Course Structure and Syllabus

3rd Year
B.Tech in Petroleum Engineering

(To be implemented for Batch 2022-26)

भारतीय पेट्रोलियम एवं ऊर्जा संस्थान

Indian Institute of Petroleum and Energy

Visakhapatnam, Andhra Pradesh - 530003

3rd Year B.Tech in Petroleum Engineering

Course Structure

Fifth Semester						
Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Advanced Reservoir Engineering	3	1	0	4	Dept. Core
2	Advanced Drilling Technology	3	1	0	4	Dept. Core
3	Hydrocarbon Production Engineering-II	3	1	0	4	Dept. Core
4	Offshore and Deep sea Technology	3	0	0	3	Dept. Core
5	Petroleum Exploration	3	0	0	3	Dept. Elective
6	Fracturing Lab	0	0	6	2	Dept. Practical
7	Reservoir Engineering lab	0	0	6	2	Dept. Practical
	Total	**15**	**3**	**12**	**22**	

Sixth Semester						
Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Oil & Gas well Testing	3	0	0	3	Dept. Core
2	Enhanced Oil Recovery	3	0	0	3	Dept. Core
3	Pipeline Engineering	3	0	0	3	Dept. Core
4	Data Analytics and AI for Process Industry	3	0	0	3	Dept. Elective
5	Open Electives- 01	3	0	0	3	Open Elective
6	Production Engineering Lab	0	0	6	2	Dept. Practical
7	EOR Lab	0	0	6	2	Dept. Practical
8	Project 1	0	0	6	2	Project
	Total	**15**	**0**	**18**	**21**	

List of Electives

1. Unconventional Hydrocarbon Resources
2. Bio Energy
3. Waste Water Management
4. Management Techniques for Industrial Sector
5. Principles of Energy Conversion
6. Solar Energy, Photovoltaic Energy
7. Advanced Separation
8. Advanced Material Design
9. Waste to Energy Conversion
10. Petroleum Engineering System Design
11. Nuclear Wind and Geothermal Energy
12. Hazardous Waste Treatment and Safety Devices
13. Analytical Techniques

List of Electives

14. Natural Gas Engineering
15. Advanced Reservoir Modelling
16. Petroleum Refinery Engineering
17. Air Pollution Control
18. Tribology & Introduction to the Lubricants
19. Energy Storage System
20. Prospecting, Field Development and Asset Management
21. Petrochemical Technology
22. Nano Materials for Hydrocarbon Industry
23. Process Modelling and Simulation
24. Hydrogen Energy

Fifth Semester

Course Type	Course Code	Name of Course	L	T	P	Credit
Dept. Core		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
Dept. Core		Advanced Drilling Technology	3	1	0	4

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 equipment, 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 equipment.
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
Dept. Core		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 reatment 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
Dept. Core		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.	**Offshore Platforms:** 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 technology: drilling rig, well construction issues, cementations, casing and mud design, mud window for vertical / horizontal drilling, gas hydrates.	Explain offshore drilling, challenges and technologies.
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.	bandonment, environmental concerns, Emerging deep water ɔgies, equipment and systems, remote operation vessels, ɔf 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
Dept. Elective		Petroleum Exploration	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.

Course Type	Course Code	Name of Course	L	T	P	Credit
Dept. Practical		Fracturing Lab	0	0	6	2

Course Objective

Specimen preparation (Drilling, cutting, grinding); Measurement of P- and S- wave velocities, estimation of elastic parameters using ultrasonic velocities; Measurement of porosity of the specimen; Tensile strength estimation; Point load strength measurement; Uniaxial compressive strength measurements; Estimation of elastic properties; Triaxial test; Post-failure analysis; Multi-stage triaxial test; Hydraulic Fracturing test

Course Type	Course Code	Name of Course	L	T	P	Credit
Dept. Practical		Reservoir Engineering Lab	0	0	6	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.

Sixth Semester

Course Type	Course Code	Name of Course	L	T	P	Credit
Dept. Core		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.
4.	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
Dept. Core		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 & CO2 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 of: continuous gas injection, CO2 flooding, WAG, SWAG, SSWAG EOR process. Necessity for CO2 sequestration; CO2 sequestration in aquifers and oil reservoirs; CO2 trapping mechanisms – Structural, hydrodynamic, residual, dissolution and mineral trappings. Challenges in CO2 sequestration.	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 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. CO2 sequestration and different geo-trapping mechanisms by which CO2 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
Dept. Core		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, Pipeline purging, Drying at the Commissioning stage.	Explain the different steps involved in pre-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	Define pipe network analysis and identify software's

	attributes.	

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
Dept. Elective		Data Analytics and AI for Process Industry	3	0	0	3

Course Objective

1. To introduce students to basic applications, concepts, and techniques of data mining.
2. To understand various key paradigms for machine learning approaches.
3. To understand and differentiate among various machine learning techniques.

Learning Outcomes

Student will be able to:

1. Understand the need for data analysis, basic techniques used in data mining and machine learning.
2. Design a data mart or data warehouse for any organization and extract knowledge using data mining techniques.
3. Design and implement machine learning solutions to classification, regression, and clustering problems; and be able to evaluate and interpret the results of various machine learning algorithms.
4. Understand the importance of big data analytics, a Big Data Platform and its uses.

Unit No.	Topics to be Covered	Learning Outcome
1.	**Introduction:** Introduction to Data Analytics and Artificial Intelligence-Some illustrations of AI problems-Data-Information- Knowledge-Applications of Data Analytics- Introduction to the Languages of Data Science: R, SQL, and Python.	Student will understand the need for this course and also learn the basics (SQL, Python libraries) needed for the rest of the course.
2.	Data warehousing: Introduction to Data warehousing, Concepts of Data warehousing- OLAP-Data Preparation and Visualization.	Students will understand a data mart or a data warehouse and extract knowledge from them using data mining techniques.
3.	Descriptive Statistics: Central Tendency and Variability, Inferential Statistics-Probability- Central Limit Theorem-Exploratory Data Analysis-Hypothesis Testing.	Student will learn to calculate and interpret the various measures of central tendency, dispersion skewness. Analyze and compare different sets of data. Making an inference about a population from a sample.
4.	Linear Regression, Classification and Clustering Techniques: KNN, Naïve Bayes and Logistic Regression- K-means and Hierarchical Clustering- Decision Trees-Support Vector Machines- Neural Networks-Association Rule Mining.	Design and implement machine learning solutions to classification, regression, and clustering problems; and be able to evaluate and interpret the results of various machine learning algorithms.

5.	Introduction to Big Data and Hadoop: Managing Big Data-Hadoop Ecosystem Tools (Sqoop and Hive). Introduction to Spark; Big Data Analysis using SparkR, SparkSQL; Case Studies; Spatial Data Model; Visualization and Query of Spatial Data; Subsurface Mapping and Correlation and applications.	Understand the importance of big data analytics, a Big Data Platform and its uses. Understand the Vector, Raster, and Image models. Multilayer representation, Queries based on geometry.

Text Books:

1. Thomas A. Runkler, Data Analytics: Models and Algorithms for Intelligent Data Analysis, Springer, 2012.
2. Data Mining: Concepts and Techniques (The Data Mining: Concepts and Techniques (The Morgan Kaufmann Series in Data Management Systems) by Jiawei Han (Author), Micheline Kamber (Author), Jian Pei.
3. Big Data and Hadoop by V. K. Jain.

References:

1. Wes McKinney, Python for Data Analysis, O' Relley, 2013.
2. Keith R. Holdaway, Harness Oil and Gas Big Data with Analytics: Optimize exploration and Production with Data Driven Models, Weily, 2014.
3. Robert Haining, Spatial Data Analysis, Theory and Practice, Cambridge University Press, 2003.

Course Type	Course Code	Name of Course	L	T	P	Credit
Dept. Practical		Production Engineering Lab	0	0	6	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 Contact Angle using Imaging Method.	To Characterize EOR fluids for their wettability, contact angle, surface tension and 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.

Course Type	Course Code	Name of Course	L	T	P	Credit
Dept. Practical		EOR Lab	0	0	6	2

Unit No.	Topics to be Covered	Learning Outcome

1. To determine Sor with surfactant flooding using core flow setup
2. To determine IFT with different surfactant solutions simulating HPHT conditions
3. Determination of MMP for given fluid system
4. To determine Sor using Foam EOR technique
5. Microfluidic Study of Enhanced Oil Recovery
6. To investigate the effects of temperature on viscosity and production rate alterationfor heavy oil: Steam flooding
7. To analyze rock fluid interaction during EOR process

Open Electives

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-01	PE30010	Unconventional Hydrocarbon Resources	3	0	0	3

Course Objective

1. This course is designed to give the students an overview of exploration, development and production from unconventional hydrocarbon energy resources such as Shale gas/oil, CBM, Gas hydrates, Heavy oil and Tar sand. The course also highlights technological advancement in exploration, drilling, completion and production for theseunconventional hydrocarbon reservoirs.

Learning Outcomes

1. Potential of Unconventional Hydrocarbon Energy resources to meet the rising energydemand.
2. Production technique and technological advancement for efficient and economicalextraction from these reservoirs.
3. Challenges associated with production and development of Unconventional Hydrocarbon Energy resources.

Unit No.	Topics to be Covered	Learning Outcome
1.	CBM: Introduction, formation and properties, exploration, isotherm studies, reserve estimation, drilling and production. system, artificial lift, hydraulic fracturing of coal seam, produced water separation and disposal, surfacefacilities, well testing.	• CBM reservoir characteristics. • Drilling, Completion and Productionmethods. • from CBM reservoir. • Hydraulic fracturing. • and fluid for CBM reservoir. • Water treatment and • disposal for CBM wells.
2.	Natural Gas Hydrates: Introduction, formation and properties, thermodynamics, kinetics and phase behavior, gas extraction methodologies.	• Thermodynamic and kinetic conditions of hydrate formation. • Gas hydrate reservoir characteristics andmethod of production.
3.	Shale Gas/ Oil: Introduction, geology, important occurrences, petro physical properties, hydro fracturing, horizontal wells, production profiles.	• Shale gas reservoir occurrence & characteristics. • Production optimization from shale reservoir.
4.	Non-Conventional Oil: Introduction to Heavy oil, extra heavy oil, Tar Sand and bituminous, oil shales; origin and occurrence worldwide, resources, reservoir characteristics, new production technologies.	• Production methodology from Heavy Oil reservoir, Tar sand and Oil shale. • Reservoir characteristics.

Text Books:

1. Natural gas Hydrates: A guide for engineers by John Carroll.
2. Coal Bed Methane: From Prospects to Pipeline by P Thakur, K Aminian and S. Schatzel.
3. Unconventional Gas Reservoirs: Evaluation, Appraisal, and Development by MR Islam.
4. Class Notes.

Reference:

1. Clathrate hydrates of Natural Gases by ED Sloan and Carolyn A Koh.

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-01	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
OP-01	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
OP-01		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	Learning Outcome
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 conversion;
4.	Electromagnetic-to-Thermal Conversion principles of solar insolation · solar collectors · thermal energy storage.	
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.)

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-02		Solar Energy, Photovoltaic Energy	3	0	0	3

Unit No.	Topics to be Covered	Learning Outcome
1.	Introduction; Nature and availability of solar energy; Principle of operation of solar cells – materials and processing, thin film, unconventional materials and systems; Concentrators; Cells and system characteristics; Power conditioning, energy storage, and grid connection; Maximum power point tracking, PV to grid – single and three phases; Economy and Life cycle costing. Solar thermal energy. Water pumping: dc and ac pump drive; Peltier refrigeration.	

Text Books:

1. Hans S. Rauschenbach, Solar Cell Array Design Handbook: The Principles and Technologyof Photovoltaic Energy Conversion. Springer (2013).
2. C. Hu and R.M. White, Solar Cells: From Basic to Advanced Systems. McGraw Hill (1983).

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-02	CH 40004	Advanced Separation	3	0	0	3

Course Objective

1. To impart understanding of various aspects of novel separation systems considering application, theory and design. Learn to develop design equations for various filtrationprocesses.

Learning Outcomes

At the end of the course, the student will be able to

1. Evaluate the design parameters for multicomponent distillation process.
2. Identify and model suitable membrane process for treatment of target contaminants.
3. Understand specific applications of novel separation process.

Unit No.	Topics to be Covered	Learning Outcome
1.	Thermodynamics: Phase equilibria, non-ideal thermodynamic property models, activity coefficient models for the liquid phase; Single equilibrium stages: Multicomponent Liquid- Liquid, Solid- Liquid, Gas-Liquid, Vapor-Liquid- Liquid systems.	Modeling and design ofmulti-component distillation system.
2.	Multicomponent multistage separations: Approximate methods, Equation tearing procedures.	Advanced knowledge about Novel Separation processes.
3.	Enhanced distillation; Supercritical extraction. Vapor-liquid flow pattern and rate based models fordistillation.	Advanced knowledge about membrane based gas separation processes anddesign expertise.
4.	Membrane separations; Adsorption, ion exchange,and chromatography.	Advanced knowledge about membrane based liquid separation processes and design expertise.

Text Books:

1. J. D. Seader and E.J. Henley, Separation Process Principles, Wiley (2006).
2. R.W. Baker, Membrane Technology and Applications, Second Edition, Wiley (2004).

Reference Books:

1. Charles Holland, Fundamentals of Multicomponent Distillation, McGraw Hill (1997).

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-02		Advanced Material Design	3	0	0	3

Unit No.	Topics to be Covered	Learning Outcome
1.	Materials characterization using optical and neutron spectroscopies; Multiscale atomistic modeling; Use of density functional theory to predict temperature dependent thermodynamic properties of new materials e.g., complex hydrides, and kinetic processes in diffusion; Introduction to molecular simulations; Semiconductor and oxide nanostructure for optoelectronic devices, high energy solar cells; Quantumdots; Thermoelectric materials.	

Text Books:

1. Edward L. Wolf, Nanophysics and Nanotechnology. Wiley Verlag (2006).
2. Peter Würfel, Physics of Solar Cells: From Basic Principles to Advanced Concepts. Wiley(2009).
3. Charles Kittel, Introduction to Solid State Physics. Wiley (2012).
4. D. C. Rapaport, The Art of Molecular Dynamics Simulation. Cambridge University Press(1995).

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-02	-	Waste to EnergyConversion	3	0	0	3

Pre-Requisites:

Basic of heat, thermodynamics, and chemical reaction engineering; Biochemical processes.

Objectives:

1. The course provides a thorough understanding of waste to energy resources, technologies and systems to convert the waste into energy (e.g., anaerobic digestion,fermentation, pyrolysis, gasification, incineration, etc.).
2. It also provides a basic understanding of the principles underlying the modern designand operation of systems based on recent research.

Learning Outcomes

1. Understand and learn the fundamental aspects involved during the conversion of wasteinto energy (e.g., anaerobic digestion, fermentation, pyrolysis, gasification, incineration, etc.)
2. Familiar with the current research scenario associated with biochemical and thermaltreatment of wastes & biomass.
3. Acquired skills will be useful in the preparation, planning, and implementation ofenergy projects.

Unit No.	Topics to be Covered	Learning Outcome
1.	Introduction to energy from waste: Characterizations and classification of waste as fuel- agro-based, forest residues, industrial waste, municipal solid waste, & E-waste.	Understand energy, energy balance, and acquainted with various source and characterization of wastes
2.	Global and Indian scenario: Environmentalaspects, Waste Management; 3R Principle of Reduce, Reuse and Recycle.	Familiar with the Global andIndian scenario and 3R principle.
3.	Waste to energy options: Biochemical and Thermochemical routes; Biochemical Options – Anaerobic Digestion, Fermentation; Thermochemical Options – Pyrolysis, Gasification, and Incineration; Other options – Biodiesel synthesis, Briquetting, Torrefaction, and Hazardous waste management.	Learn the energy options and fundamental aspects involved during the conversion of waste into energy.
4.	Properties of fuels derived from waste to energy technology: Producer gas, Biogas, Ethanol, and Briquettes, Comparison of properties with conventional fuels.	Understand the properties of fuels derived from waste.
5.	Energy production from waste plastics and E- waste, Cultivation of algal biomass from wastewater and its application in energy production. Calculations: heat & mass balances.	Familiar with the Energy production from plastics wastes & algal biomass with Heat & Mass balance.

6.	Landfills: Gas generation and collection inlandfills, Introduction to transfer stations, Case studies related to waste to energy conversion.	Learn the collection and transportation of fuel and case studies.

Books:

1. D.O. Hall and R.P. Overeed, Biomass-Renewable Energy, John Willy and Sons, New York. 1987.
2. M.M. EL-Halwagi, Biogas Technology, transfer and diffusion, Elsevier Applied science Publisher, New York, 1984.

References:

1. M. J. Rogoff and F. Screve, Waste-to-energy: technologies and project implementation. Academic Press., 2019.
2. N. B. Klinghoffer and M. J. Castaldi, Waste to energy conversion technology. Elsevier., 2013.
3. J.H. Harker, and J.R. Backhusrt, Fuel and Energy, Academic Press Inc.

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-03	PE 40010	Petroleum Engineering System Design	3	0	0	3

Unit No.	Topics to be Covered	Learning Outcome
1.	**Rig Selection and design:** Environmental loading and stability of rig. Design of Block and Tackle System, Design of Draw works Drum, Top drive drilling, Work over rig.	Ability to select drilling rig suitable and compatible to the formation
2.	**Casing and Drill string design:** Conventional and conditional Casing Design Practices, Deep well strings, Design practices for high inclined, Horizontal and Slanted wells. Liner design and setting. Drill String Design for vertical, directional and horizontal wells.	Ability to design conditional casingand drill string
3.	**Crude oil treatment:** Design of two phase and three phase separators, Heater treaters, Electrostatic heater treaters, Design of heater treaters,	Ability to design the productionsurface facilities
4.	**Design Gas lift system:** Design of Continuous gas lift system (pressure operated valves) - graphical and analytical methods. Design of Intermittent gas lift system; single point injection standard tubing installation (Pressure operated valves) - graphical and analytical methods	Ability to design the production sub-surface facilities
5.	**Design of Pump:** Design of SRP, ESP and PCP system.	Ability to design the production sub-surface facilities
6.	**Design of Compressor, Coil tubing unit.**	Ability to design the production

Text Books:

1. Well Engineering and Construction, Hussain Rabia
2. Surface Productions Operations Volume 1 & 2, Ken Arnold and Maurice Stewart
3. Surface Production Operations, Volumes 1&2, Maurice Stewart and Ken Arnold, Elsevier,2007
4. Technology of Artificial Lift Methods, Kermit E. Brown, PennWell Books,1980
5. Oil Well Drilling Engineering: Principles and Practice, H Rabia, Springer, 1986
6. Well Design: Drilling & Production: Craft, Holden & Graves.

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-03	PE40011	Nuclear Wind and Geothermal Energy	3	0	0	3

Course Objective

1. The course aims to give students a basic understanding of nuclear energy concepts suchas nuclear fission, fusion, nuclear reactors, nuclear fuel, and their management.
2. To facilitate the students to achieve a clear conceptual understanding of technical andcommercial aspects of wind energy generation.
3. To be familiar with fundamental concepts of geothermal energy generation.

Learning Outcomes

1. At the end of the course, students will learn and understand fundamental concepts of nuclear energy generation which include nuclear fission, fusion, nuclear reactors, nuclearfuel, and their management.
2. On completion of this course, the students will be able to exhibit conceptual knowledge of the technology, economics, and viability of wind energy generation.
3. Students will get to know about basic concepts of geothermal energy.

Unit No.	Topics to be Covered	Learning Outcome
1	Nuclear Energy: Basic nuclear models, radioactivity, nuclear reactions – energy systems based on fission &fusion reactions.	The course aims to give students a basic understanding of nuclear energy concepts such as nuclear fission, fusion, nuclear reactors, nuclearfuel, and their management.
	Reactor heat generations and removal; Nuclear Fuelcycle from Uranium / Thorium supply, enrichment.	
	Fuel management and waste disposal.	
	Interaction of ionizing radiation with matter, radiationdetection, shielding, and effects on human health.	
2	Wind Energy: Introduction to wind resources: windspeed and terrain properties, power density; Measurement of wind speed and turbulence.	On completion of this course, the students will be able to exhibit conceptual knowledge of the technology, economics, and viability of wind energy generation.
	Offshore wind farm: Dynamic wind and wave loadings,grid integration, operational and maintenance strategies.	
	Cost of energy from wind turbine during lifetime.	

3	Nature, occurrence, types and classification of geothermal fields;	Students will get to know about basic concepts of geothermal energy.
	Resource Exploration and Characterization.	
	Geothermal Energy Recovery.	
	Analysis of energy system proposals with reference to engineering, economic, socio-political, and environmental objectives.	

References

1. Murray, R. and Holbert, K.E., 2014. Nuclear energy: an introduction to the concepts,systems, and applications of nuclear processes. Elsevier.
2. Manwell, J.F., McGowan, J.G. and Rogers, A.L., 2010. Wind energy explained: theory,design and application. John Wiley & Sons.
3. Grant, M.A. and Bixley, P.F. Geothermal Reservoir Engineering. Second Edition. Elsevier.2011.
4. Glassley, W.E. Geothermal Energy. Second Edition. CRC Press. 20.

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective III	CH 40011	Hazardous Waste Treatmentand Safety Devices	3	0	0	3

Unit No.	Topics to be Covered	Learning Outcome
1.	• Fundamental knowledge of hazardous waste, their sources, generation, identification, classification and characterization. • Health and safety related problems of hazardous waste, routes of migration. • Minimization Technologies of hazardous waste. • Hazardous waste treatment and its disposal. • Regulatory aspects of hazardous wastes: regulation on storage handling and transportation of hazardous waste. • Clean-up of hazardous waste contaminated sites. • Risk assessment and hazardous waste management. • Management of hazardous waste case studies:pesticides and containers. • Management of hazardous nuclear waste.	

Text Books:

1. Michael D. Lagrega, Phillip L. Buckingham, Jeffrey C. Evans, Hazardous Waste Management.
2. Waveland Pr Inc. (2010).
3. S. Bhatia, Solid and Hazardous Waste Management. Atlantic (2007).
4. Mackenzie Davis, David Cornwell, Introduction to Environmental Engineering. McGraw Hill Indian Edition (2017)

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-03	CH 40006	Analytical Techniques	3	0	0	3

Course Objective

The objective of the course is to provide technical prospectus and overview of different analytical techniques for spectroscopic, spectrometric, microscopic, thermal and chromatographic characterization of materials.

Learning Outcomes

By the end of the course, the students will be able to,

1. Understand the basics and application of different analytical techniques andinstrumentation used in different analytical laboratories for material characterization.
2. Categorically interpret the fundamental properties of the material using spectroscopic, spectrometric,microscopic, thermal and chromatographic characterization instruments.

Unit No.	Topics to be Covered	Learning Outcome
1.	**Spectroscopy:** Introduction, Spectroscopy methods: Infrared, UV-Visible, Fluorescence, Nuclear Magnetic Resonance, AtomicAbsorption.	Learn Fundamentals, Working and Instrumentation of Spectroscopy.
2.	**Spectrometry:** Mass, Matrix-assisted laser desorption/ionization (MALDI).	Learn Fundamentals, Working and Instrumentation of Spectrometry.
3.	**Microscopy:** Introduction, Atomic Force Microscopy, Field Emission Scanning Electron Microscope with EDXS (Energy-dispersive X- ray spectroscopy), Transmission Electron Microscopy, Laser Scanning Confocal Microscopy, Confocal Raman.	Learn Fundamentals, Working and Instrumentation of Microscopy.
4.	**Thermal analysis:** Differential Scanning Calorimetry, Thermal Gravimetric Analysis.	Learn Fundamentals, Working and Instrumentation of ThermalAnalysis techniques.
5.	**Chromatography:** Introduction, Thin-Layer Chromatography, Types of Column Chromatography: Affinity and Ion Exchange, Gel Permeation and HPLC, Gas Chromatography–Mass Spectrometry.	Learn Fundamentals, Working and Instrumentation of Chromatography.

Text Book:

1. Keith Wilson and John Walker, Principles and Techniques of Biochemistry and molecular Biology, Cambridge University Press; 8th Edition,Cambridge University Press, (2018).

2. D. A. Skoog and D. M. West, Fundamentals of analytical chemistry, Cengage Publishers; 9th Edition. Cengage Publishers, (2014)R. M. Silverstein, F. X. Webster, D. J. Kiemle and D. L. Bryce, Spectrometric Identification of Organic Compounds, Wiley Publishers; 8thEdition, Wiley, (2014).

3. D. B. Williams and C. B. Carter, Transmission electron microscopy-a text book for material science, Springer Publishers; 2nd Edition ,Springer, (2009).

Reference:

1. G. D. Christian, P. K. Dasgupta and K. A. Schug, Analytical Chemistry, Wiley Publishers;7th Edition , Wiley, (2013)

2. Introduction to Polymer Science. Charles E. Carreher. Jr.,4th Edition,CRC Press, (2017).

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective - IV	PE 40003	Natural Gas Engineering	3	0	0	3

Course Objective

The objective of the course is to provide the basic knowledge of natural gas production, natural gas processing and gas transportation. This course also covers both upstream and refining process related to natural gas and along with highlighting the current status of production of natural gas through unconventional sources/technics and the utilization of natural gas in various forms and their value chains.

Learning Outcomes

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

(a) Explain Natural Gas Significance in Global energy scenario, its composition andutilization.
(b) Explain the Phase behavior of Natural gas and Calculate Natural Gas Properties based onits composition.
(c) Explain the subsurface well completion methods and wellbore performance.
(d) Design surface compression, dehydration, sweeting units required for natural gasprocessing.
(e) Explain transportation, storage and metering process of natural gas and conversion ofnatural gas to CNG and LPG.
(f) Explain LNG and CNG value chains.

Unit No.	Topics to be Covered	Learning Outcome
1	**Introduction:** Composition of Natural Gas, Utilization of Natural Gas, Natural Gas Industry, Natural Gas Reserves, Types of Natural Gas Resources, Future of the Natural Gas Industry.	Explain Natural Gas Significance in Global energyscenario, its composition and utilization.
2	**Properties of Natural Gas:** Phase Behaviour, properties of Natural Gas, Formation Volume Factor, etc., Determination of natural gas properties such as specific gravity, pseudocritical properties, viscosity, compressibility factor, gas density, formation andexpansion volume, and compressibility.	Explain the Phase behavior of Natural gas and Calculate Natural Gas Properties based onits composition.
3	**Production of Natural Gas:** Overview of wellCompletion and wellbore Performance.	Explain the subsurface well completion methods and wellbore performance.
4	**Gas Gathering system, transportation and Storage:** Gas Gathering system, Transmission of Natural gas, Transportation and Measurement, Pipeline Design. Flow through pipeline, issues and solutions. Underground storage. Natural Gas Metering.	Explain transportation, storage and metering process of naturalgas and conversion of natural gas to CNG and LPG.

5	**Natural Gas Processing & surface facilities:** Gas Compressor, Compressor design, Gas Flow Measurement, Principle of Separator, Design of Separator. Dehydration of Natural Gas, Design of Dehydration, Sweeting processes and sulphurrecovery, Processing of LPG, CNG system, Conversion of gas to liquid.	Design surface compression, dehydration, sweeting units required for natural gas processing.
6	**Gas Supply/Distribution:** City Gas/CNG development, CNG stations, Design aspects for City Gas Network and CNG Stations, Maintenance and safety of City Gas Networks and CNG equipment. • LNG: Import of LNG, LNG liquefaction plant and shipping, LNG regasification, LNG Plant.	Explain LNG and CNG valuechains.

Text Books:

(a) B. Guo and A. Ghalambor, Natural Gas Engineering Handbook, Gulf PublishingCompany, 2005.
(b) T. Ahmed and P. D. McKinney, Advanced Reservoir Engineering, Elseveir, 2005.
(c) D.L. Katz and R.L. Lee, Natural Gas Engineering, M

Course Type	Course Code	Name of Course	L	T	P	Credit
OP_04	PE 40012	Advanced Reservoir Modelling	3	0	0	3

Unit No.	Topics to be Covered	Learning Outcome
1.	Geostatistical modeling, quantification of connectivity, lithofacies, porosity, permeability using variogram, krigging techniques; Construction of heterogeneous reservoir models, constrained to well and seismic data; Upscaling and ranking; Stochastic simulation and modeling; Overview of uncertainty analysis and integrated studies; Case studies.	

Text Books:

1. M.J. Pyrez and C.V. Deutsch, Geostatistical Reservoir Modeling. Oxford University Press.
2. J. Caers, Modeling Uncertainty in Earth Sciences. Wiley Blackwell.
3. Matlab Reservoir Simulation Toolbox. SINTEF.
4. S. Cannon, Reservoir Modeling: A Practical Guide. Wiley

Course Type	Course Code	Name of Course	L	T	P	Credit
OP_04	PE 40003	Petroleum Refinery Engineering	3	0	0	3

Course Objective

The objective of the course is to provide technical prospectus and overview of differentprocesses and unit operations in petroleum refineries to the students.

Learning Outcomes

At the end of the course, the student will be able to

1. Characterize the crude based on the assay data and interpret different parameters associated with the crude characterization and petroleum products to different unit operations in the refinery.
2. Obtain technical information and overview of various unit operations in petroleum refinery with respective feed, products and process parameters of each unit operation inthe refinery.

Unit No.	Topics to be Covered	Learning Outcome
1.	Origin of petroleum crude oil. Evaluation of crude oil – evaluation and characterization of crude oil: TBP and other distillation tests. Petroleum products, their properties, specification and testing – different properties like flash point, fire point, smoke point, aniline point, carbon residue, kinematic viscosity, pour point, freezing point etc. Use of crude book data.	To understand the origin of Crude , understand different petroleum products and their properties.
2.	Petroleum refinery distillation – pre- fractionation and atmospheric distillation of crude. Process design for atmospheric distillation. Stabilization of naphtha. Vacuum distillation of RCO.	Understand various distillation processes of crude refining.
3.	Reforming of naphtha. Isomerization and Alkalization, Other secondary processes like Vis-breaking, Furfural/Phenol/NMP extraction, Solvent dewaxing, propane deasphalting. Delayed coking process. FCC unit.	Understanding processing ofNaphtha reforming.
4.	Hydrotreatment processes in refining: Hydro-Desulfurisation, Hydrofinishing, Hydrocraking, and Production of lube oil base stock. Residual Hydrocracking.	Understanding Hydrotreatment processes in Refining.
5	Refinery equipment: furnaces, distillation columns, reactors, pumps, compressors and piping.	Understanding refinery Equipment Design and Environmental Impact.
6	Elements of design of stream reformer naphthacracker, catalytic reformer etc.	
7	Environmental impact of refineries.	

Text Book:

1. Petroleum Refinery Engineering by W. L. Nelson,4th Edition, McGraw-Hill, (1958).
2. Petroleum Refining, Technology & Economics by J. H. Gray & G. E. Handwerk,5th Edition, CRC Press, (2007).
3. Petroleum Refinery Distillation by R. N. Watkins,2nd Edition, Gulf publishing company,(1979).
4. Modern Petroleum Refining Processes by B. K. B. Rao, 6th Edition, CBS Publishers,(2014).
5. Fundamentals of Petroleum and PetroChemical Engineering by Uttam Ray Chaudhuri, CRCPress,1st Edition,(2011).

Reference:

1. The Chemistry & Technology of Petroleum by J. G. Speight, CRC Press, 5th Edition, 2014.

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-04	CH 30009	Air Pollution Control	3	0	0	3

Course Objective

To provide the scientific and technical background of air pollution, its monitoring techniques,transport and dispersion modeling, and air pollution control technologies.

Learning Outcomes

Identify the major sources of air pollution and understand their adverse effects on health andenvironment. Evaluate the dispersion of air pollutants in the atmosphere and to develop air quality models.Choose and design control techniques for particulate and gaseous emissions.

Unit No.	Topics to be Covered	Learning Outcome
1.	**Introduction**: Introduction to principal aspects of air pollution; History of air pollution; Sources of air pollution; Effects of major air pollutants; Current policies, standards and objectives; Airpollution legislation.	Identify the major sources ofair pollution and understand their adverse effects.
2.	**Meteorology and air quality modeling:** Meteorology as applied to air pollution and dispersion of air pollutants; Atmospheric chemistry, Aerosol behaviour; Transport and dispersion modeling. Commercial air quality models (ADMS and USEPA).	Understand the dispersion of air pollutants in the atmosphere and to develop airquality models.
3.	**Monitoring and control techniques:** Monitoring of emissions and air pollutants in ambient air; Engineering control of stationary sources; Modeling and control of emission from road transport and from industrial sources. Selection of control equipments; Process change, fuel change; pollutant removal and disposal of pollutants; Control devices and systems, removal of dry particulate matter, liquid droplets and mist removal, gaseous pollutants and odor removal.	Learn fundamental aspects of sampling techniques and design aspects of air pollution control techniques.
4.	Indoor air pollution: Indoor air pollution; Personal exposure to air pollution.	Learn Indoor air pollution, causes, and their control techniques.
5.	Economics in air pollution control: Economicsand trends in air pollution control.	Economic aspects associatedwith air pollution.

Text Books:

1. H.S. Peavy, D. R. Rowe, G. Tchobanoglous, Environmental Engineering, Mcgraw-Hill(1985).
2. M.N. Rao, H.V.N. Rao, Air Pollution. McGraw Hill, Indian Edition (2017).

References:

1. Richard C. Flagan, John H. Seinfeld, Fundamentals of Air Pollution Engineering. PrenticeHall (1988).
2. Noel de Nevers, Air Pollution Control Engineering, Waveland Press, Inc (2010).

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-04	-	Tribology & Introduction tothe Lubricants	3	0	0	3

Unit No.	Topics to be Covered	Learning Outcome
1.	The fundamentals of lubricants business: • Lubricant value chain. • Types of Lubricants- Automotive, Industrial, Marine,Railroad, Air. • Applications of lubricants – Automotive (Trucks,Cars, 2-Wheelers, Tractors, Gear Oils, Natural Gas. • Engine Oils etc.) and Industrial (Cutting Oils, Rust Preventives, Rolling Oils, Compressor Oils, Hydraulic, Drilling Oils etc.) • Properties of Lubricants. • Bio-Lubricants.	
2.	• Fundamentals of Base Oils. • Type of Crude Oils. • Refinery process – Brief introduction. • Base Oil Groups. • Properties of Base Oils.	
3.	Fundamentals of Additives • Properties & key characteristics. • Composition of additives for various applications. • Additive Chemistry. • Types of additives. • Performance contribution of additive to Lubricants.	
4.	Lubricants – Automotive • Understanding of Key specifications like API, JASO,ACEA. • Global Specifications and Viscometrics. • India- Current scenarios of Lubricants in India &Future trends.	
5.	Lubricants-Industrial, Marine, Railroad, Air sector Indian Lubricant Market- • Current size & key players. • Growth Potential.	
6.	New trends impacting lubricants, base Oils and additiveindustry • BS IV to BS VI Transition by 2020. • Transition towards high-quality lighter lubricants. • New slate of Base Oils over next 10 years.	
7.	Finance and Cost optimization of Lubricants • Tools and techniques: value engineering and collaborative optimization. • Global best practices to drive down the total costs of ownership.	

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-04		Energy Storage Systems	4	0	0	4

Course Objective

1. This course covers the necessary technical knowledge of the fundamental principles and application areas of proven technologies for energy storage solutions. And to studydetails of various energy storage systems along with applications and enable to identify the optimal solutions to a particular energy storage application.

Learning Outcomes

1. After successful completion of the course, students will be able to: Students can identify available technologies for energy storage and their typical application areas with their advantages and development challenges and summarize the demand for further development, potential improvements, and possibilities for innovative solutionsin the energy storage subject field.

Unit No.	Topics to be Covered	Learning Outcome
1.	Scientific and engineering fundamentals ofall significant energy storage methods, different types of energy storage systems (ESS), and their working principals;	Students can discuss energy storage systems and provide an understanding and appreciation ofthe scientific principles.
2.	Storage of energy as hydroelectric pumped storage, thermal, compressed air storage, flywheel storage, mechanical, electrostatic, and magnetic systems, phase transitions andreversible chemical reactions, organic fuels and hydrogen, and electrochemical systems;	Student will be able to relate with various upcoming energy storage technology.
3.	Energy storage technologies; basics of batteries; materials and methods; electrochemical ESS types.	They learned about the variousparts of the battery and their functions.
4.	Safety issues; model codes and standards; traditional and emerging battery systems, EVand automotive technologies.	Understand how cells are used for everyday purposes: road, water, and air transport vehicles, portable and stationary use.

Text Book:

1. Fundamentals of Energy Storage by J. Jensen and B. Sorenson, Wiley-Interscience, NewYork.
2. Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles by San Ping Jiang, Wiley.
3. Modern electric, hybrid electric, and fuel cell vehicles fundamentals, theory, and design by

Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, CRC press.

Reference:

1. Energy Storage: Fundamentals, Materials, and Applications, by Robert Huggins, Springer Nature; 2nd ed.
2. Grid-Scale Energy Storage Systems and Applications, Fu-Bao Wu, Bo Yang, Ji-Lei Ye,Elsevier; 1st ed.

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-05	PE40007	Prospecting, Field Developmentand Asset Management	3	0	0	3

Course Objective

The objective of this course is to impart knowledge on various operations that are performedin the field to develop, manage and improve the value of a hydrocarbon asset. This course also aims to introduce basic knowledge on petroleum economics and helps students to makedecisions based on technical and economic feasibility.

Learning Outcomes

Upon successful completion of this course, the students will:

- Have a detail understanding on different activities performed in a field from explorationto abandonment phase.
- Have broad knowledge on petroleum economics and learn to make economic decisions.
- Have gained knowledge on developing, managing and improving the asset value bydifferent reservoir management practices.

Unit No.	Topics to be Covered	Learning Outcome
1.	Life cycle of a hydrocarbon field; Field development workflow; Production scheduling; Probabilistic reserve estimation.	Students will understand about various activities that are performed during different phases (i.e., exploration, appraisal, development, production & abandonment) in lifecycle of a hydrocarbon field. Familiarization on probabilistic reserve estimation by Monte-Carlo simulation.
2.	Project economic evaluation: Capital expenditures and Operating expenditures; cash flow statement; balance sheet; Net Present Value (NPV).	Students will learn in detail about the capital and operating expenditures that incurs during different phases of a hydrocarbon field. Students will learn to: prepare a cash flow statement and balance sheet; and calculate NPV. Students will learn on how to select a economically feasible project among multiple options based on NPV.

3.	Production profile of each field architecture;Offshore field architectures and production systems, Seabed boosting, Field processing facilities and product control; Flow assurance; Flow design of well; Reservoir depletion and field performance.	Students will learn about how production profile varies for different field architectures and how production profile for a field can be improved by technology intervention. Students will learn about how production systems, processing facilities and subsea systems are operated and managed in offshore fields. Students will learn about: flow assurance (i.e., it's importance, different flow assurance problems encountered during production and ways to mitigate the flow assurance); and factors and procedure to be adopted to design a well. Students will learn about: why and how reservoir depletion occurs recovery; how to evaluate the production performance of a field during depletion phase.
4.	EOR screening; Production optimization and integrated asset modeling; Data processing and management; Reservoir management case studies.	Students will learn about: How to select a suitable EOR for a field by manual and computationalmethods. How hydrocarbon production is optimized and how integrated asset modeling is performed; Different dataavailable and how it can be effectively used for improving the asset value. Ways to manage and improve the asset value by analyzing different cases/fields across the world.

Text Books:

1. Oil and Gas Exploration and Production: Reserves, Costs, Contracts. Technip 2011: Nadine Bret-Rouzaut, Jean-Pierre Favennec.
2. Real Time Reservoir Management. SPE (2012): K. Shah, O. Izgec,
3. Integrated Reservoir Asset Management: Principles and Best Practices: J. Fanchi,

References:

1. Integrated Petroleum Reservoir Management: A Team Approach: Abdus Satter, Ganesh Thakur.
2. Advanced Reservoir Management and Engineering:T. Ahmed, D. Nathan Meehan

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-05		Petrochemical Technology	3	0	0	3

Unit No.	Topics to be Covered	Learning Outcome
1.	• Survey of petrochemical industry; Availability of different feed stocks; Production, purification and separation of feed stocks; • Chemicals from methane; Production and utilization of synthesis gas, oxo reactions, etc.; Production of and chemicals from acetylene; Naphtha cracking; • Chemicals from C2, C3, C4 and higher carbon compounds; Polymers - properties, production andutilization; • Catalytic reforming of naphtha and isolation of aromatics; Chemicals from aromatics; Synthetic fibres, detergents, rubbers and plastics; Petroleum coke; • Integration of Petroleum Refining andPetrochemicals	

Text Books:

1. Hydrocarbon Chemistry by G. A. Olah and A. Molna.
2. A. Text on Petrochemicals by B. K. B. Rao.
3. Petroleum Refining, Technology and Economics by J. H. Gary and G. E. Handwerk.

Reference Books:

1. Industrial Organic Chemicals by H. A. Wittcoff and B. G. Reuben.
2. Handbook of Petrochemicals and processes by G. M. Wells.

Course Type	Course Code	Name of Course	L	T	P	Credit
OP-05	CH 40008	Nano Materials for Hydrocarbon Industry	3	0	0	3

Course Objective

- This course aims to train students to understand the concept Nanomaterial science and theirapplication in hydrocarbon Industry.

Learning Outcomes

- Students will understand the concept and science behind Nanomaterials: Synthesis,Characterization and Properties.
- Students will be well ware about the application of nanomaterials specially in HydrocarbonIndustry.

Unit No.	Topics to be Covered	Learning Outcome
1.	Introduction to metallic nanoparticles, metal oxide nanoparticles, carbon nanotubes, magnetic nanoparticles, nanoporous materials.	Students will be acquainted with the nanomaterials world.
2.	Synthesis: Chemical, electrochemical, thin films – CVD, PVD, Langmuir-Blodgett, mechanical (attrition), sol-gel, nanolithography.	Students will know the designand synthesis routes for nanomaterial production.
3.	Functionalization: Ligand incorporation, biomolecule conjugation, polymer coating.	Students will be acquainted with various functionalization techniques.
4.	Physical and chemical properties at nanoscale; Nanomaterial characterization: SEM, TEM, AFM, scanning probe microscopy, scanning tunneling microscopy, diffraction and scattering techniques, vibrational spectroscopy.	Students will be acquainted with various characterizationtechniques.
5	Use of nanomaterials in exploration and reservoir characterization, drilling, cementing, production, stimulation, petroleum refining, fuel production, and chemical sensing, Use of nanomaterials in lubricants.	Students will be well aware about the application of nanomaterials in HydrocarbonIndustry.

Text Books:

1. Dieter Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications.Wiley VCH (2013).
2. Ratna Tantra, Nanomaterial Characterization: An Introduction. Wiley (2016).

References:

1. Dieter Vollath, Nanoparticles – Nanocomposites Nanomaterials: An Introduction for Beginners. Wiley VCH (2013).
2. Daniel L. Fedlheim and Colby A. Foss, Metal Nanoparticles: Synthesis, Characterization,and Applications. CRC Press (2001).

Course Type	Course Code	Name of Course	L	T	P	Credits
OP-05	PE 40013	Process Modelling and Simulation	3	0	0	3

Course Objective

This course is intended to learn development of mathematical models using first principles and data for different chemical engineering and allied processes and also to apply numericalmethods for solving the developed mathematical models. Further, different simulation toolswill be demonstrated.

Learning Outcomes

At the end of the course, the student will be able to:

1. Apply conservation laws for different chemical engineering and allied processes.
2. Analyze ill-conditionality, stiffness and nature of steady states.
3. Develop empirical and grey-box models.
4. Solve ODEs, PDEs, DAEs.
5. Use different software tools for simulation.

Unit No.	Topics to be Covered	Learning Outcomes
1.	Introduction to modeling, a systematic approach to model building, classification of models. Conservation principles, thermodynamic principles of process systems.	Apply conservation laws for different chemical engineering and allied processes.
2.	Development of steady state and dynamic lumped and distributed parameter models based on first principles. Analysis of ill-conditioned systems.	Apply conservation laws for different chemical engineering and allied processes, Analyze ill-conditionality, stiffness and nature of steady states.
3.	Development of grey box models. Empirical model building. Regression. Statistical model calibration and validation. Population balance models. Examples.	Develop empirical and grey-box models.
4.	Solution strategies for lumped parameter models. Stiff differential equations. Solution methods for initial value and boundary value problems. Euler's method. R-K method, shooting method, finite difference methods. Solving the problems using MATLAB/SCILAB.	Solve ODEs, DAEs, Use different software tools forsimulation.
5	Solution strategies for distributed parametermodels. Solving parabolic, elliptic and hyperbolic partial differential equations. Finite element and finite volume methods.	Solve PDEs, Use differentsoftware tools for simulation.

Text Books:

1. Chemical Process Modelling and Computer Simulation, Amiya K. Jana, Prentice Hall, 2011, 2nd Edition.
2. Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, Ashok Kumar Verma, CRC Press, 2014.
3. Process Modelling, Simulation and control for Chemical Engineers, William L. Luyben,McGraw-Hill Publishing Company, 1996, 2nd Edition.

References:

1. Process Modelling and Model Analysis, K. M. Hangos and I. T. Cameron, Academic Press,2001.
2. Mathematical Modelling and Simulation in Chemical Engineering, M. Chidambaram, Cambridge University Press, 2018.

Course Type	Course Code	Name of Course	L	T	P	Credit
Op-05		Hydrogen Energy	3	0	0	3

Course Objective

This course has essential theoretical knowledge to recognize the methods of hydrogen production, purification, storage, and utilization. And to study details of various hydrogenproduction processes and storage systems along with applications and enable to identify the optimal solutions to a particular hydrogen storage application.

Learning Outcomes

On successful completion of this course, students:
Have a basic knowledge of Hydrogen Energy, Properties of Hydrogen, Productionmethods and purification, Storage methods, Safety, Environmental benefits, and Applications in the Hydrogen Economy.

Unit No.	Topics to be Covered	Learning Outcome
1.	Introduction of hydrogen energy systems, the current status of production, storage, andutilization.	To provide comprehensive and logical knowledge of hydrogen production, storage, and utilization.
2.	Hydrogen production processes, steam reformation, gasification, pyrolysis, oxidative and non-oxidative processes, green hydrogen production using nuclearenergy and renewables-wind, biomass, solar;	To know about the chemical and physical foundations of hydrogen fuel production.
3.	Separation and purification; storage, compressed storage, liquid-state storage, solid-state storage, different materials forstorage, Zeolites, Metal hydride storage, chemical hydride storage;	To design and develop a suitable hydrogen storage system to be used along with different types of the cell system.
4.	Hydrogen sensing, hydrogen utilization, hydrogen safety.	To minimize environmental hazards associated with the use of hydrogen storage technology.

Text Book:

1. Michael Hirscher, Hand Book of Hydrogen Storage, McGraw-Hill Professional.
2. J O'M Bockris, Energy options: Real Economics and the Solar Hydrogen System, HalstedPress and London publisher, 1980.
3. M.K.G. Babu, K.A. Subramanian, Alternative Transportation Fuels: Utilization in Combustion Engines, CRC Press, 2013.

Reference:

1. M. Ball and M. Wietschel, The Hydrogen Economy Opportunities and Challenges, Cambridge University Press, 2009.
2. S.A Sherif, D. Yogi Goswami, E.K. Lee Stefanakos, Aldo Steinfeld, Hand Book of Hydrogen Energy CRC Press 2014

भारतीय पेट्रोलियम एवं ऊर्जा संस्थान

Indian Institute of Petroleum and Energy

Visakhapatnam, Andhra Pradesh - 530003

Course Structure (1st Year)

First Semester						
Sl. No.	Course Name	L	T	P	Credits	Remarks
1.	Engineering Mathematics – I (Calculus)	3	1	0	4	
2.	General Chemistry	3	1	0	4	
3.	Engineering Mechanics	3	1	0	4	
4.	Introduction to materials	3	0	0	3	
5.	Engineering Graphics	1	0	3	3	
6.	English for Communication	1	0	2	2	
7.	Electrical Technology	2	0	0	2	Modular
8.	Basic Electronics	2	0	0	2	
9.	Chemistry Lab	0	0	3	3	
10.	EAA I	0	0	0	P/F	
	Total	18	3	8	27	

Second Semester						
Sl. No.	Course Name	L	T	P	Credits	Remarks
1.	Engineering Mathematics – II	3	1	0	4	
2.	Strength of materials	3	1	0	4	
3.	Physics	3	1	0	4	
4.	Programming and Data Structure	3	0	3	5	
5.	Earth Energy and Environment	2	0	0	2	Modular
6.	Fundamentals of Biological System	2	0	0	2	
7.	Electrical and Electronics Lab	0	0	3	2	
8.	Workshop	0	0	3	2	
9.	EAA II	0	0	0	P/F	
	Total	16	3	9	25	

Course Structure (2nd Year)

Third Semester						
Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Numerical Methods & Transform Calculus	4	0	0	4	Institute Core
2	Fluid Mechanics & Multiphase Flow	3	1	0	4	Institute Core
3	Object Oriented Programming	2	0	3	4	Institute Core
4	Sedimentary and Petroleum Geology	3	1	0	4	Dept. Core
5	Transport through porous media	3	0	0	3	Dept. Core
6	Fuel Lab	0	0	3	2	Dept. Practical
7	EAA III	0	0	0	0	P / F
	Total	**15**	**2**	**6**	**21**	

Fourth Semester						
Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Elements of Reservoir Engineering	3	1	0	4	Dept. Core
2	Geo-Mechanics	3	1	0	4	Dept. Core
3	Drilling and Fracturing Technology	3	1	0	4	Dept. Core
4	Hydrocarbon Production Engineering-I	3	1	0	4	Dept. Core
5	Well Logging	3	0	0	3	Dept. Core
6	Geology & Geophysics Lab	0	0	3	2	Dept. Practical
7	Drilling Engineering Lab	0	0	3	2	Dept. Practical
8	EAA IV	0	0	0	0	P / F
	Total	**15**	**4**	**9**	**23**	

Course Structure (3rd Year)

Fifth Semester						
Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Advanced Reservoir Engineering	3	1	0	4	Dept. Core
2	Advanced Drilling Technology	3	1	0	4	Dept. Core
3	Hydrocarbon Production Engineering-II	3	1	0	4	Dept. Core
4	Offshore and Deep sea Technology	3	0	0	3	Dept. Core
5	Petroleum Exploration	3	0	0	3	Dept. Elective
6	Fracturing Lab	0	0	6	2	Dept. Practical
7	Reservoir Engineering lab	0	0	6	2	Dept. Practical
	Total	**15**	**3**	**12**	**22**	

Sixth Semester						
Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Oil & Gas well Testing	3	0	0	3	Dept. Core
2	Enhanced Oil Recovery	3	0	0	3	Dept. Core
3	Pipeline Engineering	3	0	0	3	Dept. Core
4	Data Analytics and AI for Process Industry	3	0	0	3	Dept. Elective
5	Open Electives- 01	3	0	0	3	Open Elective
6	Production Engineering Lab	0	0	6	2	Dept. Practical
7	EOR Lab	0	0	6	2	Dept. Practical
8	Project 1	0	0	6	2	Project
	Total	**15**	**0**	**18**	**21**	

Course Structure (4th Year)

Seventh Semester						
Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Reservoir Simulation	3	1	0	4	Dept. Core
2	HSE	2	0	0	2	Dept. Core
3	Industrial Psychology & Professional Ethics	2	0	0	2	Modular
4	Economics	2	0	0	2	
5	Open Electives- 02	3	0	0	3	Open Elective
6	Reservoir Simulation Lab	0	0	6	2	Dept. Practical
7	Industrial Training	0	0	6	2	
8	Project 2	0	0	6	2	
	Total	**12**	**1**	**18**	**19**	

Eight Semester						
Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Open Electives- 03	3	0	0	3	Open Elective
2	Open Electives- 04	3	0	0	3	Open Elective
3	Open Electives- 05	3	0	0	3	Open Elective
4	Project 3	0	0	18	6	
5	Comprehensive Viva	0	0	6	2	
	Total	**9**	**0**	**24**	**17**	

List of Electives

Open Electives- 01

1. Unconventional Hydrocarbon Resources
2. Bio Energy
3. Waste Water Management
4. Management Techniques for Industrial Sector
5. Principles of Energy Conversion

Open Elective- 02

1. Solar Energy, Photovoltaic Energy
2. Advanced Separation
3. Advanced Material Design
4. Waste to Energy Conversion

Open Elective- 03

1. Petroleum Engineering System Design
2. Nuclear Wind and Geothermal Energy
3. Hazardous Waste Treatment and Safety Devices
4. Analytical Techniques

Open Elective- 04

1. Natural Gas Engineering
2. Advanced Reservoir Modelling
3. Petroleum Refinery Engineering
4. Air Pollution Control
5. Tribology & Introduction to the Lubricants
6. Energy Storage System

Open Elective- 05

1. Prospecting, Field Development and Asset Management
2. Petrochemical Technology
3. Nano Materials for Hydrocarbon Industry
4. Process Modelling and Simulation
5. Hydrogen Energy