**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA**
**KAKINADA – 533 003, Andhra Pradesh, India**

**DEPARTMENT OF PETROLEUM ENGINEERING**

# COURSE STRUCTURE AND SYLLABUS

## For UG – R20

## B. TECH - PETROLEUM ENGINEERING

*(Applicable for batches admitted from 2020-2021)*

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA**

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# DEPARTMENT OF PETROLEUM ENGINEERING

## II Year – I SEMESTER

| S. No | Course Title | Category | Code | Hours per week | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| 1 | Mathematics – III | BS | | 3 | 0 | 0 | 3 |
| 2 | Petroleum Geology | PCC | | 3 | 0 | 0 | 3 |
| 3 | Fluid Mechanics for Petroleum Engineers | PCC | | 3 | 0 | 0 | 3 |
| 4 | Heat Transfer Operations | PCC | | 3 | 0 | 0 | 3 |
| 5 | Material and Energy Balances | PCC | | 3 | 0 | 0 | 3 |
| 6 | Petroleum Geology-Laboratory | PCC | | 0 | 0 | 3 | 1.5 |
| 7 | Fluid Mechanics for Petroleum Engineers-Laboratory | PCC | | 0 | 0 | 3 | 1.5 |
| 8 | Heat Transfer Operations- Laboratory | PCC | | 0 | 0 | 3 | 1.5 |
| 9 | Python Programming | SC | | 1 | 0 | 2 | 2 |
| MC | Environmental Science | MC | | 2 | 0 | 0 | 0 |
| | | | **Total credits** | | | | **21.5** |

## II Year – II SEMESTER

| S. No | Course Title | Category | Code | Hours | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| 1 | Management and Organisational Behaviour | HS | | 3 | 0 | 0 | 3 |
| 2 | Mathematics –IV | BS | | 3 | 0 | 0 | 3 |
| 3 | Instrumentation, Process Dynamics & Control | PCC | | 3 | 0 | 0 | 3 |
| 4 | Thermodynamics for Petroleum Engineers | PCC | | 3 | 0 | 0 | 3 |
| 5 | Drilling & Well Completions | PCC | | 3 | 0 | 0 | 3 |
| 6 | Instrumentation, Process Dynamics & Control -Laboratory | PCC | | 0 | 0 | 3 | 1.5 |
| 7 | Mathematical methods for Petroleum Engineers –Laboratory | PCC | | 0 | 0 | 3 | 1.5 |
| 8 | Drilling Fluids - Laboratory | PCC | | 0 | 0 | 3 | 1.5 |
| 9 | Industry Exploration Project | SC | | 1 | 0 | 2 | 2 |
| **Total credits** | | | | | | | **21.5** |
| **Internship 2 Months (Mandatory) during summer vacation** | | | | | | | |
| **Honors/Minor courses (The hours distribution can be 3-0-2 or 3-1-0 also)** | | | | **4** | **0** | **0** | **4** |

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| II Year - I Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| **MATHEMATICS – III (Vector Calculus, Transforms and PDE)** | | | | | |

**Course Objectives:**

- To familiarize the techniques in partial differential equations
- To furnish the learners with basic concepts and techniques at plus two level to lead them into advanced level by handling various real-world applications.

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

- interpret the physical meaning of different operators such as gradient, curl and divergence (L5)
- estimate the work done against a field, circulation and flux using vector calculus(L5)
- apply the Laplace transform for solving differential equations (L3)
- find or compute the Fourier series of periodic signals (L3)
- know and be able to apply integral expressions for the forwards and inverse Fourier transform to a range of non-periodic waveforms (L3)
- identify solution methods for partial differential equations that model physical processes (L3)

**UNIT –I: Vector calculus: (10 hrs)**
Vector Differentiation: Gradient– Directional derivative – Divergence– Curl– Scalar Potential.

Vector Integration: Line integral – Work done – Area– Surface and volume integrals – Vector integral theorems: Greens, Stokes and Gauss Divergence theorems (without proof) and problems on above theorems.

**UNIT –II: Laplace Transforms: (10 hrs)**
Laplace transforms – Definition and Laplace transforms of some certain functions– Shifting theorems – Transforms of derivatives and integrals – Unit step function –Dirac's delta function Periodic function – Inverse Laplace transforms– Convolution theorem (without proof).
Applications: Solving ordinary differential equations (initial value problems) using Laplace transforms.

**UNIT –III: Fourier series and Fourier Transforms: (10 hrs)**
Fourier Series: Introduction– Periodic functions – Fourier series of periodic function – Dirichlet's conditions – Even and odd functions –Change of interval– Half-range sine and cosine series.
Fourier Transforms: Fourier integral theorem (without proof) – Fourier sine and cosine integrals – Sine and cosine transforms – Properties (article-22.5 in text book-1)– inverse transforms – Convolution theorem (without proof) – Finite Fourier transforms.

**UNIT –IV: PDE of first order**: **(8 hrs)**
Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions – Solutions of first order linear (Lagrange) equation and nonlinear (standard types) equations.

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**UNIT – V: Second order PDE and Applications: (10 hrs)**

Second order PDE: Solutions of linear partial differential equations with constant coefficients –non-homogeneous term of the type $e^{ax+by}, \sin(ax+by), \cos(ax+by), x^m y^n$.

Applications of PDE: Method of separation of Variables– Solution of One-dimensional Wave, Heat and two-dimensional Laplace equation.

**Text Books:**

1. **B. S. Grewal,** Higher Engineering Mathematics, 44th Edition, Khanna Publishers.
2. **B. V. Ramana,**Higher Engineering Mathematics, 2007 Edition, Tata Mc. Graw Hill Education.

**Reference Books:**

1. **Erwin Kreyszig,** Advanced Engineering Mathematics, 10th Edition, Wiley-India.
2. **Dean. G. Duffy,** Advanced Engineering Mathematics with MATLAB, 3rd Edition, CRC Press.
3. **Peter O' Neil,** Advanced Engineering Mathematics, Cengage.
4. **Srimantha Pal, S C Bhunia,** Engineering Mathematics, Oxford University Press.

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| II Year - I Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| **PETROLEUM GEOLOGY** | | | | | |

**Learning Objectives:**
The students will be able to learn:

- The basics of geology, viz: formation of earth, layers of earth and different types of rocks, formation of various types of sedimentary basins for oil and gas accumulation.
- The different geological environments relate to petroleum industry.
- The different sources for hydrocarbons, reservoir and cap-rocks, characterization of reservoir rocks.
- The classification of reservoir pore space, permeability, migration and entrapment, temperature-pressure conditions for the generation of oil and gas from sediments.

**UNIT-I:**
Origin of the earth and envelops of the earth: Crust, mantle, core- internal dynamics process-plate tectonics- continental drift, external dynamic process- weathering, erosion and deposition. Identification of different structural features encountered in oil exploration viz: joints, faults, folds, unconformities. Origin of igneous, sedimentary and metamorphic rocks. Structures and textures-petrographic character of conglomerate, sandstone, shale, limestone and dolomite.

**UNIT-II:**
Introduction to sedimentary basins and deltaic systems: Source rocks- Definition of source rocks, organic source rocks, nature and types of source rocks- shale.
The process of diagenesis, catagenesis and metagenesis in the formation of source rocks, Kerogen-types, thermal maturation, sub-surface pressure temperature conditions for the generation of oil and gas from the source sediments – oil window.

**UNIT-III:**
Characteristics of Reservoir rocks: Classification and nomenclature- clastic reservoir rocks, carbonate reservoir rocks, unconventional, fractured and miscellaneous reservoir rocks, marine and non-marine reservoir rocks - concept of shale oil – $CO_2$sequestration.
Reservoir Properties and Cap Rocks: Reservoir pore space, porosity- primary and secondary porosity, effective porosity, fracture porosity – permeability, saturation- effective and relative permeability relationship between porosity, permeability. Cap rocks: definition and characteristics of cap rocks.

**UNIT-IV:**
Hydrocarbon migration: Geological framework of migration and accumulation, the concept of hydrocarbon migration from source beds to the carrier beds, carrier beds to the reservoir.
Free path ways for migration: short distance and long-distance migration, evidence for migration, oil and gas seepages.

**UNIT-V:**
Entrapment and accumulation of hydrocarbons: Classification and types of traps, structural, stratigraphic and combination type of traps, traps associated with salt domes-delineation of reservoir boundaries.

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Sedimentary Basins: Sedimentary basins -origin and classification, types of basins and their relationship to hydrocarbon prospects, tectonic classification, stratigraphic evolution and hydrocarbon accumulations of the following basins: Krishna - Godavari basin, Assam – Arakan basin, Cambay basin and Mumbai off-shore.

**Outcomes:**
The students are able to:

- Discern the dimension of the earth structure, composition, origin of the earth. It deals essence of scientific studies dealing with the origin, age, structure of the earth and with the evolution, modification, and extinction of various surface and subsurface physical features.
- Apply the concepts of igneous, sedimentary, metamorphic rocks to evaluate drilling operations.
- Identify different source rocks from which hydrocarbons are generated.
- Apply the concepts of formation of source rocks to identify the migration characteristics of hydrocarbons.
- Classify the sources of reservoir rocks, pore space, porosity.
- Gain knowledge of fluid hydrocarbons migration.
- Classify and evaluate the sedimentary basins in India.
- Evaluate and solve technical problems related to the exploration and production of hydrocarbon reservoirs.

**Text Book:**

1. Geology of Petroleum, A.I. Levorsen, 2nd Edition. CBS, Publishers, 2006.

**Reference Books:**

1. Elements of Petroleum Geology, Richard, C. Shelley, Elsevier, 1997.
2. Sedimentary basins of India- ONGC bulletin.
3. Unconventional Petroleum Geology, Caineng Zou et al., Elsevier, 2013.

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| II Year - I Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| **FLUID MECHANICS FOR PETROLEUM ENGINEERS** | | | | | |

**Learning Objectives:**

The students will be able to learn:

- The fluid flow in circular and non-circular conduits as well as the flow past solids.
- Calculations associated to the estimation of friction factor and pressure drop in the circular conduits.
- The basic concepts of fluidization and to estimate pressure drop in packed and fluidized beds.
- The Bernoulli's equation for the transport of acidic, alkaline, hydrocarbon and miscellaneous incompressible fluids in pipelines.
- The pressure drops and energy requirements associated to compressible fluid flow in circular and rectangular ducts.
- The principles of fluid flow in various types of pumps, fans and blowers.
- The concepts of various flow measuring devices.

**UNIT-I:**
Basic concepts of dimensional analysis, nature of fluids, hydrostatic equilibrium, applications of fluid statics.
Fluid flow phenomena-laminar flow, shear rate, shear stress, rheological properties of fluids.
Difference between flow through pipes and porous media.

**UNIT-II:**
Basic equation of fluid flow –mass balance in a flowing fluid; continuity, differential momentum balance; equations of motion, macroscopic momentum balances, mechanical energy equations.
Incompressible Newtonian/non-Newtonian flow in pipes and channels- shear stress and skin friction in pipes, laminar flow in pipes and channels, turbulent flow in pipes and channels, friction from changes in velocity or direction, losses in pipes.

**UNIT-III:**
Flow past immersed bodies, drag and drag coefficient, flow through beds of solids, motion of particles through fluids.
Fluidization, conditions for fluidization, minimum fluidization velocity, types of fluidizations, expansion of fluidized bed, applications of fluidization, continuous fluidization, slurry and pneumatic transport.

**UNIT-IV:**
Transportation and metering of fluids- pipes, fittings and valves, pumps: positive displacement and centrifugal pumps.
Measurement of flowing fluids: full bore meters, insertion meters; venturi meter, rotameter, orifice meter, hot wire anemometer, Pitot tube, and other flow metering devices.

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**UNIT-V:**
Flow of compressible fluids- definitions and basic equations, processes of compressible flow, isentropic flow through nozzles, adiabatic frictional flow, and isothermal frictional flow. Compressors, fans, blowers, steam ejectors and jets.
Flow through porous media and application of Darcy's law.

**Outcomes:**
The students are able to:

- Analyze fluid flow in circular and non-circular conduits.
- Do the calculations associated with the estimation of friction factor and pressure drop in circular conduits.
- Perform the calculations involving Bernoulli's equation for the transportation of incompressible and compressible fluids.
- Estimate pressure drop in packed and fluidized beds.
- Carry out calculations associated with fluid flow in pumps, compressors, fans and blowers.
- Calculate, analyze and calibrate various flow measuring devices.

**Text Books:**

1. Unit Operations of Chemical Engineering, McCabe,W.L., J.C.Smith& Peter Harriot McGraw-Hill, 7th Edition, 2001.
2. Fluid mechanics for Petroleum Engineers, Elemer Bobok, Elsevier,1993.

**Reference Books:**

1. Introduction to Fluid Mechanics, Fox, R.W. and A. T. McDonald, 5th Edition, John Wiley& Sons, 1998.
2. Transport Processes and Unit Operations, Christie J. Geankoplis, PHI, 2003
3. Chemical Engineering, Vol-1: Fluid flow, Heat Transfer and Mass Transfer, J. M. Coulson and J. F. Richardson, Pergamon Press, 4th Edition, 1990.
4. Fluid Mechanics for Chemical Engineers, Noel De Nevers, Tata McGraw-Hill, 2011.
5. Fluid Flow for Chemical and Process Engineers, Bragg R and F. A. Holland, 2nd Edition, Hodder Stoughton Educational, 1995.
6. Fluid Flow for the Practicing Chemical Engineer, Patrick Abulencia, J and Louis Theodore, John wiley and Sons, 2009.

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| II Year - I Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| **HEAT TRANSFER OPERATIONS** | | | | | |

**Learning Objectives:**
The students will be able to learn:

- The importance of heat transfer in process Industries. Learn different modes of heat transfer and difference between steady and unsteady state heat conduction.
- The importance of LMTD and learn construction and working of different types of heat exchangers.
- The different convective methods and analogy between momentum, heat and mass transfer.
- The phenomena of heat transfer by conduction, convection & radiation.
- The methodology to carry out the detailed process design of shell and tube heat exchangers.

**UNIT-I:**
Importance of heat transfer in process Industries and Conduction: Nature of heat flow, Modes of heat transfer, Fourier's law, Thermal conductivity and its variation with temperature.
Steady state heat conduction: heat conduction through porous media, composite wall and resistance in series.
Unsteady state heat conduction: Equation for one-dimensional conduction with constant surface temperature and varying surface temperature; Semi-infinite solid.

**UNIT-II:**
Principles of heat flow in fluids: Typical heat exchange equipment, counter current and parallel current flows, energy balances, rate of heat transfer, overall heat transfer coefficient, electrical analogy, critical radius of insulation, logarithmic mean temperature difference. Variable overall coefficient, multi-pass in exchangers, individual heat transfer coefficients, resistance form of overall coefficient, fouling factors, classification of individual heat transfer coefficients, magnitudes of heat transfer coefficients, effective coefficients for unsteady-state heat transfer

**UNIT-III:**
Heat Transfer to Fluids without Phase change: Regimes of heat transfer in fluids, thermal boundary layer, heat transfer by forced convection in laminar flow, heat transfer by forced convection in turbulent flow, the transfer of heat by turbulent eddies. Analogy between transfer of momentum and heat, heat transfer to liquid metals, heating and cooling of fluids in forced convection outside tubes.
Heat transfer to fluids with phase change: Heat transfer from condensing vapors, heat transfer to boiling liquids.

**UNIT-IV:**
Natural convection: Natural convection to air from vertical shapes and horizontal planes, effect of natural convection in laminar flow heat transfer.
Radiation: Properties and definitions, black body radiation, real surfaces, and the grey body. Absorption of radiation by opaque solids, radiation between surfaces, radiation and shielding, combined heat transfer by conduction, convection and radiation.

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**UNIT-V:**
Heat exchange equipment design: General design of heat exchange equipment, heat exchangers, condensers, boilers and extended surface equipment, heat transfer in agitated vessels, scraped surface heat exchangers, heat transfer in packed beds, heat exchanger effectiveness (NTU method).
Evaporators: Types of evaporators, performance of tubular evaporator. Capacity and economy, methods of feeding, multiple effect evaporators, vapor recompression.

**Outcomes:**
The students are able to:

- Apply the fundaments of heat transfer in process Industries.
- Differentiate the modes of heat transfer, steady and unsteady state heat conduction.
- Calculate the LMTD
- Apply the principles of convection to design various heat transfer equipment.
- Analyze the phenomena of heat transfer by conduction, convection & radiation.
- Carry out the detailed process design of shell and tube heat exchangers.

**Text Books:**

1. Unit Operations of Chemical Engineering, McCabe, W.L., J.C Smith and Peter Harriott, 7th Edition, McGraw-Hill, 2005.
2. Process Heat Transfer, D.Q. Kern, Tata- McGraw-Hill, 1997.
3. Heat Transfer, Holman, J.P., 9th Edition, Tata McGraw-Hill, 2008.

**Reference Books:**

1. Heat Transfer, Y.V.C. Rao, Universities Press (India) Pvt. Ltd., 2001.
2. Schaum's Outline of Heat Transfer, Donald Pitts and L. E. Sisson, 2nd Edition, McGraw-Hill, 1998.
3. A Text Book on Heat Transfer, Sukhatme, P., 5th Edition, Universities Press (India) Pvt. Ltd., 2005.
4. Heat Transfer: Principles and Applications, Binay Dutta, K., PHI Learning, 2009.
5. Chemical Engineering: Fluid Flow, Heat Transfer and Mass Transfer, Coulson, J.M.; Richardson, J.F.; Backhurst, J.R.; Harker, J.H., Vol.1, 6th Edition, Reed Elsevier India, 2006.

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## DEPARTMENT OF PETROLEUM ENGINEERING

| II Year - I Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| **MATERIAL AND ENERGY BALANCES** | | | | | |

**Learning Objectives:**

The students will be able to learn:

- Unit conversions in process calculations.
- The elementary material balances in physical and chemical processes.
- The elementary energy balances in reactive and non-reactive processes.
- Formulation of combined material and energy balances for combustion of fuels.
- The relevance of thermodynamics in process calculations.
- The complex process calculations using MS Excel/MATLAB.

**UNIT-I:**
Stoichiometric relations: Basis of calculations, methods of expressing compositions of mixtures and solutions, density and specific gravity, Baume and API gravity scales, units and inter conversions.
Behavior of Ideal gases: Kinetic theory of gases, application of ideal gas law, gaseous mixtures, gases in chemical reactions.

**UNIT-II:**
Material balances: Tie components, yield and material balance with and without reaction, conversion. Material balance calculations in simple drying, dissolution and crystallization processes. Processes involving chemical reactions. Processes involving recycles, bypass, purge and other complexities.

**UNIT-III:**
Energy Balances: Energy, energy balances, heat capacity of gases, liquid and mixture solutions. Kopp's rule, Latent heats, heat of fusion and heat of vaporization, Trouton's rule, Kistyakowsky equation for nonpolar liquids enthalpy and its evaluation.
Calculation and applications of heat of reaction, combustion, formation and neutralization, Kirchhoff's equation, enthalpy concentration change, calculation of theoretical and actual flame temperatures.

**UNIT-IV:**
Vapor pressure and VLE: Liquefaction and liquid state, vaporization, boiling point, Effect of temperature on vapor pressure, Antoine equation, vapor pressure plots (ternary), estimation of critical properties, vapor pressure of immiscible liquids and ideal solutions, Raoult's law, non-volatile solutes.
Humidity and Saturation: Relative and percentage saturation or dew point, wet bulb and dry bulb temperature, use of humidity charts for engineering calculations

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**UNIT-V:**
Combustion Calculations: Introduction to fuels, calorific value of fuels, coal, liquid fuels, Gaseous fuels, air requirement and flue gases, combustion calculations, incomplete combustion, material and energy balances, thermal efficiency calculations.

**Outcomes:**
The students are able to:

- Apply the unit conversions fundamentals in process calculations.
- Formulate and solve elementary material balances in physical and chemical processes.
- Formulate and solve elementary energy balances in reactive and non-reactive processes.
- Apply the concepts and solve the combined material and energy balances in combustion calculations.
- Impart the thermodynamics in process calculations.
- Conceptualize an integrated methodology that encompasses the knowledge in other subjects (Physical Chemistry, Thermodynamics and Mathematics) and MS Excel/MATLAB for a systematic and structured approach towards chemical process calculations.

**Text Books:**

1. Chemical Process Principles, Part-I, Material and Energy Balances, Hougen O A, Watson K. M. and Ragatz R.A., 2nd Edition, CBS Publishers & distributors, New Delhi, 2010.
2. Basic Principles and Calculations in Chemical Engineering, D.H. Himmelblau, 7th Edition. PHI, New Delhi, 2009.

**Reference Books:**

1. Elementary Principles of Chemical Processes, R. M. Felder and R. W. Rousseau, 3rd Ed., Wiley, 1999.
2. Handbook Chemical Engineering Calculations, N. Chopey, 3rd Edition, Mc-Graw Hill, 2004.
3. Stoichiometry, Bhatt, B. I., Thakore S. B., 5th Ed., Tata Mc-Graw Hill Education 2010.
4. Stoichiometry and Process Calculations, K. V. Narayanana and B. Lakshmikutty, PHI Learning Private Ltd., 2017
5. Principles of Chemical Engineering Processes: Material and Energy Balances, Nayef Ghasem and R. Henda, 2nd Edition, CRC Press, 2015.

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| II Year - I Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 1.5 |
| **PETROLEUM GEOLOGY - LABORATORY** | | | | | |

**Learning Objectives:**
The students will be able to:

- Distinguish between sandstone and carbonate reservoir rocks.
- Differentiate source rocks and the reservoir rocks.
- Identify location of outcrop on the topo-sheet.
- Learn the locational geological mapping and traversing.
- Measure strike and dip.
- Learn the importance of litho-stratigraphic columns and plotting geological cross sections.
- Determine the location of oil-water contact in the reservoir.

**List of Experiments:**

1. Identifying the distinction between sandstone and carbonate reservoir rocks.
2. Location of observed outcrop on the topo-sheet. Locational Geological mapping and traversing.
3. Measurement of the strike, dip along for the calculation of apparent and true thickness of outcrops.
4. Preparation of correlations for litho stratigraphic columns and estimation of geological cross section.
5. Preparation of structural contour map and location of Oil Water Contact (OWC)
6. Identification of various hydrocarbon traps.
7. Mapping of contour lines/ Isolines for different geological structures.
8. Correlation of SP and $\gamma$- ray data for well lithology.
9. Mapping of the migration petroleum system.
10. Identifying source rock parameters

**Outcomes:**
The students will be able to:

- Assess the differences between sandstone and carbonate reservoir rocks.
- Identify the various hydrocarbon traps.
- Plot the litho stratigraphic column graphically and estimate the geological cross-section.
- Correlate the SP and Gamma ray data for well mapping.
- Plot contour lines for interpretation of a geological structure.
- Calculate the source rock parameters.
- Map the migration petroleum systems.
- Confirm the height of the oil-bearing sand.
- Use the maps to estimate reservoir area and thickness.

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| II Year - I Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 1.5 |
| **FLUID MECHANICS FOR PETROLEUM ENGINEERS – LABORATORY** | | | | | |

**Learning Objectives:**

The students will be able to learn:

- The discharge coefficient of orifice, venture & notches.
- The point velocity using pitot tube
- Measure the average velocities and flowrates using various devices.
- Estimate the skin and form frictional losses in pipes and fittings,
- Verify the Bernoulli's and Ergun equations in packed and fluidized beds,
- Verify Newton's law of viscosity.
- Estimate of mechanical efficiency of centrifugal pump.
- Hands-on experience and communication skills will be achieved.
- Verify Stoke's law and to determine terminal velocity.
- The determination of discharge coefficient of orifice, venture & notches.
- The friction factors in pipes.
- The pressure drop calculations in packed and fluidized beds.
- Fluid viscosity, characteristics of centrifugal pump, characterization of fluid flow, verification of Bernoulli's theorem, and measurement of point velocities. Hands-on experience and communication skills will be achieved.

**List of Experiments:**

1. Identification of laminar and turbulent flows; Major equipment - Reynolds's apparatus
2. Measurement of point velocities; Major equipment - Pitot tube setup
3. Verification of Bernoulli's equation; Major equipment – Bernoulli's Apparatus
4. Calibration of Rotameter; Major equipment – Rotameter Assembly
5. Variation of Orifice coefficient with Reynolds Number; Major equipment - Orifice meter Assembly.
6. Determination of Venturi coefficient; Major equipment – Venturi meter Assembly
7. Friction losses in Fluid flow in pipes; Major equipment - Pipe Assembly with provision for Pressure measurement
8. Pressure drop in a packed bed for different fluid velocities; Major equipment - Packed bed with Pressure drop measurement.
9. Pressure drop and void fraction in a fluidized bed; Major equipment - Fluidized bed with Pressure drop measurement
10. Studying the coefficient of contraction for a given open orifice; Major equipment - Open Orifice Assembly

11. Studying the coefficient of discharge in a V-notch; Major equipment - V-notch Assembly
12. Studying the Characteristics of a centrifugal pump; Major equipment - Centrifugal Pump
13. Viscosity determination using Stoke's law; Major equipment – Terminal Velocity determination column.

**Outcomes:**

The students are able to:

- Determine the discharge coefficients of orifice and venturi meters as well as notches.
- Measure the point velocity using pitot tube.
- Measure the velocities and flowrates using various devices.
- Estimate the skin and form frictional losses in pipes and fittings.
- Verify the Bernoulli's and Ergun equations in packed and fluidized beds.
- Verify Newton's law of viscosity.
- Estimate the mechanical efficiency of centrifugal pump.
- Determine terminal velocity using Stoke's law.

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| II Year - I Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 1.5 |
| **HEAT TRANSFER OPERATIONS – LABORATORY** | | | | | |

**Learning Objectives:**
The students will be able to learn:

- The determination of thermal conductivities of composite wall and metal rod.
- The estimation of the natural and forced convective heat transfer coefficients (both film and overall coefficients).
- The determination of critical heat flux for pool boiling of water.
- The estimation of temperature distribution along the length of a pin-fin under natural and forced convection conditions
- The determination of Stefan-Boltzmann constant, emissivity of a metal plate etc.

**List of Experiments:**

1. Determination of total thermal resistance and thermal conductivity of composite wall.
2. Determination of thermal conductivity of a metal rod.
3. Determination of natural convective heat transfer coefficient for a vertical rod.
4. Determination of critical heat flux for pool boiling of water.
5. Determination of forced convective heat transfer coefficient for air flowing through a pipe.
6. Determination of overall heat transfer coefficient in double pipe heat exchanger.
7. Study of the temperature distribution along the length of a pin-fin under natural and forced convection conditions
8. Estimation of un-steady state film heat transfer coefficient between the medium in which the body is cooled.
9. Determination of Stefan – Boltzmann constant.
10. Determination of emissivity of a given plate at various temperatures.

**Outcomes:**
The students are able to:

- Experimentally determine of thermal conductivities of composite wall and metal rod.
- Calculate the natural and forced convective heat transfer coefficients (both film and overall coefficients) from experimental data.
- Estimate the experimental critical heat flux from pool boiling of water.
- Determine the temperature distribution along the length of a pin-fin under natural and forced convection conditions
- Determine the Stefan-Boltzmann constant, emissivity of a metal plate etc.

# JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
## KAKINADA – 533 003, Andhra Pradesh, India

## DEPARTMENT OF PETROLEUM ENGINEERING

| II Year - I Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 1 | 0 | 2 | 2 |
| **PYTHON PROGRAMMING** | | | | | |

**Course Objectives:**

The Objectives of Python Programming are:

- To learn about Python programming language syntax, semantics, and the runtime environment
- To be familiarized with universal computer programming concepts like data types, containers
- To be familiarized with general computer programming concepts like conditional execution, loops & functions
- To be familiarized with general coding techniques and object-oriented programming

**Course Outcomes:**

- Acquire essential programming skills in computer programming concepts like data types, containers
- Acquires the ability to accomplish coding tasks related to the basics of programming in the Python language
- Acquires the ability to accomplish coding tasks related conditional execution, loops
- Acquires the ability to accomplish coding tasks related to the fundamental notions and techniques used in object-oriented programming

**UNIT – I:**

Introduction: Introduction to python, program development cycle, input, processing, and output, displaying output with the print function, comments, variables, reading input from the keyboard, performing calculations, operators. type conversions, expressions, more about data output.

Data Types, and Expression: String assignment, and comment, numeric data types and character sets, using functions and modules.

Decision Structures and Boolean Logic: if, if-else, if-elseif-else Statements, nested decision structures, comparing strings, logical operators, Boolean variables. repetition structures: introduction, while loop, for loop, calculating a running total, input validation loops, nested loops.

**UNIT – II:**

Control Statement: Definite iteration for loop formatting text for output, selection if and if else statement conditional iteration the while loop

Strings and Text Files: Accessing character and substring in strings, data encryption, strings and number systems, string methods text files.

**UNIT – III:**

List and Dictionaries: Lists, defining simple functions, dictionaries

Design with Function**:** Functions as abstraction mechanisms, problem solving with top-down design, design with recursive functions, case study gathering information from a file system, managing a program's namespace, higher order function.

Modules: Modules, standard modules, packages.

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**UNIT – IV:**
File Operations: Reading config files in python, writing log files in python, understanding read functions, read(), readline() and readlines(), understanding write functions, write() and writelines(), manipulating file pointer using seek, programming using file operations.
Object oriented programming**:** concept of class, object and instances, constructor, class attributes and destructors, real time use of class in live projects, inheritance, overlapping and overloading operators, adding and retrieving dynamic attributes of classes, programming using oops support.
Design with classes: objects and classes, data modelling examples, case study an ATM, structuring classes with inheritance and polymorphism.

**UNIT – V:**
Errors and Exceptions: Syntax errors, exceptions, handling exceptions, raising exceptions, user-defined exceptions, defining clean-up actions, redefined clean-up actions.
Graphical user interfaces: the behavior of terminal-based programs and GUI – based, programs, coding simple GUI-based programs, other useful GUI resources.
Programming**:** introduction to programming concepts with scratch.

**Text Books:**

1. Fundamentals of Python First Programs, Kenneth. A. Lambert, Cengage.

**Reference Books:**

1. Introduction to Python Programming, Gowrishankar. S, Veena A, CRC Press.
2. Introduction to Programming Using Python, Y. Daniel Liang, Pearson.

**e-Resources:**

https://www.tutorialspoint.com/python3/python_tutorial.pdf

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## DEPARTMENT OF PETROLEUM ENGINEERING

| II Year - I Semester | | L | T | P | C |
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| | | 2 | 0 | 0 | 0 |
| **ENVIRONMENTAL SCIENCE (MC)** | | | | | |

**Learning Objectives:**
The objectives of the course are to impart:

- Overall understanding of the natural resources.
- Basic understanding of the ecosystem and its diversity.
- Acquaintance on various environmental challenges induced due to unplanned anthropogenic activities.
- An understanding of the environmental impact of developmental activities.
- Awareness on the social issues, environmental legislation and global treaties.

**Course Learning Outcomes:**

**UNIT-I:**
**Multidisciplinary nature of Environmental Studies:** Definition, scope and importance – sustainability: Stockholm and Rio summit–global environmental challenges: global warming and climate change, acid rains, ozone layer depletion, population growth and explosion, effects; role of information technology in environment and human health.
**Ecosystems:** Concept of an ecosystem. - structure and function of an ecosystem; producers, consumers and decomposers. - energy flow in the ecosystem - ecological succession. - food chains, food webs and ecological pyramids; introduction, types, characteristic features, structure and function of forest ecosystem, grassland ecosystem, desert ecosystem, aquatic ecosystems.

**UNIT-II:**
**Natural Resources:** Natural resources and associated problems.
Forest resources: Use and over – exploitation, deforestation – Timber extraction – Mining, dams and other effects on forest and tribal people.
Water resources: Use and over utilization of surface and ground water – Floods, drought, conflicts over water, dams – benefits and problems.
Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources.
Food resources: World food problems, changes caused by non-agriculture activities-effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity.
Energy resources: Growing energy needs, renewable and non-renewable energy sources use of alternate energy sources.
Land resources: Land as a resource, land degradation, Wasteland reclamation, man induced landslides, soil erosion and desertification; Role of an individual in conservation of natural resources; Equitable use of resources for sustainable lifestyles.

**UNIT-III:**
**Biodiversity and its conservation:** Definition: genetic, species and ecosystem diversity-classification - Value of biodiversity: consumptive use, productive use, social-Biodiversity at national and local levels. India as a mega-diversity nation - Hot-sports of biodiversity - Threats to biodiversity: habitat loss, man-wildlife conflicts. - Endangered and endemic species of India – Conservation of biodiversity: conservation of biodiversity.

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**UNIT – IV:**

**Environmental Pollution:** Definition, Cause, effects and control measures of Air pollution, Water pollution, Soil pollution, Noise pollution, Nuclear hazards. Role of an individual in prevention of pollution. - Pollution case studies, Sustainable Life Studies. Impact of Fire Crackers on Men and his well being.

**Solid Waste Management:** Sources, Classification, effects and control measures of urban and industrial solid wastes. Consumerism and waste products, Biomedical, Hazardous and e – waste management.

**UNIT – V:**

**Social Issues and the Environment:** Urban problems related to energy -Water conservation, rain water harvesting-Resettlement and rehabilitation of people; its problems and concerns. Environmental ethics: Issues and possible solutions. Environmental Protection Act -Air (Prevention and Control of Pollution) Act. –Water (Prevention and control of Pollution) Act -Wildlife Protection Act -Forest Conservation Act-Issues involved in enforcement of environmental legislation. -Public awareness.

**Environmental Management**: Impact Assessment and its significance various stages of EIA, preparation of EMP and EIS, Environmental audit. Ecotourism, Green Campus – Green business and Green politics.

The student should Visit an Industry / Ecosystem and submit a report individually on any issues related to Environmental Studies course and make a power point presentation.

**Text Books:**

1.Environmental Studies, K. V. S. G. Murali Krishna, VGS Publishers, Vijayawada
2.Environmental Studies, R. Rajagopalan, 2nd Edition, 2011, Oxford University Press.
3.Environmental Studies, P. N. Palanisamy, P. Manikandan, A. Geetha, and K. Manjula Rani; Pearson Education, Chennai

**Reference:**

1.Text Book of Environmental Studies, Deeshita Dave & P. UdayaBhaskar, Cengage Learning.
2.A Textbook of Environmental Studies, Shaashi Chawla, TMH, New Delhi.
4.Environmental Studies, Benny Joseph, Tata McGraw Hill Co, New Delhi.
5.Perspectives in Environment Studies, Anubha Kaushik, C P Kaushik, New Age International Publishers.

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**DEPARTMENT OF PETROLEUM ENGINEERING**

| II Year - II Semester | | L | T | P | C |
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| | | 3 | 0 | 0 | 3 |
| **MANAGEMENT AND ORGANIZATIONAL BEHAVIOUR (Common to Civil, EEE, ECE, CSE, ChE & PE branches)** | | | | | |

**Course Objectives:**

- To familiarize with the process of management, principles, leadership styles and basic concepts on Organisation.
- To provide conceptual knowledge on functional management that is on Human resource management and Marketing management.
- To provide basic insight into select contemporary management practices and Strategic Management.
- To learn theories of motivation and also deals with individual behavior, their personality and perception of individuals.
- To understand about organizations groups that affect the climate of an entire organizations which helps employees in stress management.

**Unit I**

**Introduction**: Management and organizational concepts of management and organization- Nature and Importance of Management, Functions of Management, System approach to Management - Taylor's Scientific Management Theory, Fayol's Principles of Management, Leadership Styles, Social responsibilities of Management. Designing Organizational Structures: Basic concepts related to Organization - Departmentation and Decentralization, MBO, Process and concepts.

**Unit II**

**Functional Management:** Human Resource Management (HRM) Concepts of HRM, Basic functions of HR Manager: Manpower planning, Recruitment, Selection, Training and Development, Wage and Salary Administration Performance Appraisal, Grievance Handling and Welfare Administration, Job Evaluation and Merit Rating. - Marketing Management: Concepts of Marketing, Marketing mix elements and marketing strategies.

**Unit III**

**Strategic Management:** Strategic Management and Contemporary Strategic Issues: Mission, Goals, Objectives, Policy, Strategy, Programmes, Elements of Corporate Planning Process, Environmental Scanning, Value Chain Analysis, SWOT Analysis, Steps in Strategy Formulation and implementation, Generic Strategy alternatives. Bench Marking and Balanced Score Card as Contemporary Business Strategies.

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**Unit IV**

**Individual Behavior:** Perception-Perceptual process- Impression management- Personality development – Socialization – Attitude- Process- Formation- Positive attitude- Change – Learning – Learning organizations- Reinforcement Motivation – Process- Motives – Theories of Motivation: Maslow's Theory of Human Needs, Douglas McGregor's Theory X and Theory Y, Herzberg's Two-Factor Theory of Motivation,

**Unit V**

**Group Dynamics:** Types of Groups, Stages of Group Development, Group Behaviour and Group Performance Factors, Organizational conflicts: Reasons for Conflicts, Consequences of Conflicts in Organization, Types of Conflicts, Strategies for Managing Conflicts, Organizational Climate and Culture, Stress, Causes and effects, coping strategies of stress.

**Course Outcomes:**

- After completion of the Course the student will acquire the knowledge on management functions, global leadership and organizational structure.
- Will familiarize with the concepts of functional management that is HRM and Marketing of new product developments.
- The learner is able to think in strategically through contemporary management practices.
- The learner can develop positive attitude through personality development and can equip with motivational theories.
- The student can attain the group performance and grievance handling in managing the organizational culture.

**TEXT BOOKS**

Subba Rao P., *Organizational Behaviour,* Himalaya Publishing House. Mumbai
L.M. Prasad, Principles and Practice of Management.

**Reference Books:**


1. *K. Ashwathappa, Organisational Behaviour, Himalaya Publishing House, 12th Revised Edition*
2. Fred Luthans *Organizational Behaviour*, TMH, New Delhi.
3. Robins, Stephen P., *Fundamentals of Management,* Pearson, India.
4. Kotler Philip & Keller Kevin Lane: Marketing Mangement 12/e, PHI, 2007
5. Koontz & Weihrich: *Essentials of Management*, 6/e, TMH, 2007
6. Kanishka Bedi, *Production and Operations Management*, Oxford University Press, 2007.

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| II Year - II Semester | | L | T | P | C |
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| | | 3 | 0 | 0 | 3 |
| **MATHEMATICS – IV (Complex Variables and Statistical Methods) (Common to all branches of Second Year except CSE ant IT)** | | | | | |

**Course Objectives:**

- To familiarize the complex variables.
- To familiarize the students with the foundations of probability and statistical methods.
- To equip the students to solve application problems in their disciplines.

**Course Outcomes:** At the end of the course students will be able to

- apply Cauchy-Riemann equations to complex functions in order to determine whether a given continuous function is analytic (L3)
- find the differentiation and integration of complex functions used in engineering problems (L5)
- make use of the Cauchy residue theorem to evaluate certain integrals (L3)
- apply discrete and continuous probability distributions (L3)
- design the components of a classical hypothesis test (L6)
- infer the statistical inferential methods based on small and large sampling tests (L4)

**UNIT – I: Functions of a complex variable and Complex integration: (10 hrs)**

Introduction – Continuity – Differentiability – Analyticity –Cauchy-Riemann equations in Cartesian and polar coordinates – Harmonicand conjugate harmonic functions – Milne – Thompson method.
Complex integration: Line integral – Cauchy's integral theorem – Cauchy's integral formula – Generalized integral formula (all without proofs) and problems on above theorems.

**UNIT – II:Series expansions and Residue Theorem: (10 hrs)**

Radius of convergence – Expansion in Taylor's series, Maclaurin's series andLaurent series.
Types of Singularities: Isolated – Essential –Pole of order m– Residues – Residue theorem (without proof) – Evaluation of real integral of the types $\int_{-\infty}^{\infty} f(x)dx$ and $\int_{c}^{c+2\pi} f(\cos\theta,\sin\theta)d\theta$.

**UNIT – III: Probability and Distributions: (10 hrs)**

Review of probability and Baye's theorem – Random variables – Discrete and Continuous random variables – Distribution functions – Probability mass function, Probability density function and Cumulative distribution functions – Mathematical Expectation and Variance – Binomial, Poisson, Uniform and Normal distributions.

**UNIT – IV: Sampling Theory: (8 hrs)**

Introduction – Population and Samples – Sampling distribution of Means and Variance (definition only) – Central limit theorem (without proof) – Representation of the normal theory distributions – Introduction to t, $\chi^2$ and F-distributions – Point and Interval estimations – Maximum error of estimate.

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**UNIT – V: Tests of Hypothesis: (10 hrs)**
Introduction – Hypothesis – Null and Alternative Hypothesis – Type I and Type II errors – Level of significance – One tail and two-tail tests – Tests concerning one mean and two means (Large and Small samples) – Tests on proportions.

**Text Books:**

1. **B. S. Grewal,** Higher Engineering Mathematics, 44th Edition, Khanna Publishers.
2. **Miller and Freund's,** Probability and Statistics for Engineers,7/e, Pearson, 2008.

**Reference Books:**

1. **J. W. Brown and R. V. Churchill**, Complex Variables and Applications, 9th edition, Mc-Graw Hill, 2013.
2. **S.C. Gupta and V.K. Kapoor**, Fundamentals of Mathematical Statistics, 11/e, Sultan Chand & Sons Publications, 2012.
3. **Jay l. Devore,** Probability and Statistics for Engineering and the Sciences, 8th Edition,Cengage.
4. **Shron L.Myers, Keying Ye, Ronald E Walpole,** Probability and Statistics Engineers and the Scientists,8th Edition, Pearson 2007.
5. **Sheldon, M. Ross**, Introduction to probability and statistics Engineers and the Scientists, 4thEdition, Academic Foundation,2011.

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## DEPARTMENT OF PETROLEUM ENGINEERING

| II Year - II Semester | | L | T | P | C |
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| | | 3 | 0 | 0 | 3 |
| **INTRUMENTATION, PROCESS DYNAMICS & CONTROL** | | | | | |

**Learning objectives:**
The student will be able to learn:

- The basic elements of an instrument and its static and dynamic characteristics.
- The various types of industrial thermometers.
- The various types of instruments for measurement of pressure, vacuum, head and density measurement.
- The behavior and logic of different types of advanced controllers and their strategies.
- The how Laplace transforms can be used to get solutions of transfer function equations for different types of systems.
- The basic procedure to derive transfer functions for first order, pseudo second order and second order systems.
- The importance of under damped second order systems in relation to the real-life situations.
- The calculation of the overall transfer function and thus offset calculation from the control system block diagram.
- The concept of stability, stability criterion and frequency response analysis for sinusoidal forcing functions.
- The behavior and tuning of a controller and the calculation of controller parameters.
- The inherent and effective characteristics of different types of control valves and the usage of valve positioners to induce linear characteristic into a non-linear control valve.

**UNIT-I:**
Fundamentals: Elements of instruments, static and dynamic characteristics of instruments.
Industrial Thermometers**:** Mercury in glass thermometer, bimetallic thermometer, pressure spring thermometer, thermo-electricity, types of thermocouples, thermocouple lead wires, resistance-thermometers, RTD and bridge circuits (2 wire, 3 wire and 4 wire - method), radiation receiving elements, pyrometers.

**UNIT-II:**
Pressure, vacuum and head: Liquid column manometers, measuring elements for gauge pressure and vacuum, indicating elements for pressure gauges, measurement of absolute pressure - measuring pressure in corrosive liquids, static accuracy and response of pressure gauges.
Density and specific gravity measurements, direct measurement of liquid level, pressure measurement in open vessels, level measurements in pressure vessels, measurement of interface level, density measurement and level of dry materials.

**UNIT-III:**
Introduction to process dynamics and control, Response of First Order Systems, Physical examples of first order systems.
Response of first order systems in series, Second order systems and transportation lag. Control systems, controllers and final control elements.

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## DEPARTMENT OF PETROLEUM ENGINEERING

**UNIT-IV:**
Closed loop transfer functions, Transient response of simple control systems, stability criterion, Routh test, root locus, introduction to frequency response, Bode stability criterion, concept on gain and phase margins

**UNIT-V:**
Advanced control strategies: Cascade control, Feed forward control, ratio control, dead time compensation, internal model control, controller tuning and process identification. control valves.

**Outcomes:**
The students are able to:

- Analyze the basic elements of an instrument and its characteristics.
- Measure the various process variables using the appropriate types of instruments process variables (temperature, pressure, flow rate, composition, pH, viscosity, density, dry bulb and wet bulb temperatures)
- Apply the partial fractions and Laplace transforms for converting ordinary differential equations into simple algebraic equations which are easier to solve.
- Differentiate the types of unsteady and steady state balances.
- Describe processes with appropriate block diagrams.
- Model a process numerically.
- Identify the stability limits of a system.
- Apply the advance control strategies.
- Tune the process controllers.
- Experimentally determine the dynamic behavior of a process.
- Design and operate control valves.

**Text Book:**

1. Industrial Instrumentation, Donald P. Eckman, CBS, 2004.
2. Process Systems Analysis and Control, D.R. Coughanowr, 3rd Ed. McGraw Hill

**Reference Books:**

1. Chemical Process Control, G. Stephanopoulos, Prentice Hall, 1984.
2. Coulson and Richardson's Chemical Engineering, Volume-3, 3rd Edition: Chemical and Biochemical Reactors and Process Control, Richardson J. F. et.al, Elsevier India, 2006.
3. Automatic Process Control, Donald P. Eckman, John Wiley, Reprint 2011.
4. Instrumentation and Control Systems, K. Padmaraju, Y.J. Reddy, McGraw Hill Education, 2016.
5. Process Dynamics and Control, Dale Seaborg, Thomas F. Edgar, Duncan Mellichamp, 2nd Edition, Wiley India Pvt. Ltd., 2006.
6. Principles of Process Control. Patranabis, 3rd Edition McGraw-Hill Education Pvt. Ltd., 2012.
7. Modern Control Engineering, Katsuhiko Ogata, 5th Edition, Prentice Hall, 2010.
8. Principles and Practices of Automatic Process Control, Carlos A. Smith, Armando B. Corripio, 3rd International Edition, John Wiley and Sons, 2005.

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| II Year - II Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |
| **THERMODYNAMICS FOR PETROLEUM ENGINEERS** | | | | | |

**Learning Objectives:**

The students will be able to learn:

- The laws of thermodynamics and their application to petroleum engineering systems.
- The volumetric properties, thermodynamic property relations and equations of states for pure substances.
- The concepts of chemical potentials, Gibbs and Helmholtz free energies.
- The phase behavior and properties of pure fluids with applications to the analysis of petroleum systems.
- The concept of residual and excess property relations.
- The concepts of fugacity and partial molar properties.
- VLE calculations using Raoult's law, modified Raoult's law, Henry's law activity coefficient models, generalized gamma/phi formulation and K-values.
- VLE calculations from equation of state.
- The concepts of Vapor Liquid–Liquid Equilibrium (VLLE), Solid- Liquid Equilibrium (SLE), Solid-Vapor Equilibrium (SVE) and equilibrium adsorption of gases on solids.

**UNIT-I:**

Introduction: The scope of thermodynamics, defined quantities; temperature, volume, pressure, work, energy, heat, Joules experiments, SI units.

The first law and other basic concepts: The first law of thermodynamics, thermodynamic state and state functions, enthalpy, The steady-state steady flow process, equilibrium, the reversible process, constant-V and constant- P processes, heat capacity.

**UNIT-II:**

Volumetric properties of pure fluids: The PVT behavior of pure substances, virial equations, the ideal gas, the applications of the virial equations, cubic equations of state, generalized correlations for gases.

**UNIT-III:**

The second law of thermodynamics: Statements of the second law, heat engines, thermodynamic temperature scales, thermodynamic temperature and the ideal-gas scale, entropy, entropy changes of an ideal gas, mathematical statement of the second law, the third law of thermodynamics, calculation of ideal work and lost work, examples on thermodynamic behavior of oil and natural gas under reservoir conditions.

**UNIT-IV:**

Thermodynamic properties of fluids: Property relations for homogeneous phases, residual properties, two phase systems, thermodynamic diagrams, tables of thermodynamic properties, generalized property correlations for gases.

Thermodynamics of flow processes: Principles of conservation of mass and energy for flow systems, analysis of expansion processes; turbines, throttling, compression processes, compressors and pumps.

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**UNIT-V:**
Solution thermodynamics: Basic concepts of chemical potential, phase equilibria, partial properties, fugacity coefficient, residual and excess Gibbs free energy, correlations for the estimation of fugacity coefficient, residual and excess Gibbs energy in vapor liquid equilibria.
Phase Equilibria: Gamma/Phi formulation of VLE, VLE from Virial Equations of State and cubic equations of state, introduction to Vapor- Liquid–Liquid Equilibrium (VLLE), Solid- Liquid Equilibrium (SLE) and Solid-Vapor Equilibrium (SVE), Equilibrium adsorption of gases on solids – introduction to phase changes in petroleum reservoirs.

**Outcomes:**
The students are able to:

- Apply the laws of thermodynamics and their application to petroleum engineering systems.
- Apply the volumetric properties, thermodynamic property relations and equations of states to the pure substances.
- Analyze the concepts of chemical potentials, Gibbs and Helmholtz free energies.
- Assess the requirement of properties of pure fluids and their mixtures to the analysis of petroleum systems.
- Apply the concepts of fugacity, fugacity coefficients in the calculation of phase equilibrium.
- Perform VLE calculations using Raoult's law, modified Raoult's law, Henry's law activity coefficient models, generalized gamma/phi formulation and K-values.
- Carry out VLE calculations from equation of state.
- Apply the concepts of Vapor Liquid–Liquid Equilibrium (VLLE), Solid- Liquid Equilibrium (SLE), Solid-Vapor Equilibrium (SVE) and equilibrium adsorption of gases on solids to petroleum systems.

**Text Book:**

1. Introduction to Chemical Engineering Thermodynamics, Smith, J. M., H. C. Van Ness and M.M. Abbott, 6th Edition, 8th reprint, McGraw Hill, 2006.

**Reference Books:**

1. Characterization and Properties of Petroleum Fractions, M. R. Riaze, ASTM, International, 2005.
2. Equation of State and PVT analysis, Tarek Ahmed, Gulf publishing company, 2007.
3. Engineering and Chemical Thermodynamics, Koretsky, M. D., John Wiley & Sons, 2004.
4. Introductory Chemical Engineering Thermodynamics, Richard Elliott, J. and Carl T. Lira, 2nd Edition, Prentice Hall, 2012.
5. Chemical, Biochemical and Engineering Thermodynamics, Stanley Sandler, 4th Edition, Wiley India Pvt. Ltd, 2006.
6. Thermodynamics: Applications in Chemical Engineering and the Petroleum Industry, Vidal, J., Edition Technip, 2003.
7. Chemical and Process Thermodynamics, Kyle, B.G., 3rd Edition, PHI Learning, 2008.
8. Chemical Engineering Thermodynamics, Thomas E. Dauber, McGraw Hill, 1985.

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## DEPARTMENT OF PETROLEUM ENGINEERING

| II Year - II Semester | | L | T | P | C |
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| | | 3 | 0 | 0 | 3 |
| **DRILLING & WELL COMPLETIONS** | | | | | |

**Learning Objectives:**

The students will be able to learn:

- The planning of drilling a well, the process of drilling and various equipment used for drilling and design of the drill string.
- The drilling fluid importance and its properties and hydraulics.
- Different types of casings lowered in a well, the requirement of cementation in a well and cement slurry design.
- The different tools used for directional drilling and various techniques, fishing, stuck pipe and well control concepts.
- The fundamentals of well testing.
- The concept of surface and subsurface equipment.
- The planning and designing of well completion after testing of the hydrocarbon zones available.
- To know the subsurface circulating equipment and packers and testing of multi zones in a well with DST/RFT with logging tools as well as surface testing equipment.

**UNIT-I:**

Overview of drilling: Drilling plan - GTO -types of drilling, hydrostatic pressure, pore pressure, causes of abnormal pore pressure, abnormal pore pressure evaluation, measurement while drilling & logging while drilling data, direct measurements of pore pressure, drilling fluid properties, drilling fluid hydraulics calculations - bit hydraulics formation integrity tests – fracture gradient determination – theory of Wellbore – FIT procedural guidelines – predicting fracture gradient.

**UNIT-II**

Wellbore stability – In-situ stress - determination of rock properties, failure criteria – stress distribution around a wellbore - safe mud weights to prevent hole collapse, kick tolerance use of kick tolerance to calculate wellbore pressures.

Casing: Functions of casing – types of casing – casing properties and specifications – casing connections – factors influencing casing design – combination strings – tension criterion - compression loads – biaxial effects – tri axial analysis.

Cementation: Introduction to cement slurries - cementing nomenclature - cement additives.

**UNIT III**

(a) Directional drilling: Well planning - deflection tools and techniques - face orientation - direction control with rotary assemblies - navigation drilling systems; horizontal wells – well profile design considerations – torque and drag –extended reach well design – multilateral wells.

Well control: Kicks – BOP - special kick problems and procedures to free the pipes and fishing operations

(b) Well completions: Types of wells- types of completion. Perforation methods.

Packers: Function – Application.

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**UNIT IV**

Completion equipment (SSD, SSSV, mandrels, packers, locks etc.,) –Subsea well completions, permanent gauges - memory gauges - intelligent completion equipment. Tubing string design.

**UNIT-V**

Drill Stem Testing: General Procedure and considerations - test tool components and arrangement - analysis of test data.

HPHT and horizontal well completions, work over operations, CTU & slick line operations.

**Outcomes:**

The students are able to:

- Apply the principles of drilling to various equipment used for drilling.
- Assess the application of drilling fluids depending upon the formations.
- Know different types of casings and the concepts of cementation.
- Gain knowledge on the usage of different tools for directional drilling, fishing, stuck pipe and well control.
- Apply the fundamentals of well completions.
- Test the multi zones in a well with DST/RFT with logging tools as well as surface testing equipment.

**Text Books:**


1. Petroleum Engineering: Drilling and Well Completion, Carl Gatlin, Prentice-Hall, Inc., 1960.
2. Working Guide to Drilling Equipment and Operations, William Lyons, Gulf Publishing, 2009.
3 Well Completion and Servicing, D. Perrin, Micheal Caron, Georges Gaillot, Editions Technip, 1999.
4 Primer of Well Service, Workover and Completion, Petroleum Extension Service (PETEX), University of Texas at Austin, 1997.


**Reference Books:**


1. Drilling Engineering, J.J. Azar and G. Robello Samuel, Pennwell Books, 2007.
2. Oil Well Drilling Engineering: Principles and Practice, H. Rabia, Graham & Trotman, 1985.
3. Drilling Engineering: A Complete Well Planning Approach, Neal Adams, Tommie Charrier Pennwell, 1985.
4. Practical Well Planning and Drilling Manual, Steve Devereux, Pennwell, 1998.
5. Formulas and Calculation for Drilling, Production and Workover, Norton J. Lapeyrouse, 2nd Edition, Gulf Publishing, 2002.
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**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA**
**KAKINADA – 533 003, Andhra Pradesh, India**

## DEPARTMENT OF PETROLEUM ENGINEERING

| II Year - II Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 1.5 |
| **INSTRUMENTATION, PROCESS DYNAMICS & CONTROL – LABORATORY** | | | | | |

**Learning Objectives:**

The students will be able to learn:

- The calibration and determination of the time lag of various first and second order instruments.
- The determination of the response in single and two capacity systems with and with-out interaction.
- The advanced control methods used for complex processes in the industries. Different experiments like Temperature, level and pressure control can be configured and studied.
- The experimental procedures for open loop (Manual control) and the on/off controller, Proportional controller, PI controller, PD controller, PID controller, Tuning of controller (Open loop and close loop methods).
- The control valve operation and its flow characteristics.
- The determination of the damping coefficient and response of U-tube manometer.

**Experiments:**

1. Determination of time constant & transportation lag for mercury in glass thermometer with and without thermal well.
2. Sinusoidal response of mercury in glass thermometer with and without thermal well.
3. Study of dynamic response of single tank liquid level system.
4. Study of dynamic response of two tank non-interacting liquid level system.
5. Study of dynamic response of two tank interacting liquid level system.
6. Determination of damping coefficient for U-tube:
7. Study of control valve characteristics and determine valve flow coefficient for the following valves:
    a) Equal percentage valve
    b) Quick opening valve
    c) Linear valve
8. Determination of hysteresis for the following valves:
    a) Equal percentage valve
    b) Quick opening valve
    c) Linear valve
9. Temperature control trainer:
    a) Open loop response
    b) On-off control
    c) P-control
    d) PID-control
    e) Auto tuning
10. Level control trainer:
    a) Open loop response
    b) On-off control
    c) P-control
    d) PID-control
    e) Auto tuning

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA**
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**DEPARTMENT OF PETROLEUM ENGINEERING**

11. Pressure control trainer:
    a) Open loop response
    b) On-off control
    c) P-control
    d) PID-control
    e) Auto tuning

**Outcomes:**

The students will be able to:

- Calibrate and determine the time lag of various first and second order instruments.
- Perform experiments to find the response in single and two capacity systems with and with-out interaction.
- Apply the advanced control methods used for complex processes in the industries.
- Perform different experiments like Temperature, level and pressure control.
- Carry out experiments on the open loop (Manual control) and the on/off controller, Proportional controller, PI controller, PD controller, PID controller, Tuning of controller (Open loop and close loop methods).
- Operate the control valve and assess its flow characteristics.
- Estimate the damping coefficient and response of U-tube manometer.

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA**
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## DEPARTMENT OF PETROLEUM ENGINEERING

| II Year - II Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 1.5 |
| **MATHEMATICAL METHODS FOR PETROLEUM ENGINEERS – LABORATORY** | | | | | |

**Learning Objectives:**

The students will be able to learn:

- The application of MATLAB to solve various rigorous and iterative problems related to various petroleum engineering topics.
- The what-if analysis for the variations in the parameters using mathematical methods.

**List of problems:**

1. Solution of simultaneous equations for steady state material balance on a separation train.
2. Linear regressions after proper transformation to a linear expression for vapor-pressure correlation by Clapeyron Equation.
3. Fitting polynomials & correlations using vapor pressure data.
4. Solution of single non-linear algebraic equation for bubble point calculation of an ideal binary mixture.
5. Least square method of analysis to obtain the relation between friction factor and Reynolds number.
6. Graphical integration for calculation of average velocity for flow of water.
7. Determination of molar volume and compressibility from Redlich – Kwong equation
8. Calculation of flow rate in a pipeline.
9. Calculation of compressibility factors using van der Waals equation.
10. Thermodynamic properties of steam from Redlich – Kwong equation
11. Method of lines for partial differential equations to obtain temperatures along the slab.
12. Correlation of experimental data on heat capacity, viscosity and thermal conductivity to polynomials.

**Outcome**:

- The students are able to write MATLAB code and solve typical problems encountered in petroleum engineering.

**Textbook:**

1. Problem solving in Chemical and Biochemical Engineering with POLYMATH, Excel and MATLAB, Michael B. Cutlip and Mordechai Shacham, 2nd edition, Prentice Hall, 2008.

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA**
**KAKINADA – 533 003, Andhra Pradesh, India**

## DEPARTMENT OF PETROLEUM ENGINEERING

| II Year - II Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 1.5 |
| **DRILLING FLUIDS – LABORATORY** | | | | | |

**Learning Objective:**

The students will be able to learn the determination of the properties of different drilling fluids.

**List of Experiments:**

1. Measurement of drilling fluid weight.
   Equipment: The Baroid mud balance

2. Measurement of mud viscosity.
   Equipment: Marsh funnel

3. Measurement of pH of mud.
   Equipment: pH meter and hydrion pH dispensers

4. Determination of mud rheology (Viscosity, Gel strength, and Yield point).
   Equipment: The Baroidrheometer

5. Determination of the loss of liquid from a mud.
   Equipment: Standard API filter press

6. Measurement of a drilling mud cake and evaluate resistivity.
   Equipment: Baroid digital resistivity meter

7. Measurement of the effect of adding bentonite on mud properties.

8. Drilling fluid contamination test (Salt, Gypsum & Cement contamination) and their effect on the drilling fluid properties.

9. Measurement of solid and liquid content and emulsification characteristics of drilling fluid.
   Equipment: Sand content set, fann emulsion and electrical stability testers

10. Measurement of Oil, water, solid and clay content.
    Equipment: Oil/ water retort kit

11. Measurement of water ratios for Portland cement slurry.
    (Effect of water ratio on free water separation normal and minimum water content and thickening time)
    Equipment: The atmospheric consistometer

12. Measurement of specific gravity of cement slurry
    Equipment: specific gravity bottles

13. Measurement of consistency of cement
    Equipment: vi-cat apparatus

14. Measurement of initial and final setting times of given cement slurry.

15. Measurement of compressive strength of cement test moulds and effect of temperature and pressure on setting of the slurry.
    Equipment: Compressive strength testing machine

**Outcomes:**
The students are able to**:**

- Assess the quality of various muds and their applications in drilling safely accounting the desired parameters.
- Carry out consultation jobs for healthy construction of open oil / gas wells.

**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA**
**KAKINADA – 533 003, Andhra Pradesh, India**

## DEPARTMENT OF PETROLEUM ENGINEERING

| II Year - II Semester | | L | T | P | C |
|---|---|---|---|---|---|
| | | 1 | 0 | 2 | 2 |
| **INDUSTRY EXPLORATION PROJECT** | | | | | |

**Learning Objectives:**

The students will be able to:

- Get in-depth understanding of role of petroleum engineering in a process industry.
- Gain familiarity with organizational structure, work environment & culture, anatomy of petroleum processes and equipment involved in a process industry.
- Interact with the teams of engineers and operating personnel in a process industry.
- Know the challenges in design, operation and production of a process industry.

**Methodology:**

The total students of a class are divided into small groups. Each group would be sent to a petroleum industry for 7 days, preferably on each Saturday in a week of 6-8 students along with a Faculty member. The host petroleum industry provides a mentor (an experienced engineer). The students are expected to study all aspects of the industry under the guidance of the mentors (Faculty and Industry). At the end of the 7day program, each student should submit a report, which will be evaluated by a two-member team of faculty nominated by the Head of the Department.

**Outcomes:**

The students are able to:

- Get exposed to various professional activities in a petroleum industry.
- Judge the importance and relevance of various subjects in curriculum.
- Know the possible career options in a petroleum industry.
- Assess the scale of operations.
- Acquaint with different forms of technical communication

# JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
## KAKINADA – 533 003, Andhra Pradesh, India

## DEPARTMENT OF PETROLEUM ENGINEERING

### SUMMER INTERNSHIP

**Learning Objectives**:

The main objective of the internship is to gain up-to-date, practical experience in the real-working situation, in contrast to information gained during studies concerning mainly theoretical background of petroleum engineering.

The students are guided (through the industry representative) to learn the following aspects:

- Application of the engineering skills, learned in class room, in real world.
- Working as a team to deliver the results along with senior engineering professionals, technicians, managers etc.
- Working safely in industrial environment.
- Result oriented approach in plant operation, troubleshooting and engineering work.
- Present and / or report the work / project outcomes to various disciplines, departments & interest groups with confidence.

Every student should undergo summer training (summer internship program) in a petroleum industry (like ONGC)/service providing industry (like Halliburton) for 4-6 weeks and submit a report.

**Outcomes**:
The students are able to:

- Work safely in industrial environment.
- Work with various interest groups, disciplines, professionals, managers and technicians etc.
- Polish the engineering skills by applying the practical knowledge in day-to-day operations, trouble-shooting and minor-modifications.
- Build relations between university and industry that helps mutual collaboration and cooperation over long-term.
- Develop/strengthen the basic skills of interviewing, analysis, report writing, communication, decision-making, and problem solving.

# JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
## KAKINADA – 533 003, Andhra Pradesh, India

## DEPARTMENT OF PETROLEUM ENGINEERING

### HONORS/MINOR COURSES

**Learning Objectives:**
The students are able to:

- Avail the expertise in a specific subject from nation-wide reputed faculty, through MOOC (Massive Open Online Course)
- Develop the ability for self-actualization and in getting opportunity for life-long learning

There shall be a Discipline Centric Elective Course through Massive Open Online Course (MOOC) as Program Elective course. The student shall register for the course (Minimum of 12 weeks) offered by SWAYAM/NPTEL through online. The course is selected in consultation with MOOCS coordinator/Mentor and with the approval of Head of the Department. During the course, the coordinator monitors the student's progress in the SWAYAM/NPTEL courses.

The students need to submit all the assignments given and take final exam. Each student has to earn a certificate by passing the exam. Each student will be awarded the credits given in curriculum only after submission of the certificate. If student does not pass the subjects registered through SWAYAM/NPTEL, the same or alternative equivalent subject may be registered and studied again through SWAYAM/NPTEL in the next semester to submit the certificate.

The list of MOOCS/department courses is given in the Appendix to do honors in petroleum engineering. The eligible student is expected to choose the subjects from the list. To fulfill the criteria of qualifying for honors degree, **16 credits** should be obtained at the end of final semester. In order to get minor degree, a student has to select and do the courses in any one discipline other than petroleum engineering to fulfil the criteria of 16 credits.

The total **16 credits** for honors or minor degree should be obtained from the fourth semester to the end of eighth semester. A candidate can take a 4-credit course in each semester during the above-mentioned period.
It may be noted that, each student is to get minimum SGPA/CGPA (as per JNTUK guidelines) without any backlogs in each semester to do honors / minors degree.

**Outcomes:**
The students will be able to:

- Overcome the digital divide in acquiring fast developing technologies / knowledge and be part of digital revolution.
- Acquire subject specific expert knowledge from National Resource Pool.
- Understand his /her academic / professional priorities for future development.