

**DEPARTMENT OF PETROLEUM ENGINEERING**

# **SYLLABI OF COURSES**

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**BACHELOR OF ENGINEERING  
PROGRAMME IN PETROLEUM**

**BATCH: 2015-16 ONWARDS**

**NED UNIVERSITY OF ENGINEERING & TECHNOLOGY,  
KARACHI-75270, PAKISTAN**

## PETROLEUM ENGINEERING

### Course of Studies (Batch 2015-16 onwards)

First Year									
Fall Semester					Spring Semester				
Course Code	Course Title	Credit Hours			Course Code	Course Title	Credit Hours		
		Th	Pr	Total			Th	Pr	Total
PE-101	Fundamentals of Petroleum Engineering	2	0	2	PE-102	Engineering Geoscience	2	1	3
EE-116	Principles of Electrical Engineering	3	1	4	ME-101	Engineering Mechanics	3	1	4
CE-105	Engineering Surveying	3	1	4	ME-102	Engineering Drawing	3	1	4
CY-109	Applied Chemistry	3	1	4	PH-122	Applied Physics	3	1	4
MT-114	Calculus	3	0	3	HS-104	Functional English	3	0	3
HS-105 / HS-127	Pakistan Studies or Pakistan Studies for foreigners	2	0	2					
	<b>Total</b>	<b>16</b>	<b>3</b>	<b>19</b>		<b>Total</b>	<b>14</b>	<b>4</b>	<b>18</b>
Second Year									
MT-221	Linear Algebra & Ordinary Differential Equations	3	0	3	PE-205	Computer Programming & Application	2	1	3
PE-202	Petroleum Geology	2	1	3	CE-212	Mechanics of Solids	3	1	4
PE-203	Reservoir Petrophysics	2	1	3	CH-207	Fluid Mechanics II	3	1	4
CE-215	Fluid Mechanics	3	1	4	PE-207	Drilling Engineering-I	2	1	3
PE-206	Thermodynamics-I	2	1	3	MT-331	Probability & Statistics	3	0	3
HS-205 / HS-209	Islamic Studies or Ethical Behaviour(For Non-Muslims)	2	0	2					
	<b>Total</b>	<b>14</b>	<b>4</b>	<b>18</b>		<b>Total</b>	<b>13</b>	<b>4</b>	<b>17</b>
Third Year									
PE-302	Reservoir Fluid Properties	2	1	3	PE-312	Drilling Engineering II	2	1	3
PE-313	Structural Geology & Geophysical Exploration	2	1	3	PE-308	Petroleum Production Economics	2	0	2
PE-306	Subsurface Production Engineering	2	0	2	PE-304	Reservoir Engineering-I	3	1	4
PE-310	Natural Gas Engineering	2	1	3	PE-311	Fundamentals of Well Logging	2	1	3
EL-305	Instrumentation & Control	3	1	4	MT-471	Applied Numerical Methods	2	1	3
HS-304	Business Communication & Ethics	3	0	3					
	<b>Total</b>	<b>14</b>	<b>4</b>	<b>18</b>		<b>Total</b>	<b>11</b>	<b>4</b>	<b>15</b>
Final Year									
PE-401	Reservoir Simulation	3	1	4	PE-413	Oil and Gas Field Production Facilities	3	1	4
PE-402	Reservoir Engineering-II	2	1	3	PE-414	Water Flooding and Introduction to Enhanced Oil Recovery	3	1	4
PE-408	Well Testing	3	1	4	PE-406	Petroleum Refinery Engineering	2	1	3
PE-412	Introduction to Unconventional Oil, Gas & Energy Resources	2	0	2	PE-407	Petroleum Property, Environment & Safety Management	2	0	2
PE-411	Project Planning & Management	2	0	2	PE-410	Petroleum Engineering Project	0	3	3
PE-410	*Petroleum Engineering Project	-	3	3					
	<b>Total</b>	<b>12</b>	<b>6</b>	<b>18</b>		<b>Total</b>	<b>10</b>	<b>6</b>	<b>16</b>

\*Duration one academic year; requires literature survey and Preliminary work during this semester

## **DETAIL CONTENTS OF COURSES (FIRST YEAR)**

### **PE-101 FUNDAMENTALS OF PETROLEUM ENGINEERING (2+0)**

#### **Introduction**

Petroleum engineering and petroleum industry. Origin, discovery, development and future prospects of Hydrocarbons. Petroleum play. Distribution of petroleum resources on local and international level. Important units.

#### **Reservoir**

Reservoir rock and flow properties. Formation evaluation.

#### **Drilling**

The onshore and offshore operations. The rig functions, well planning, bits, drilling fluid and casing accessories.

#### **Production**

Introduction to production, processing and transportation. Well completion. Flow in pipes and surface production facilities. Production forecasting, reserve categories. Environmental concerns. Corrosion and its control.

### **EE-116 PRINCIPLES OF ELECTRICAL ENGINEERING (3+1)**

Electric and Magnetic circuits; electric circuits, Kirchhoff's Laws, superposition theorem, substitution theorem, Thevenin's theorem, Norton theorem, Rosen's theorem of star/mesh transformation, proof for DC circuits and their application to circuit analysis, Magnetic circuit, Series and parallel circuits, Principle of calculation of ampere turns for magnetic circuits of electromagnets, Transformers, Bipolar and Multipolar DC machines, Inductances in series and parallel, Hysteresis loss, Eddy current loss, Lifting power of a magnet. AC Single phase and poly phase systems; single phase systems, series, parallel and series and parallel circuits, J operator method and polar methods, Resonance and measurement of power and power factors, poly- phase systems, poly-phase generation, star and delta connections, voltage and current relations, measurement of power and power factor, Balanced and unbalanced load analysis.

DC Machines; Construction, Simple lap and wave windings, Equalizing connections and dummy coils. Elementary concept of armature reaction commutation, Cross and demagnetizing ampere turns. DC generators, types, EMF equation, losses, efficiency performance curves characteristics, critical resistance, speed and effects of armature reaction of OCC, Internal and external characteristics from OCC neglecting and accounting armature reaction, Calculation of series ampere turns for level and over compounding, motors, principle, EMF, torque, speed and speed regulation, types Characteristics, Performance curves loss's and efficiency, speed and torque problems involving magnetization curve, charging and ignition circuits of automobiles. AC Synchronous machines; construction, stator single layer, double layer and concentric windings, damping windings, Coil Span factor, distribution factor, leakage and armature reaction, Synchronous impedance, Alternation, types, EMF equation, speed and frequency, Losses and efficiency Alternator on load, Voltage regulation by synchronous impedance method, Synchronous motor, Types Principle of working, Vector diagram on Load and its analysis for stator current, power factor, torque and mechanical output. Effect of Variation of excitation Losses and efficiency. AC Induction Machines, Induction Motors, Construction Type, Rotating field theory principle of working Slip and its

effect on motor current quantity. Losses efficiency and performance curves starting, Full load maximum torque relation, Torque slip characteristics. Transformer; Construction Principle of working; EMF equation, Transformation ratings, No load working and vector diagram magnetizing Current, Vector diagram load, Equivalent circuit; Open circuit and short circuit test, Losses, Efficiency and performance curves; All day efficiency; Percentage and per unit R, X and Z, Voltage regulation and Kappa's regulation diagram, Transformer as a mutually inductive circuit. Converting Machines; Rotary Converters; Construction; Principle of working; Transformer connection; Voltage and current ratings of single and three phase converters; Mercury arc rectifiers, Construction, Operation; Transformer connection, Voltage and current ratio of single phase and three phase rectifiers.

### **CE-105 ENGINEERING SURVEYING (3+1)**

Basics of Surveying; Definition, Types and Classes of Surveys Including Plane table Survey, Evolution of Surveying, Surveying Instrumentation, Survey Reference, Units of Measurement, Location Methods, Accuracy and Precision, Errors and Mistakes, Accuracy Ratio, Stationing Filed Notes and Field Management. Measurement of Distances, Methods of Linear Measurements, Types of Measurement, Chains, Type, Standard Condition for use of Steel Tapes, Taping Accessories and their Use, Systematic Taping Field Notes for Tapping. Conventional and Electronic field books, Electronic Distance Measurement (EDM), Principles Of Electronic Distance measurement, EDM Characteristics Prisms, EDM Instruments Accuracies, EDM operations, Geometry of Electronic Distance measurements, and Total station. Leveling; Definitions Theory of Differential leveling Effects of Curvature and Refraction, Types of Levels, Automatic Level, Digital Leveling Operations, Techniques of Leveling, Benchmark Leveling (Vertical Control Survey) Profile and Cross-section Leveling, Reciprocal Leveling Peg Test, Errors in Leveling Contours and their Characteristics, Various Methods of Contouring. Angles and Directions; Horizontal and Vertical Angles, Meridians, Types of Horizontal Angles, Azimuths, Bearing, Relationship between Bearings and Azimuths, Reverse Directions, Azimuth and Bearings Computations, Magnetic Declination, Types of Compasses. Theodolites\Tachometers; Introduction, Types of Theodolites. Repeating, Directional and Electronic Theodolites, Temporary Adjustment, Measurement of Horizontal and Vertical Angles, Prolonging a Straight Line Permanent Adjustment. Use of Tachometers in Computation of Horizontal and Vertical Distances. Traverse Surveys; Open and Closed Traverses, Latitude and departures Computation of Error of Closure and the Accuracy of a Traverse, Traversing with Total Station Instruments, Rules of Adjustment on the Original Data, computation of Omitted Measurement, Area of Closed traverse, Method, Use of Computer programs. An Introduction to Geometrics; and Global Positioning System; Geometrics defined, Branches of Geometrics, Remote sensing, Techniques of Remote sensing, Background information on Global Positioning, Receivers, Satellites, Error, GPS Surveying Techniques and Application.

### **CY-109 APPLIED CHEMISTRY (3+1)**

**Gases:** Kinetic Gas Equation, Vander Waal's Equation, Critical phenomenon, Liquefaction of gases, Specific heat ratio between Cp/Cr.

**Properties of Solutions and Liquids:** Surface Tension, Viscosity, Osmosis, Osmotic Pressure, pH-Buffer solution, Spectrophotometer, Basic concepts of Colloidal Chemistry, Classification purification (dialysis).

**Thermochemistry:** Heat of reaction, Relation between H and U measurement of heat reaction, Bomb Calorimeter.

**Electrochemistry:** Laws of Electrolysis, E.M.F. series, corrosion (Theories, inhibition & protection).

**Water and Sewage:** Impurities, hardness, water softening by ion exchange method, purification of water for potable and industrial purposes, Sewage treatment.

**Fuels:** Types of fuels, classification of fossil fuels. Calorific Values

**Metals and Alloys:** Properties and general composition of metals and alloys such as Iron, Copper, Aluminum, Chromium, Zinc used in engineering field.

**Engineering Materials:** Inorganic Engineering materials: Cement, Glass Organic Engineering Materials: Polymers, Rubbers, Plastics and Paints.

### **MT-114 CALCULUS (3+0)**

Set and Function; Define rational, irrational and real numbers; rounding off a numerical value to specified number of decimal places or significant figures; solving quadratic and rational inequalities involving modulus with graphical representation; Definition of set, set operations, Venn diagrams, De Morgan's Law, Cartesian product, Relation, Function and their types (absolute value, greatest integer and combining functions). Graphs of some well-known functions. Limit of function and continuous and discontinuous function with graphical representation.

Propositional Logic; Definition of Proposition, Statement and Argument, Logical Operators, Simple and Compound proposition, various types of connectives, Truth table, tautology, Contradiction, Contingency and Logical equivalence. Boolean Algebra; Definition Boolean function, duality, some basic theorems & their proofs, two valued Boolean algebra, Truth functions, Canonical sum of product form, Digital logic gates & Switching circuit designs. Complex Number; Argand diagram, De Moivre formula, root of polynomial equations, curve and regions in the complex plane, standard functions and their inverses (exponentials, circular and Hyperbolic functions). Differential calculus, Differentiation and Successive differentiation and its application, Leibnitz theorem, Taylor and Maclaurin theorems with remainders in Cauchy and Lagrange form, power series, Taylor and Maclaurin series, L'Hospital's rule, extreme values of a function of one variable using first and second derivative test, asymptotes of a function, curvature and radius of curvature of a curve, partial differentiation, exact differential and its application in computing errors, extreme values of a function of two variables with and without constraints. Solution of non-linear equation using Newton Raphson method. Integral Calculus; indefinite integrals and their computational techniques, reduction formulae, definite integrals and their convergence. Beta and Gamma functions, and their identities, applications of integration.

Center of Pressure and depth of center of pressure. Solid Geometry, Coordinate Systems in three dimensions. Direction cosines and ratios, vector equation of straight line, plane and sphere curve tracing of two and three variables. Surface of revolutions, transformations (Cartesian to polar & cylindrical).

### **HS-105 PAKISTAN STUDIES (2+0)**

Historical and ideological Perspective of Pakistan Movement; Two Nation Theory; Deflation and Signature; Factor Leading towards the Creation of Pakistan; Quaid-e-Azam and the Demand of Pakistan.

Land of Pakistan; Geo-Physical condition; Geo-Political Strategic Importance of Pakistan; Natural resources, mineral, water and power. Constitutional Process; Early efforts to make a constitution; problems and issues; Constitution of 1956 and 1962 and their abrogation; Constitutional and Political Crises of 1971; Constitution of 1973; Recent Constitutional Deployment Contemporary Issues. Foreign Policy; Relations of Pakistan with neighbours; the Muslim World; Super Powers. Human Rights; Conceptual foundation of human Rights; Significance and importance; Comparison of Islamic and Western perspective of Human rights; An overview of UN system for protection of Human Rights; Review of Importance International treaties and Conventions Pakistan's response to Human Rights issue at National and International level.

### **PE-102 ENGINEERING GEOSCIENCES (2+1)**

#### **Introduction:**

The earth as planet and its origin, processes and chemistry. Geological time scale and earth history.

#### **Mineral systems, Type of rock and its properties:**

Crystallographic system, and minerals, Igneous, sedimentary, and metamorphic rocks.

#### **Geological history:**

History and development of life, origin of life. Stratigraphy, fossils and process of organic evolution.

#### **Earthquake and seismic waves:**

Geophysics, Earthquakes, wave's seismology, prediction of earthquakes and preventive measures against earthquakes. Continental and oceanic crust, mantle, gravity and apostasy.

#### **Mountains, basins and plate tectonics:**

Origin of mountains. Earth magnetism. Physiographic features of the ocean basins and formation of sedimentary basins. Continental drift and plate tectonics. Processes occurring at the earth's surface: geology and u-streams, deltas, coasts, glaciers, past and future climates. Geology of petroleum. Application of geoscience in petroleum engineering.

### **ME-101 ENGINEERING MECHANICS (3+1)**

Statics of Particles; Forces in a plane, Newton's First Law, Free body diagram, Forces in space (rectangular components), Equilibrium of a particle in space. Kinematics of Particles; Rectilinear and curvilinear motion of particles, Components of velocity and acceleration Motion relative to a frame in translation. Kinetics of Particles; Newton's Second Law, dynamic equilibrium, Rectilinear and curvilinear motion, Work and energy, Kinetic energy of particles, Principle of Work and energy, Conservation of energy, impulse and momentum, Impulsive forces and conservation of momentum impact direct and oblique, Conservation of angular momentum. Rigid Bodies; Equivalent systems of forces, Principle of transmissibility, Moment of a force, Couple Avignon's Theorem Center of gravity of a three-dimensional body and centroids of a volume. Moments of inertia, radius of gyration parallel axis theorem. Equilibrium of Rigid Bodies; Free-body diagram, Equilibrium in two and three dimensions. Reaction of supports and connections, Equilibrium of two-force and three-force bodies. Kinematics of Rigid Bodies; General plane

motions, Absolute and relative velocity and acceleration. Plane Motion and Rigid Bodies, Forces and acceleration, Energy and momentum, Conservation of linear and momentum. Friction, Law of dry friction, Angles of friction, wedges, Square-threaded screw, Journal and thrust bearing, Belt friction. Analysis of Structure; Internal forces Newton's Third Law, Simple and space trusses, joints and sections, Frames.

### **ME-102 ENGINEERING DRAWING (3+1)**

Drawing equipment and the use of instruments, Basic drafting techniques and standards, Geometrical curves including plan curves, Cycloid, Hypocycloid and Involute. Intersections at various positions of geometrical bodies such as prisms, pyramids, cylinders and cones. Development of surfaces of prisms, Pyramids, cylinders and cones. Freehand sketching of machine and engine components. Locking arrangements, foundation bolts, Stuffing box, Shaft couplings, Foot step bearing, Pulleys, Engine connecting rod, Concept of working of component parts of machines and engines size description, dimensions and specifications, Limit dimensioning and geometric tolerance, Limits, Fits and tolerances, conventional symbols. Sectioning of machine and engine components, Orthographic projections and standard practices. Isometric views with particular reference to piping and ducting.

### **PH-122 APPLIED PHYSICS (3+1)**

Introduction; Scientific notation and significant figures. Type of errors in experimental measurements. Unit's different system. Graphical Techniques (log semi-log and other non-linear graphs). Vectors; review of vectors, Vectors derivatives. Line and surface integrals. Gradient of scalar Machines; the limits of Mechanics. Coordinate systems. Motion under constant acceleration, Newton laws and their applications. Galilean invariance. Uniform circular motion. Frictional forces. Work and energy, Potential Energy, Energy Conservation, Energy & our Environment, Angular Momentum. Electrostatics and Magnetism, Coulombs law, Electrostatics potential energy of discrete. Charges. Continuous Charge distribution, Gauss's law. Electric field around conductors. Dielectric. Dual trace oscilloscope with demonstration. Magnetic fields, Magnetic force on current, Hall effect, Biot-Savart law, Ampere's law, Field of rings and coil, Magnetic dipole, Diamagnetism, Paramagnetic and Ferromagnetism Semiconductor Physics; Energy levels in semiconductor, Hole concept, Intrinsic and Extrinsic regions, Law of Mass Action, P-N junction, Transistors, Simple circuits. Waves and Oscillations; Free oscillation of system with one and more degree of freedom, Solution for Modes, Classical wave equations, Transverse modes for continuous string, Standing waves, Dispersion relation for waves, LC network and coupled pendulums, Plasma oscillations. Optics and Lasers; Harmonic travelling waves in one distention, Near and far fields, Two-slit interference, Huygens Principles, Single-slit diffraction, Resolving power of optical instruments, Diffraction Grating , Lasers. Population inversion, resonant cavities, Quantum efficiency, He-Ne, Ruby and CO<sub>2</sub> lasers. Dopler Effect and sonic boom. Modern Physics; inadequacy of classical physics. Plank's explanations of back body radiation, Photoelectric effect, Compton effect, Bohr theory of Hydrogen atom, Atomic spectra, Reduce mass, De-Broglie hypothesis, Brags Law, Electron microscope, Uncertainty relations Modern atomic models, Zeeman effect, Atomic nucleus, Mass-energy relation, Binding energy, Nuclear forces and fundamental forces, Exponential decay and half-life. Radioactive equilibrium in a chain, Secular equilibrium, Nuclear stability, Radiation detection instruments. Alpha decay, Beta decay, Gamma decay attenuation nuclear radiation hazards and safety, Medical uses of Nuclear Radiation, Fission Energy release, Nuclear Reactors, Breeder Reactor, Nuclear Fusion.

### **HS-101 ENGLISH (3+0)**

Study Skills (sessional tests only); Reading, dictionary, library skills, speed reading, writing outlines, note taking . Oral communication (sessional tests only); confidence building, class discussions, speeches, verbal interaction. Advanced reading comprehension; using texts dealing with science, literature and human rights (as per HEC recommendation.). Précis writing; rules of précis writing practice précis. Controlled & guided writing; pre writing (planning, information gathering, preparing to write), writing, search for topic sentences, developing a theme, following up ideas and arguments, outline plans etc. Essay writing; Types of writing – narrative, descriptive, expository, argumentative etc, Using guided writing to organize essays, Including human rights as essay topics (as per HEC recommendation). Writing short reports; short background of report and its importance, memo report, brief reports on events seen / experienced like visit to an exhibition etc. Letter writing; format and layout, formal letters, types of letters – invitations (acceptance and refusals), condolence, thanks, congratulations, to the editor, chairman class advisor, dean, vice chancellor etc. Applied Grammar; morphology, types of sentences, sentence analysis, tenses, jumbled sentences, question tags, homonyms and homophones and their use in sentences , punctuation – sentences and paragraphs, use of idioms

### **HS-127 PAKISTAN STUDIES FOR FOREIGN STUDENTS (2+0)**

#### **Land of Pakistan:**

Land & People – Physical features and demography, Geographical and strategic importance of Pakistan, Natural resources – Mineral, water, and power, Natural Landscape, Environmental issues in Pakistan, Cultural heritage: important remnants of ancient civilizations in Pakistan

#### **Creation of Pakistan:**

A brief Historical survey of Muslim community in the sub-continent, Two-Nation theory – its origin & development, Rationale for Pakistan – Factors leading to the demand of Pakistan, Emergence of Pakistan, Role of Quaid-e-Azam the struggle for Pakistan

#### **Government & Politics in Pakistan:**

Political History of Pakistan – A brief account (1947 to date), Constitution of Pakistan 1973 – Salient features, Governmental structure – Federal, Provincial and Local.

#### **Pakistan in the Community of Nations:**

An overview of Pakistan's foreign policy, Relations of Pakistan with neighbors, Super Powers, and the Muslim World

#### **Pakistan's Stand Point on Human Rights:**

Constitutional provisions, Comparative analysis of Western and Islamic perspective of Human Rights, Pakistan's Stand on national and international level

## **DETAIL CONTENTS OF COURSES (SECOND YEAR)**

### **PE-207 DRILLING ENGINEERING I (2+1)**

#### **Introduction :**

Drilling and drilling rig components.

#### **Drilling Fluids science and well planning:**

Drilling fluids. Managing drilling operations. Planning and drilling vertical wells, rig selection, rig equipment, drill bits. Coring methods and equipments.

#### **Casing, Cementing and Well control:**

Casing design, landing and cementing practices. Well control. Drilling problems; stuck pipe remedial, borehole instability, recovery operation and fishing operations. Safety issues, drilling economics, AFE (Authorization of final expenditures).

### **PE-202 PETROLEUM GEOLOGY (2+1)**

#### **Introduction:**

Petroleum geology. Origin of Petroleum, physical & chemical properties, composition of hydrocarbons, conventional and unconventional resources.

#### **Sedimentary rocks and plate tectonics:**

Sedimentary rocks and environment of deposition. Plate tectonics and its movements, sedimentary basins, stratigraphic nomenclature and sequence stratigraphy. Sedimentary basins of Pakistan.

#### **Geologic time and petroleum systems:**

Geologic time and correlation. Petroleum system, elements and processes. Petroleum source and reservoir rocks, seal/ cap rock and traps. Reservoir types, properties and geological considerations. Potential petroleum reservoirs of Pakistan and surrounding areas.

#### **Structural geology and field maps:**

Primary and secondary structures; dip, strike and thickness of beds. Outcrops and cross sections. Rocks Deformation: classification of folds, faults, joints and unconformities. Field maps, digital maps and remote sensing techniques.

### **PE-203 RESERVOIR PETROPHYSICS (2+1)**

#### **Introduction to rock properties:**

Physical properties of reservoir rocks, including porosity, permeability, fluid saturations, compressibility, wettability, capillary pressure, electrical, mechanical and thermal properties. Core analysis, core preparation, cleaning and drying.

**Description and measurement of rock properties:**

Significance, definition and methods of measurement of rock properties; porosity, absolute permeability, relative permeability, Klinkenberg Effect, and fluid saturation. Permeabilities and porosities of different types of rocks. Relation between porosity and permeability. Typical relative permeability data, gas-oil & water-oil relative permeabilities and three-phase relative permeability. Critical gas saturations and assessing the reliability of fluid saturation from mass balances. Wettability, interfacial tension, methods of measurement and significance in petroleum recovery. Capillary pressure and fundamental concepts behind capillary pressure data to reservoir scale. Generalization (averaging) of capillary pressure data, the “J” function and its significance in reservoir engineering. Averaging and normalization of relative permeability data. Empirical correlation for relative permeability.

**PE-206 THERMODYNAMICS – I (3+1)**

Fundamentals; thermodynamics properties, intensive and extensive properties; pressure; temperature; zeroth Law of thermodynamics. Energy, potential energy; kinetic energy; internal energy; first law of thermodynamics; non-flow energy equation; steady flow energy equation; flow work. PVT diagram for single phase. Reversibility, Carnot cycle; Second law of thermodynamics; entropy; uses of entropy, Mollier’s chart. Behaviour of ideal and real gases; compressibility, various gas equations; principle of corresponding states. Gaseous mixture; single species two phase mixture; dryness fraction, sub cooled and superheated liquid. VLE equilibrium; binary mixtures; ideal solutions; Raoult’s law; Henry’s Law; bubble point, dew point. Vapor power cycles; steam power plant; Air standard cycles; Diesel and Otto cycles. Refrigeration cycle; reversed Carnot; COP heat pump and refrigerators. Reciprocating compressors.

**HS-205 ISLAMIC STUDIES (2+0)**

Fundamental of Islam, Tauheed, Argument for the oneness of God. Impact of Tauheed on human life. Place of man in the universe, purpose of creation. Textual study of Surah Al-Rehman & Surah Al-Furqan, Prophethood Serat-life of the Prophet (PBUH) as an embodiment of Islamic ideology. Faith in the hereafter, Akhrat. Effect of the believer on worldly life. Ibadat concept major Ibadat. Basic source of shariah, sources of knowledge. Moral & social philosophy of Islam, Islam as a living force. Application of Islamic teachings to the socio-economic development. Challenges in the 21<sup>st</sup> century.

**PE-205 COMPUTER PROGRAMMING &APPLICATION (2+1)**

**Introduction:**

Effective use of computer resources and software tools. Communication and user interfaces, lectures, seminars and class projects. Windows, use of graphics and knowledge of the software and hardware.

**Computer programming languages:**

Introduction to C++, Matlab and C language, windows, MS Excel & Macros. Applications in petroleum industry.

**Database management:**

Management of data base, theoretical base and application of statistical methods commonly employed in the analysis of petroleum data.

**CE-212 MECHANICS OF SOLIDS (3+1)**

Different Stress States; Uniaxial state of stresses & strains; relationship between elastic constants; Responses of materials under different sets of monotonic loading; normal & shearing stress & strains; Gradually & suddenly applied loads; Distributions of direct stress on uniform & non-uniform members; thermal stresses & strain. Bending Theory; theory simple bending, position of neutral axis, moment of resistance and section modulus; bending & shearing stress distribution in beams; Relationship between load, shear force & bending moment; stresses in composite sections; curvature, slope & deflections of beams using integration methods. Biaxial State of Stress; biaxial state of stresses, resolution of stresses principal plane, principal stresses & strains; graphical representation of stresses & strain, Mohr's circle of stresses & strains. Theory of Torsion; theory of torsion of solid & hollow circular shafts, shearing stress distribution & angle of twist, strength & stiffness of shaft. Cylinders; analysis of thin & thick cylinders. Stability; struts & columns; euler, Rankin & other formula for bucking load of columns; stability analysis of columns under eccentric loading.

**CH-207 FLUID MECHANICS II (3+1)**

Two and three dimensional fluid flow, Navier Stokes equations, applications, Euler's equation, transport equations.

Potential Flow: Definition, irrotational flow, stream function, application of Bernoulli's equation to irrotational flow, flow around a cylinder. Flow through porous media, fluidization.

Non-Newtonian fluid flow, circular pipes, power law, bingham plastic, transition from laminar to turbulent flows. Surface tension and surface energy, wetting and contact angle, interfacial tension, forces due to curved surfaces.

Boundary layer: Prandtl's Boundary layer theory, laminar and turbulent boundary layers, flow over a flat plate, flow in circular pipes.

Pumps, Compressors and Turbines; positive displacement and centrifugal; stability; fluid engine and turbine efficiency; Gas-Liquid flow; horizontal and vertical flow, gas liquid flow with boiling.

**CE-215 FLUID MECHANICS (3+1)**

**Basic Concepts and Definitions:**

Units, density, specific weight, mass, viscosity, etc.

**Fluid Statics:** Pascal's Law, Measurement of pressure, Pressure head, Manometers, Hydrostatics forces on submerged areas (vertical, inclined, and curved), Buoyancy of fluids.

### **Fluid Kinematics:**

Type of flows, Streamline and streak lines, Velocity and acceleration in steady & unsteady flow, Continuum, Lagrange and Eulerian descriptions, Equation of continuity flow, mass flow rate, weight flow rate, Stream function and velocity potential function and orthogonality.

### **Energy Consideration in Steady Flow:**

Concept of Energy and Head, General Equations of Energy and Bernoulli's assumption for incompressible fluids, Hydraulic grade line and energy line, Power consideration, cavitation.

### **Impulse-Momentum:**

Basic principle, Force on pressure conduits Reducers and Bends, jet of water, structure In open channel

### **Similitude:**

Definitions, Geometric, Kinematic and Dynamic similarities, Dimensionless numbers, Buckingham-Pi Theorem

### **Steady Flow through Pressure Conduits-I:**

General equation of friction, laminar and turbulent flow, Reynold's Number, Velocity profile in circular pipes, Nikuradse's experiment- viscous sub layer: smooth, transition and fully rough pipe concepts and equations & Moody's diagram, Minor losses.

### **Practical Part - Fluid Properties and flow measurement:**

Fluid properties, Hydrostatic Pressure, velocity measurements, Orifices meter, free and forced vortex, venturi meter, notches & weirs.

## **MT-221 LINEAR ALGEBRA & ORDINARY DIFFERENTIAL EQUATIONS (3+0)**

Linear Algebra; Linearity and linear dependence of vectors, basis, dimensions of vectors space, field matrix and type of matrices (singular, nonsingular, symmetric, non-symmetric, upper, lower, diagonal), Rank of a matrix using row operations and special method, echelon and reduced echelon forms of a matrix, determination of consistency of system of linear equation using rank, matrix of linear transformation, eigen value and eigen vectors of a matrix, Diagonalization. Application of linear algebra in relevant engineering problem. 1<sup>st</sup> Order Differential Equations; Basics concepts; Formation of differential equations and solution of differential equations by direct integration and by separating the variables. Homogenous equations and equations reducible to homogenous form; Linear differential equations of the order and equations reducible to the linear form; Bernoulli's equations and orthogonal trajectories; Application in relevant Engineering. 2<sup>nd</sup> and Higher Order Equations; Special types of 2<sup>nd</sup> order differential equations with constant coefficients and their solutions; The operator D; Inverse operator 1/D; Solution of differential by operator D methods; Special cases, Cauchy's differential equations; Simultaneous differential equations; simple application of differential equations in relevant Engineering. Partial Differential Equation; Basics concepts and formation of partial differential equations; Linear homogeneous partial differential equations and relations to ordinary differential equations, Solution of first order linear and special types of second and higher order differential equations; D'Alembert's solution of the wave equation and two dimensional wave equations; Lagrange's solution,

Various standard forms. Fourier Series; Periodic functions and expansions of periodic functions in Fourier series and Fourier coefficients; Expansion of function with arbitrary periods; Odd and even functions and their Fourier series; Half range expansions of Fourier series.

### **MT-331 PROBABILITY & STATISTICS (3+0)**

Statistics; Introduction, Types of data & variables, presentation to data, object, classifications, Tabulation, Frequency distribution, Graphical representation, Simple & Multiple Bar diagrams, Sartorial & Pie-Diagram, Histogram, Frequency Polygon, Frequency Curves & their types. Measures of Central Tendency and Dispersion; Statistics Averages, Median, Mode, Quartiles, Range, Moments, Skewness & Kurtosis, Quartile Deviation, Mean Deviation, Standard deviation, Variance & its coefficient, Practical Significance in related problems. Curve Fitting; Introduction, fitting of a first and second degree curve, fitting of exponential and logarithmic curve, related problems. Principle of least squares, Second order Statistics & Time series not in bit detail. Simple Regression & Correlation; Introduction, Scatter diagrams, Correlation & its Coefficient, Regression Lines, Ranc correlation and its coefficient, Probable Error (P.E.) Related problems. Sampling & Sampling Distribution; Introduction, Population, Parameter & Statistic, Objects of sampling, Sampling distribution of Mean, Standard errors, Sampling & Non-sampling Errors, Random Sampling, Sampling with & without replacement, Sequential Sampling, Central limit theorem with practical significance in related problems. Statistical Inference and Testing of Hypothesis; Chi-square distribution/test, one tails & two tails test, Application in related problems. Probability; Basic concepts, Permutation & Combination, Definitions of probability, Laws of probability; Conditional probability, Baye's rule. Related problems in practical significance. Random variables; Introduction, Discrete & Continuous random variables, Random Sequences and transformations, Probability distribution, Probability density function, Mathematical expectations, Moment Generating Function (M.G.F.). Markova random walks chain/Related problems. Probability Distributions; Introduction, Discrete probability distributions, Binomial, Poisson, Hyper geometric & Negative binomial distribution, Continuous probability distribution, Uniforms Exponential & Normal distribution & their coefficient, Probable Error practical significance.

### **HS-209 ETHICAL BEHAVIOUR (FOR NON MUSLIMS) (2+0)**

**Introduction to Ethics:** Definition of Ethics, Definition between normative and positive science, Problem of freewill, Method of Ethics, Uses of Ethics.

**Ethical Theories:** History of Ethics: Greek Ethics, Medieval, Modern Ethics, Basic concept of right and wrong: good and evil, Utilitarianism, hedonism, self-realization: egoism, intuitionism, rationalism; Kant's moral philosophy.

**Ethics & Religion:** The relation of Ethics to religion; Basic ethical principles of major religions: Hinduism, Judaism, Buddhism, Zoroastrianism, Christianity, Islam.

**Ethics, Society, and moral theory:** Ethical foundation of Rights and Duties, Applied Ethics, Society as the background of moral life, Universalism and Altruism, Theories of punishment.

## **DETAIL CONTENTS OF COURSES (THIRD YEAR)**

### **PE-302 RESERVOIR FLUID PROPERTIES (2+1)**

#### **Introduction to reservoir fluid and its behavior:**

Properties of reservoir fluids, phase behavior of single and multi-component mixtures, saturation pressures and compositions. Properties of formation waters and relevance in reservoir engineering.

#### **Sampling:**

Sampling and methods of sampling of reservoir fluids. The fluids chain.

#### **PVT analysis/experiments:**

PVT analysis of reservoir fluids through experiments like CCE, CVD, DE & Separator test. Petroleum Reservoir fluid types, classification and its constituents. Field observations of PVT properties. Gas-Liquid Equilibrium (Flash Calculations).

Compositional analysis of petroleum reservoir fluids, examples of typical compositional data on hydrocarbons and formation water. Empirical correlation's for determining PVT properties. Surface separators, convergence pressure, and general low-pressure calculation.

### **PE-304 RESERVOIR ENGINEERING – I (3+1)**

#### **Introduction:**

Reservoir pressure distribution, temperature and reservoir fluids. Reservoir drive mechanisms. Reservoir physical features.

#### **Reserves estimation:**

Volumetric Estimation of Hydrocarbons Initially in Place (HCIIP). Material Balance Equation and applications for under- saturated, saturated, retrograde, wet and dry gas reservoirs.

#### **Fluid flow behavior:**

Darcy law of fluid flow system and well performance/ productivity index. Modes of well operation and general pressure dynamics, types and stages of flow and skin factors. Time to reach minimum bottom hole pressure and saturation pressure paths. Rate predictions using tank model for compressible liquid (single layer reservoir and multilayer reservoir with and without cross flow), low pressure gas and modified black oil.

### **PE-306 SUBSURFACE PRODUCTION ENGINEERING (2+0)**

#### **Wellbore deliverability:**

Well bore flow performance. Gradient curves and generation of vertical lift performance curves. Use of IPR/VLP matching to predict production rate, rate sensitivity, tubing diameter requirement and well deliverability. Near well bore condition and damage characterization. Flow through chokes.

#### **Completion and work-over:**

Completion and work-over fluids. Work-over operations including various completions designs, reservoir and mechanical considerations, sand control and remedial cementing. Perforations, stimulation, horizontal well completion technology and operations. Wireline operations. Tubing design and tubing movement calculations. Surface and Subsurface equipment.

### **PE-311 FUNDAMENTALS OF WELL LOGGING (2+1)**

#### **Introduction:**

Display of well-log data and graphical conventions. Wellbore environment and the physics of mud-filtrate invasion.

#### **Types of logs and its applications:**

Temperature and caliper logs, gamma-ray logging principles and applications. Spontaneous potential (SP) logs, principles and applications. Electrical properties of rocks and Archie's relationships. Resistivity logs. Modern resistivity logging tools. Density logging and litho-density logs, principles and applications. Neutron logging, principles and application. Joint interpretation of density and neutron log measurements. Principles of sonic logging and applications. Estimation of total and effective porosity from combinations of logs. Estimation of total and effective fluid saturation from combinations of logs. Petro-physical interpretation of well logs acquired in shaly-sands. Cased Hole logging and production Logging.

### **EL-305 INSTRUMENTATION & CONTROL (3+1)**

Introduction, instrumentation and control system terminologies. Open loop and closed loop system. Mathematical models of physical systems, transfer function, interaction and non-interactive system, development block diagrams tachometers, signal conditioning activator; Transient response of first and second order system, steady state analysis, Transportation lag, dynamic response of a gas absorber and heat exchange. Controller design, P control, I control, PID control, stability criteria, root locus method, frequency response of control system, D control ( bode diagram, Nyquist diagram). Introduction to non-linear system. Simulation of control system.

### **HS-304 BUSINESS COMMUNICATION AND ETHICS (3+0)**

Communication skills (oral), definitions and conditions. Modes, verbal, non-verbal, vocal, non-vocal, sender, receiver, en-coding, decoding, noise, context, emotional maturity, relationships, etc. Language, perception, non-verbal, body language, physical appearance, cultural differences etc. Personal and interpersonal skills / perceptions, communication dilemmas and problems, public speaking-speaking situation, persuasion, making presentation, interviews. Business writing, formal / business letters, e-mail-

job applications and resumes / CV, inquires, complaints / adjustments, orders, quotations, banking etc. Memos layout, language, style, meeting management, notice, agenda, conducting / participating, writing minutes, contracts and agreements, (basic theoretical knowledge and comprehension), research / scientific reports, types, structure, layout / presentation, writing minutes, tenders etc. (basic theoretical knowledge and comprehension). Engineering / business ethics, need and objective for code of ethic and its importance, type of ethic, involvement and impact in daily life problems / conflicts / dilemmas in application ( case studies). Sexual harassment / discrimination in the workplace, why it occurs, myths regarding sexual harassment, how to deal with it gender equality, respect etc. Codes of conduct, Pakistan Engineering Council Code for Gender Justice, brief study of other codes of conduct.

### **PE-312 DRILLING ENGINEERING II (2+1)**

#### **Wellbore hydraulics:**

Design of circulation system, hydrostatic pressure in gas and liquid columns. Hydrostatic pressure in complex fluid columns. Annular pressure during well control operations. Non-static well conditions. Rheological Model (Newtonian and Non-Newtonian model). Mud hydraulics.

#### **Formation damage:**

Formation damage during drilling, causes and prevention of formation damage.

#### **Casing design:**

Casing design procedures, collapse, burst and tension. Abnormal pressures prediction and well control. Fracture gradient prediction. Well design for safety and efficiency.

#### **Cementation design:**

Design of primary and secondary cementing jobs. Liner cementing, setting of cement plugs.

#### **Bit selection:**

Bit selection & evaluation of wear penetrating cementing. Flow through jet bits. jet bit nozzle selection.

#### **Directional & horizontal drilling:**

Directional drilling, wellbore surveying techniques. Horizontal drilling, coiled tubing drilling. BHA design for vertical and directional wells.

#### **Planning and budgeting:**

Planning, budgeting and cost control of drilling operation, tangible and intangible expenditure.

### **PE-308 PETROLEUM PRODUCTION ECONOMICS (2+0)**

Introduction to the standards and practices of economic analysis in the petroleum industry. Brief review of the principles of economic evaluation. ROR and NPV analysis.

Definition of risk and uncertainty, decision, analysis, decision tree analysis and estimation of future money values. Typical decision making situations including risk analysis and EMV calculations and alternative reservoir depletion schemes. Analysis involves reserve estimation and forecasting of capital investment, operating cost and manpower requirement.

Petroleum taxation regulations, profitability criteria, cut off criteria unit operations, SPE-Petroleum resource and reserve classification.

Before tax cash flow models, after cash flow models. Capital budgeting techniques. Investment selection decision making.

### **PE-313 STRUCTURAL GEOLOGY AND GEOPHYSICAL EXPLORATION (2+1)**

#### **Introduction:**

Elements of map scale structure, location, structure contouring and thickness Measurement. Fold and fault geometry, cross section, data projection & dip sequence analysis. Structure restoration and validation,

#### **Seismic, structural and stratigraphic interpretation and processing:**

Seismic, structural and stratigraphic interpretation and seismic interpretations definition. Requirement for seismic data acquisition and processing and pitfalls of seismic interpretations.

#### **Geophysical/geological interpretation:**

Geophysical and geological interpretation, tying, time depth conversion interpretation, structural interpretation general consideration, contouring and faults.

#### **Seismic method characteristics:**

Stratigraphic interpretation, versatile colour display, seismic attribution, reef analysis, sand reservoir, sand-shale analysis and direct hydrocarbon indicators.

### **PE-310 NATURAL GAS ENGINEERING (2+1)**

#### **Introduction:**

Properties of natural gas. Production, transportation, storage and gauging of gas. Sales gas customer requirement.

#### **Facilities designing for gas processing:**

Gas field development, design of gathering systems, field treatment and processing of natural gas e.g: gas dehydration and gas sweetening. Compressors and horsepower requirements. Flow through pipelines and pressure drop. Gas hydrates, LNG, Storage of natural gas. Gas to liquids (GTL). Gas metering separator selection. Corrosion prevention methods.

**MT-471 APPLIED NUMERICAL METHODS (2+1)**

Error Analysis, Types of errors (relative, absolute, inherent, round off, truncation), significant digits and numerical instability, flow chart. Use any Computational tools to Analysis the Numerical Solutions. Linear Operators; Functions of operators, difference operators and the derivative operators, identities. Difference Equations, Linear homogenous and non-homogenous difference equations. Solution of Non-linear Equations; Numerical methods for finding the roots of transcendental and polynomial equations (Secant, Newton – Raphson, Chebyshev and Giraffe's root, squaring methods), rate of convergence and stability of an iterative method. Solution of Linear equations; Numerical methods for finding the solutions of system of linear equations (Gauss-Eliminations, Gauss-Jordan Elimination, triangularization, Cholesky, Jacobi and Gauss-Seidel). Interpolation & Curve Fitting, Lagrange's Newton, Hermit, Spline least approximation (Linear and non-linear curves). Numerical Integration & Differentiation, Computation of integrals using simple Trapezoidal rule, 1/3th Simpson's rule, 3/8th Simpson's rule. Composite Simpson's and Trapezoidal rule, computation of solutions of differential equations using (Euler method, Euler modified method Range Kutta method of order 4), Numerical Solutions of Partial differential Equations, Optimization problem (Simplex Method), Steepest Ascent and steepest Descent Methods.

## **DETAIL CONTENTS OF COURSES (FOURTH YEAR)**

### **PE-401 RESERVOIR SIMULATION (3+1)**

Basic theory and practice in reservoir simulation. Deriving mass and momentum balance equations. Introduction to the finite difference methods and solution techniques. Time stepping, analysis of accuracy, convergence and stability and discretization. Numerical schemes for solving sparse matrix equation. Flow simulation using field data. Reservoir model; up-scaling. Specifying rock-fluid interactions. Treatment of wells in reservoir flow simulation. Interpreting flow simulation results and history matching. Various techniques for developing black-oil, compositional, thermal and dual-porosity models. Fracture reservoir simulation.

### **PE-402 RESERVOIR ENGINEERING – II (2+1)**

#### **Water influx modeling:**

Natural water influx, water drive and aquifer classification. Water drive diagnosis. Key aquifer properties and water influx models.

#### **Wet and dry gas reservoir:**

Estimating gas well rates. Volumetric and water drive gas reservoir performance. Material balance method to diagnose water influx. Analytical models to compute gas reservoir performance.

#### **Black oil reservoir:**

Empirical methods to estimate ultimate oil recovery.

#### **Material balance and recovery strategies:**

Estimating oil well rates under different drives mechanisms. Early well performance. Case histories. Volatile oil and gas condensate reservoir. Correlation to estimate ultimate oil recovery. Volatile oil and condensate reservoir performance. Early gas condensate well performance and case histories.

#### **Decline curve analysis:**

Decline curve models, effect of  $b$  and  $D_i$  on rate performance. Methods to estimate  $b$  and  $D_i$ .

### **PE-408 WELL TESTING (3+1)**

Introductory materials objectives of well tests, reservoir model. Fundamentals of flow in porous media, material balance concepts (constant compressibility and dry gas systems), steady state and pseudo steady state flow concept. Derivation of the diffusivity equation using Boltzmann transformation for slightly compressible fluid. Pressure draw down, build-up tests. Injection & fall off tests. Concept interpretations modified isochronal test and flow-after flow test. Average reservoir pressure; Reservoir limits tests. Flow of real gas through porous media. Modification of the diffusivity equation for gas. Application of pseudo-pressure function, pressure square and pressure methods for analysis of gas well test. Gas well deliverability test. Type curve matching; Analysis of well tests affected by phase redistribution. Well testing of hydraulically fractured and naturally fractured Wells. Drill stem testing and analysis. Interference and pulse testing, design and implementation of well tests.

## **PE-412 INTRODUCTION TO UNCONVENTIONAL ENERGY RESOURCES (2+0)**

### **Introduction:**

Economic significance, technical, economic, political, and environmental constraints on development of unconventional resources.

### **Naturally fractured reservoir:**

Natural fractures; importance in unconventional reservoirs, origin, occurrence, and predictability. Fracture effects on hydrocarbon storage, porosity, and permeability, permeability anisotropy and coning. Breakthrough and boundaries roles in exploration. Roles in reservoir management; primary and enhanced recovery. In-situ stresses; importance in unconventional reservoir performance. Classification of fractured reservoirs.

### **Low-permeability (Tight) sands:**

Occurrences, resources and reservoir characteristics. Drilling and completion methods. Reservoir management, limitations on development and present activity.

### **Coal-bed gas:**

Occurrences, resources and reservoir characteristics. Drilling and completion methods. Facilities, reservoir management, limitations on development and present activity. Water and environmental issues.

### **Shale reservoirs (gas and oil):**

Occurrences, resources and reservoir characteristics. Drilling and completion methods. Facilities, reservoir management, limitations on development and present activity. Water and environmental issues.

### **Heavy oil:**

Occurrences, resources and reservoir characteristics. Drilling and completion methods. Facilities, reservoir management, limitations on development and present activity. Water and environmental issues.

### **Gas hydrates:**

Occurrences, resources and reservoir characteristics. Drilling and completion methods. Facilities, reservoir management, limitations on development and present activity. Water and environmental issues.

### **Gas storage:**

Types and locations of gas storage reservoirs, technical issues and terminology. Gas storage volumes and economics. CO<sub>2</sub> Storage.

### **Other unconventional energy resources:**

Geothermal energy, Coal conversion to Gas, Coal-to-gas and In-situ gasification.

## **PE-411 PROJECT PLANNING & MANAGEMENT (2+0)**

### **Introduction:**

Project management context and project management. Processes integration management; project plan development, project plan execution and overall change control.

### **Scope management:**

Initiation scope planning, scope definition, scope verification and scope change control.

### **Time management:**

Activity definition, activity sequencing, activity duration estimation, schedule development and schedule control.

### **Cost management:**

Resource planning, cost estimating, cost budgeting and cost control.

### **Quality management:**

Quality planning, quality assurance and quality control.

### **HR management:**

Organizational planning, staff acquisition and team development. Communication management; communications planning, information distribution, performance reporting and administrative closure.

### **Risk management:**

Risk identification, risk quantification, risk response development and risk response control. Procurement management, procurement planning, solicitation planning, solicitation, source selection, contract administration, contract close-out. Closing; administrative closure, contract close-out, and lessons learnt. Computing project management software, PERT, Gantt Chart/Network, CPM, S Curves etc. CPM, statistical techniques.

## **PE-413 OIL AND GAS FIELD PRODUCTION FACILITIES (3+1)**

### **Introduction:**

Petroleum fluid characteristics, composition, density and gravity, emissions, viscosity, and fluid flow in pipes. Horizontal well productivity. Multiphase flow in both vertical and inclined tubing. Flow correlations and pressure drop prediction.

### **Production optimization (nodal analysis):**

**Process Control;** Flow control, pressure control, level control, temperature control, safety shut down and pressure relief.

**Well stimulation;** Hydraulic fracturing and matrix acidizing. Modeling; propagation models, 2D, Pseudo 3D, PKN, GDK.

**Produced water treatment:**

Skimmer tanks. Coalescers, hydro cyclones, flotation cells, disposal piles and injection wells. Tanks; volume and construction, final separation and vapor recovery options and emissions (flash calculations). Surface separation operations including types, application and design of two and three phase separators.

**Artificial lift methods:**

Artificial lift methods and applications including gas-lift, electrical submersible pumping, and sucker rod pumping. Types of installation and design.

**PE- 414 WATER FLOODING AND INTRODUCTION TO ENHANCED OIL RECOVERY (3+1)**

**Introduction to Enhanced oil recovery (EOR):**

Introduction to EOR methods and EOR status. Basic petrophysics properties; Permeability/porosity, Relative permeability, capillary pressure and residual oil saturation. Overview of EOR methods: EOR processes for heavy oil and light oil. Chemical methods and gas injection methods. Thermal methods. Status of worldwide EOR projects and evaluation.

**EOR simulators:**

Overview of commercial simulators for EOR methods.

**Waterflood:**

Decline curve analysis. Mobility ratios, displacement efficiency, sweep efficiency, performance prediction and water sources.

**Chemical methods–polymer flood:**

Polymers, polymer properties and rheology, fractional flow and laboratory results. Field projects.

**Chemical methods:**

Surfactant flood; surfactants, surfactant-brine-oil phase behavior, surfactant solution properties, trapped oil and oil mobilization. Relative permeability and capillary pressure and laboratory results. Field projects.

Alkaline Flood: Laboratory screening, soap generation and phase behavior. Laboratory tests, field examples.

**Conformance control Methods:** Bulk gels, micro gels, foam, field projects.

**Gas flooding:**

Immiscible and Miscible gas injection. CO<sub>2</sub> properties. Phase diagrams, continuous, slug and WAG injection. Relative permeability models. Field examples.

**Thermal methods:**

Steam flooding, cyclic and continuous steam injection. Thermal properties of rock and fluids. Effect of temperature on fluid and rock properties. SAGD. In situ combustion and evaluation of heat losses. Field examples.

**PE-406 PETROLEUM REFINERY ENGINEERING (2+1)**

**Introduction**

Introduction, overall refinery flow, refinery feed-stocks and products analysis.

**Refinery Processes**

Crude distillations (atmospheric & vacuum) case studies, coking catalytic reforming and isomerization, catalytic cracking, hydrogenating, catalytic hydro cracking and hydro processing.

**Refinery Products:**

Product blending, supporting process and petrochemicals.

**Refinery Economics**

Cost estimation and economic evaluation of refinery investment.

**Corrosion**

Corrosion testing, prevention & its problem to petroleum refinery industry.

**PE-407 PETROLEUM PROPERTY, ENVIRONMENT & SAFETY MANAGEMENT (2+0)**

**Petroleum Laws and Legislations:** Historical development of petroleum legislation. General principles in petroleum law. Rules and regulations in Pakistan. Pakistan's on-shore and off-shore petroleum exploration policy. Environmental hazards of petroleum industry including exploration drilling, production, refining, distribution and storage. Oil spills and distribution contamination of groundwater by non- aqueous phase liquids. National environmental quality standard and their implementation, occupational health and safety management procedures, audit and inspection. Risk assessment, accident investigation and concept of total loss control. Labs; visit to oil and gas fields and related research organization, assignment on specific problems.

**PE-410 PETROLEUM ENGINEERING PROJECT (0+6)**

Team design, project applying principles of petroleum engineering, development of problem specific software, dealing with special case studies. Petroleum design considerations will include areas of detailed reservoir characterization, well test analysis, recovery and production forecasting, preliminary drilling completion and facility design and economic evaluation. Students will be evaluated through both oral examination and major written report.