks and the processes involved in the biofuel generation.
2. Importance of the available natural resources as the sustainable, efficient, and cost-effective bioenergy sources will be discussed.

Unit No.	Topics to be Covered	Learning Outcome
1.	Introduction to Bioenergy; Current status, merits & demerits. Feedstock,: starch, oilseed, lignocellulogic and algae based, fuel logistics of Biomass.	Students will get an overview of bioenergy, types of biofuels and their sources.
2	Biological conversion technologies, enzyme hydrolysis, ethanol fermentation, comparisons of fossil fuels and bio fuels.	Students will understand the technical aspects of biomass conversion technologies.
3.	Fundamentals of anaerobic digestion, Microbial fuel cells, Bio-refinery. Economic, Social and Ecological Impacts of Bioenergy at Local, National and Global Levels.	Students will learn the importance of microbes in biofuel processes. Learn economic, social and ecological impacts of bioenergy.
4.	Life cycle assessment, current and emerging challenges to bioenergy development, Govt. policies and standards.	Students will learn about different bioenergy policies and the challenges involved.

Text Book:

1. Y. Li, and S. K. Khanal, Bio Energy: Principles & Applications: Wiley-Blackwell 2016.
2. S. Lee, and Y T Shah, Bio Fuels and Bio Energy: Processes and Technologies, CRC Press, 2012

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective: I	CH 30010	Wastewater Management	3	0	0	3

Course Objective

1. The course provides a thorough understanding of wastewater management to convert the "burden (i.e., wastewater)" into "resources (i.e., clean water, energy, and fertilizer).

Learning Outcomes

1. Understand the categorization of wastewater, and its sources with various characterization methods.
2. Learn the fundamental aspects of physical, chemical, and biological processes for wastewater treatment.
3. Convert the "burden (i.e., wastewater)" into "resources (i.e., clean water, energy, and fertilizer) using wastewater management techniques.
4. Select suitable treatment strategy to target specific contaminants.

Unit No.	Topics to be Covered	Learning Outcome
1.	Introduction to water and wastewater engineering, Methods for characterizations of wastewater properties.	Understand categorization of wastewater, their sources along with various characterization methods.
2.	Physical, chemical and biological process for wastewater treatment, primary, secondary and tertiary treatment including suspended growth and attached growth methods.	Learn the fundamental aspects of physical, chemical, and biological processes for wastewater treatment.
3.	Advanced oxidations process for removal of recalcitrant components in wastewater, nutrient removal, sludge treatment and its removal.	Learn AOPs and their application in the treatment of recalcitrant pollutants along with sludge management.

4.	Progress in zero discharge techniques. Case studies related to treatment of Industrial and municipal effluents.	Learn various case studies related to wastewater treatment .
5.	Standards and regulations.	Learn various standards and regulations.

Text Book:

1. W. Eckenfelder (Jr.) Industrial Water Pollution Control, McGraw Hill (1999).

2. G. Tchobanoglous., L. Burton, and H.D. Stensel, Wastewater Engineering Treatment and Reuse (Metcalf & Eddy), McGraw Hill (2002).

Reference:

1. H.S. Peavy, D. R. Rowe, G. Tchobanoglous, Environmental Engineering, Mcgraw-Hill (1985).

2. A. P. Sincero and G.A. Sincero, Physical-Chemical Treatment of Water and Wastewater, CRC press (2002).

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective		Principles of Energy Conversion	3	0	0	3

Pre-requisite courses

Basics of Thermodynamics.

Course Objective

1. Compare competing energy conversion technologies on an economic and efficiency basis.
2. Be familiar with basic principles of thermal, mechanical, chemical, nuclear, and solar energy conversion.
3. Be familiar with thermodynamic processes and power cycles (thermal and mechanical energy).
4. Be familiar with basic principles of energy storage.

Learning Outcomes

1. At the end of the course students will learn and understand the basic principle involved in energy conversion.
2. Students will get to know about energy conversion efficiency.
3. Students will learn about thermodynamic processes and power cycles.
4. Students will get to know about Thermal, chemical, nuclear, wind energy conversion principles.
5. Students will get to know about the basic principles of energy storage.

Unit No.	Topics to be Covered	LearningOutcome
1.	Energy, Growth Rate & Energy Economics energy, energy classification, units, energy conversion, conversion efficiency · energy information and perspectives.	Students will learn and understand the basic principle involved in energy conversion.
2.	Thermal-to-Mechanical Conversion · Early engines & efficiency · Thermodynamics & power cycles & efficiency · Rankine Cycle · Brayton Cycle.	Students will learn about thermodynamic processes and power cycles.
3.	Chemical-to-Thermal Conversion · principles of combustion, fuels: coal, petroleum, gas.	Students will be familiar with basic principles of thermal, mechanical, chemical, nuclear, and solar energy

4.	Electromagnetic-to-Thermal Conversion principles of solar insolation · solar collectors · thermal energy storage.	conversion;
5.	Electromagnetic-to-Electrical Conversion principles of photovoltaics.	
6.	Nuclear-to-Thermal Conversion · principles of nuclear energy · pressurized water reactors · boiling water reactors · boiling water, graphite-moderated reactors · Gen-IV reactors.	
7.	Mechanical-to-Mechanical Conversion · principles of wind energy.	
8.	Chemical-to-Electrical Conversion · principles of fuel cells.	
9.	Introduction to Energy Storage · hydrogen · flow batteries · compressed gas, flywheel.	Students will be familiar with basic principles of energy storage.

Text Books:

1. Energy Conversions by Kenneth Weston.
2. Principles of Energy Conversion by Culp, McGraw-Hill Companies.
3. Lecture notes.

Reference Books

1. BEI International, Hambling, P., (Ed.), Modern Power Station Practice: Nuclear Turbines, and Associated Plant, Pergamon Press, 1992.
2. Drbal, L. F., Boston, P. G., Westra, K. L., Black and Veatch, Power Plant Engineering, Kluwer Academic, 1995.
3. Elliott, T. C., Chen, K., and Swanekamp, R., Standard Handbook of Power Plant Engineering, McGraw-Hill Professional, 2nd ed., 1997 El-Wakil, M. M.,
4. Power Plant Technology, McGraw-Hill, 1984. Jog, M., Hydro-electric and Pumped Storage Plants, John Wiley, 1989. Fritz, J. J., Small and Mini Hydropower Systems, McGraw-Hill, 1984. Central Board for Irrigation and Power (CPIB), India, Design and Construction Features of Selected Dams in India, 1983. Borbely, Anne-Marie, and Kreider, Jan J., (Eds.), Distributed Generation: The Paradigm for the New Millennium, CRC Press, 2003. Larminie, J., and Dicks, A., Fuel Cell Systems Explained, John Wiley, 2003. Vielstich, W., Lamm, A., and Gasteiger, H., Handbook of Fuel Cells: Fundamentals, Technology, Applications, John Wiley, 2003 Appleby, A. J., and Foulkes, F. R. Fuel Cell Handbook, van Nostrand Reinhold, 1996. Harrison, R., Hau, E., and Snel, H., Large Wind Turbines: Design and Economics, John Wiley, 2001.)

Management Techniques for Industrial Sector

……..Will be offered later……..