Course Structure and Syllabus

4th 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

Course Structure (contd..)

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**	

Seventh Semester

Course Type	Course Code	Name of Course	L	T	P	Credit
Dept. Core	PE40001	Reservoir Simulation	3	1	0	4

Course Objective

1. The purpose of this course is to introduce the fundamental principles and mathematical equations governing fluid flow in reservoir, and formulation of numerical models and solution techniques behind reservoir simulation in order to predict flow of fluids (typicallyoil, water and gas).

Learning Outcomes

At the end of this course, students will be able to:

1. Understand basic concepts and partial differential equations for single phase andmultiphase flow of fluid in reservoir.
2. Use finite difference formulations for numerical predictions of fluid flow behaviour duringinjection or production conduct the calibrations of a reservoir simulation model.
3. Predict and optimize future performance of petroleum reservoirs using reservoirsimulation.

Unit No.	Topics to be Covered	Learning Outcome
1.	Introduction to reservoir simulation.	Concepts of modelling and simulation.
2.	Introduction tc integrated reservoir modeling.	Use of geophysical, geological, petro physical and engineering data with geostatistical methods to create reservoir description.
3.	Basic Equations for single phase flow.	Continuity equation in various flow geometries, Derivation of Generalized flow equations, Different form of flow equations, initial and boundary conditions.
4.	Finite Difference Approximation to linearflow equations.	Method of grid constructions, Approximation of spatial and time derivatives, Implementation of initial and boundary conditions, Explicit and implicit formulations, well representation, treatment of source and sink terms; Stream tube; automatic time step control; simulation of naturally fractured reservoir.
5	Solution techniques of single phase flow equations.	Linearization techniques; incompressible, slightly compressible and compressible flow problems; Use of Balance Calculation in Reservoir Simulation.

6	Multiphase flow simulation.	Concept of Black oil and compositional models; Conservation equations in a multiphase flow system; Flow equations; Finite difference approximation; Simultaneous Solution method, Implicit Pressure Explicit Saturation method, Sequential Solution method. Multiphase flow in two and three dimensions.
7	History matching.	Inverse modeling, parameterization, objective function formation, calibration and tuning algorithm, Bayesian formulation and uncertaintyquantification, optimization algorithms.

Text Book:

1. K. Aziz, A. Settari, Petroleum Reservoir Simulation. Applied Science Publisher (2006).
2. Turgay Ertekin, J.H. Abou-Kassem, and G.R. King, Basic Applied Reservoir Simulation.Society of Petroleum Engineers (2001).

Reference

1. Chen, Zhangxin. Reservoir simulation: mathematical techniques in oil recovery. Society forIndustrial and Applied Mathematics (2007)
2. Shahab D. Mohaghegh, Data-Driven Reservoir Modeling. Society of Petroleum Engineers(2017).
3. James R. Gilman and Chet Ozgen, Reservoir Simulation: History Matching and Forecasting. Society of Petroleum Engineers (2013).

Course Type	Course Code	Name of Course	L	T	P	Credit
Dept Core		Health Safety and Environment (HSE)	2	0	0	2

Course Objective

1. Understand the unsafe situations that can arise in process plants.
2. To take action to make the plant safer.
3. Prevent the accident.
4. Mitigate the consequences should an accident occur.

Learning Outcomes

1. Understand the different unsafe situations that can arise in a chemical plant.
2. Forewarn their subordinates and inform their seniors about unsafe situations.
3. Suggest/ take actions to prevent such situations and mitigate the consequences.

Unit No.	Topics to be Covered	Learning Outcome
1.	Safety in Chemical and Petroleum industry; Setting & layout of chemical plant. Forms of hazards: chemical, toxic, explosion, electrical, mechanical, radiation, noise hazards. Control and prevention of hazards.	Understand basic terminologies ofprocess safety. Will be able to read and appreciatedocuments related to process safety. Case studies.
2.	Toxicity, Asphyxiation, respiratory and skineffect of petroleum hydrocarbons, sour gases. Thresh-hold limits. Analysis of documented accidents: For Petroleum Engineering student only: Leakage of drilling, fracturing and completion fluids, Blow out, effect of corrosive atmosphere	Will understand the entry, metabolismand effect of toxicants in the body. Will understand specific toxicant effects from case studies. Will understand source and dispersionmodels of emissions. Case studies.
3.	Characteristics of chemical with special reference to safe storage & handling. Layout of storage, modes of transport, associated hazards control and prevention. Safety audit: objective, procedure, engineering standards, Factories Act and Regulation, regulating agencies. Offshore safety. Offshore oil spill and oil spill control. Safety and Environmental Management Systems, SEMS	Will appreciate risks and hazards associated with storage and handling of flammable materials. Will understand offshore safetychallenges. Case studies

4.	Risk Analysis: hazard and operability (HAZOP) studies. hazard analysis (HAZAN), fault tree analysis, consequence analysis, scenario and probabilistic assessment. Onshore and Offshore Emergency Management Plans. Safety System: Manual & automatic shutdown system, blow down systems. Gas detection system. Fire detection and suppression systems. Personal protection system & measures. HSE Policies. Disaster & crisis management in Petroleum Industry. Environment: Environment concepts, impact on eco-system, air, water and soil. The impact of drilling & production operations on environment, Environmental transport of petroleum wastes. Waste treatment and disposal methods, remediation of contaminated sites.	Will be able to do risk assessment. Will be familiarize with the safetyaudit and standards.

Text Book:

1. Crowl, D.A., Louvar, J. F., "Chemical Process Safety – Fundamentals with Applications". Prentice-Hall, Pearson, 2011.

Reference:

1. CCPS," Guidelines for Engineering Design for Process Safety", AIChE

Course Type	Course Code	Name of Course	L	T	P	Credit
		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.
3. 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
		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
Dept. Practical	PE 40004	Reservoir Simulation Lab	0	0	3	2

Course Objective

- The objective of this lab is to understand reservoir engineering simulation using state- of-the-art commercial reservoir simulation software and data commonly available in industry where emphasis is paid on reservoir description, reservoir model design and calibration, production forecasting and optimization, economic analysis and decision making under uncertainty.

Learning Outcomes

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

1. Establish reservoir simulation workflow.
2. Create black oil model to simulate reservoir conditions.
3. Model oil recovery from sub-surface using compositional tools.

Unit No.	Topics to be Covered	Learning Outcome
1.	Reservoir simulation basics.	To have basic Understanding the basic concepts of simulation and modelling.
2.	Getting started with CMG.	Using and creating a simple modelwith CMG software.
3.	Building, running and analyzing a “black oil” reservoir simulation model by importing contour map data.	To build, run and analyze a black oil reservoir model in IMEX by importing contour map file and reservoir properties.
4.	Perform history-matching of IMEX reservoir model.	To analyze match between simulation and production data.
5.	Establish a water flood + chemical EORmodel of coreflood using CMG-STARS.	To create a compositional reservoir model in STARS for chemical enhanced oil recovery (cEOR).
6.	Perform history-matching of reservoir orcore model.	To analyze match between simulation and experimental data, and determine rock-fluidparameters.

Electives

Open Electives- 01

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.

Bio Energy

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.)

Open Elective- 02

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.

Open Elective- 03

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).

Open Elective- 04

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.

Open Elective- 05

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

Course Structure

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 (contd..)

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 (contd..)

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 (contd..)

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