

Title of the Program: M.Sc. Petroleum Technology**SEMESTER - I****(22 Credits)****PT 111 T : Geology and Geochemistry of Petroleum (4 Credits)****Credit 1: Petroleum and its Occurrences:**

- a) Petroleum: A Natural Resource; Historical Overview of Search for Petroleum. Definition and Relation of Petroleum Geology to other Sciences. Exploration: Role of Geosciences. Major challenges for petroleum geology and its significance in different phases of Exploration and Production.
- b) Surface indications and direct detection of hydrocarbons. Modes of surface and subsurface occurrence. Factors controlling the occurrences of petroleum. Unconventional resources of Hydrocarbons : Gas Hydrates, Shale Gas, Basin Centric Gas, Coal Bed Methane, Tight Gas Sands.
- c) Origin of Petroleum: Theories of Organic and Inorganic origin. Source Rock concept. Kerogen: Source Material and Formation, Composition and Distribution. Oil window concept.
- d) Migration and accumulation of Oil and Natural Gas:
Primary and Secondary Migration. Trapping Mechanism and formation of Oil and Gas Fields: Types of trapping mechanism (Structural, Stratigraphy and Fluid Traps). Traps associated with Salt domes.

Credit 2: Reservoir Rocks and Reservoir Fluids:

- a) Classification, Nomenclature, Fragmental Reservoir Rocks, Sandstone, Carbonate, Fractured Reservoir rocks and Miscellaneous.
- b) Reservoir Fluids: Water, Oil and Gas and their distribution in Reservoir. Classification of Oil Field Waters and their characters. Important constituents of Oil and Gas.
- c) Porosity and Permeability: Types, Origin and geological Factors influencing Porosity and Permeability. Imbibition and Wettability, Capillarity, Displacement Pressure and Relative Permeability.

Credit 3: Introduction to Geochemistry

- a) Paraffins, Cycloparaffins or Naphthenes, Aromatic Hydrocarbons, Olefin Hydrocarbons, Sulphur Compounds, Nitrogen Compounds, Oxygen Compounds Organo-Metallic Hydrocarbons; H/C Ratio of Hydrocarbons; Kerogens: Formation, Composition and Digenesis.
- b) **Oil Fields Brines** Composition, Classification, Origin and alteration of Oil Field Brines; Importance of Oil Field water analysis, Effects of water circulation on Hydrocarbons.
- c) **Properties:** Density, Viscosity, Surface Tension, Color, Fluorescence, Cloud Point and Pour Point, Aniline Point, Optical Properties, Flash Point, Refractive Index and Calorific Value.
- d) **Hydrocarbon Thermodynamics** Liquid Phase Behaviour, Molecular Behaviour; Changes in Phases with Changes in Pressure Temperature; Pure Hydrocarbons, Hydrocarbon Mixtures, Low Shrinkage- Gas, High Shrinkage - Gas, Retrograde Condensate Gas, Wet and Dry Gas.
- e) Analytical Techniques Quantitative and Qualitative Steps in Analysis of Petroleum;

Analytical Methods in Geochemistry for Reservoir Rocks and Fluids

Credit 4: Crude oil:**a) Classification**

Physical, Chemical and Genetic Classification of crude oil

b) Separation mechanism

Distillation and Classification of Petroleum; First, Second and Third Generation Petrochemicals; Miscellaneous Petrochemicals

c) Petrochemical Industry in India;

Integrated Petrochemicals Complex; Use of Natural Gas as Petrochemical Feedstock; Future of Petrochemical Industries.

REFERENCE BOOKS:

Geology of Petroleum A.L. Levenson
Petroleum Geology F.K. North
The world of Petroleum B.G. Deshpande
Introduction to Petroleum Geology G.D. Hobson E.L. Tiratsoo
Petroleum Geology R.E. Chapman
Principles of Petroleum Geology W.L. Russel
An Introduction to Physics and chemistry of Petroleum Kinghorn
Introduction to Petrochemicals Sukumar Maiti
Geochemistry in Petroleum Exploration
D.W. Waples Petroleum Geochemistry and Geology John Hunt
Chemicals from Petroleum A.L. Waddams
Analytical Chemistry Day & Underwood
Instrumental Methods Willard De Merit
Instrumental Methods of Analysis Ewing

PT 112 T: Structural Geology in Petroleum Exploration**(4credits)****Credit 1: Classification and study of traps for oil and gas accumulation:**

a) Definition and essential elements of a trap b) Stratigraphic relations of structural traps c) Traps on closed anticlines d) Effect of possible escape of oil and gas through faults e) Closure and closed area of faulted structures f) Closure against faults g) Assumptions about imperviousness of fault planes h) Closure of anticline bounded by faults on up dip side i) Closures produced by intersecting faults j) Stratigraphic control of the sealing of fault traps k) Formation of trap in relation with movement of up dip fault block l) Relations of lithologic variations in a reservoir to closure and closed m) Types of traps and their definitions n) Classification of traps of oil and gas accumulation o) Regional variations in types of traps p) Traps in relation to age and lithology of rocks q) Coverrocks.

Credit 2: Study of Folds and Faults:**a) Folds :**

i) Mechanical adjustments during folding of sedimentary formations: i) Slippage ii) Flowage-Drag folds: mechanism of formation and use of drag folds in determination of major structure b) Competent and incompetent rocks c) Method to calculate depth of folding principle, assumptions and limitations of the method d) Characteristics of folds important to petroleum geologist: i) Closure ii) Cross folding and multiple axes in relation to closure and closed area iii) Reversal iv) Character of anticline after subtracting regional dip v) Determination of dips of axial plane and crestal plane vi) Change in size of folds with depth e) Recognition and representation of folds f) Office techniques in study of folds: i) Equal area and stereographic projections ii) Pi diagrams iii) Contour diagrams iv) Beta diagrams g) Use of computers in preparing Pi and Beta diagrams

b) Faults:

Surface recognition of faults: i) Alignments ii) Offsets / displacements iii) Topographic expressions iv) Valleys and ridges along faults v) Distinguishing fault scarps and erosional scarps or escarpments vi) Scarps-Tectonic or fault scarps, Erosional scarps or Fault line scarps (resequent and obsequent scarps) vii) Expression on Areal maps viii) Expression on Air plane photographs ix) Expression on Structure contour maps and on isopach maps.

a) Recognition of Subsurface faults: i) Strata higher or lower than expected ii) Abnormal intervals iii) Omission and repetition of strata

b) Determination of movements along faults d) Reversals due to faulting e) Origin of Enechelon folds and faults f) Relation of faults and folds to basement structure g) Relations of oil and gas fields to faults.

Credit 3: Study of Joints, Fractures and Unconformities:**a) Joints and fractures:**

- a) Importance of joints and fractures of reservoir rocks in petroleum geology b) Geological relations of joints their uses:
 - i) Relation to stress ii) Relation to regional alterations
 - iii) Relation to local structures iv) Relation to regional structures
 - c) Role of joints and fractures in migration of oil and gas:
 - i) Economic importance- Fractures as reservoir rocks ii) Stratigraphic conditions favouring production
 - iii) Oil and gas production from basement rocks iv) Structural conditions favouring production
- Characteristics of oil and gas production: determining nature of reservoir, significance of lithology, lithologic nature of reservoirs, production from both fractures and pores, characteristics of fracture production, pressure differences and interferences, rate of decline and estimating recovery

b) Unconformities:

- a) Stratigraphic and structural relations at the unconformities:
 - i) Truncation ii) Overlap iii) Onlap iv) Offlap v) Transgression vi) Regression
- b) Recognition of unconformities at the surface and on aerial maps
- c) Recognition of Subsurface unconformities
- d) Effects of unconformities on oil and gas prospects.

Credit 4: Study of Oil and gas fields associated with structures**a) Salt domes:**

- a) Definition, importance, value, geographic distribution and classification of salt domes
- b) Salt stalk, overhang and source salt layer
- c) Marginal upturning and uplift
- d) Rim synclines, cap rock and false cap (origin)
- e) Faulting associated with salt domes
- f) Topographic / geologic expressions and surface indications of salt domes
- g) Salt structures
- h) Piercement and Non Piercement salt domes
- i) Salt anticlines, salt ridges, residual highs and anticlines on downthrown side of fault
- j) Salt domes associated with compressional folds
- k) Model studies of salt domes
- l) Time of formation
- m) Origin of salt domes:
 - i) Role of compression and bouny, distinguishing features
 - ii) Mechanism of salt dome emplacement
- n) Central subsidence, shapes of salt domes and mutual relation
- o) Oil and gas production from salt domes

b) Buried hills:

- a) Traps within buried hills
- b) Traps in sediments around buried hills
- c) Traps over buried hills
- d) Buried hills and recurrent folds
- e) Production from traps associated with buried hills.

REFERENCE BOOKS

1. Techniques of modern Structural Geology Folds and Fractures : John G. Ramsay
2. Structural Analysis and Synthesis Stephen M Rowland, Ernest Duebendorfer
3. Applied Subsurface Geological mapping Daniel Tearpock, Richard Bischke.
4. Structural Geology for Petroleum Geologist William Russell
5. Plate tectonics and Crustal evolution Kent C. Condie
6. Aspects of tectonics-Focus on South central K.S.Valdiya Asia
7. Structural Geology Ramsay
8. Structural Methods for Petroleum Exploration Badgley
9. Structural Geology for Petroleum Russell and Badgley
10. Foundations of Structural Geology-third Park R.G edition.

PT 113 T: Sedimentology**(2 Credits)****Credit 1: Mechanism of sediments:****a) Sediment transport by fluid motion:**

Fluid properties & fluid motion: i) Physical properties of fluid; ii) Stokes Law; iii) Reynolds number & Froude number; iv) Laminar & Turbulent flow
 Modes of transportation of sediment grains: Sediment gravity flows: i) Grain flows, Debris flows, Liquefied flows & Turbidity flows; ii) Deposits of sediment gravity flows.

b) Terrigenous clastic sediments:

- i) Clastic grains & identification of parental rocks
- ii) Classification of sediments and sedimentary rocks
- iii) Gravel and conglomerate
- iv) Sand and sandstone
- v) Clay, silt and mudrock
- vi) Textures and analysis of terrigenous clastic sedimentary rocks

c) Biogenic, Chemical and Volcanogenic sediments:

- i) Limestone
- ii) Evaporite minerals
- iii) Cherts
- iv) Sedimentary phosphates
- v) Sedimentary ironstone
- vi) Carbonaceous (organic) deposits
- vii) Volcaniclastic sedimentary rocks

d) Diagenesis:

- i) Diagenetic processes
- ii) Clastic diagenesis
- iii) Carbonate diagenesis

Credit 2: Sedimentary Environments:**a) Introduction:**

- i) Concept of Sedimentary Environment
- ii) Classifications of Sedimentary Environments
- iii) Study of Sedimentary Environments based on physical, chemical, biological & geomorphic variables:
 - Continental / Non-marine: Desert, Alluvial fans, Fluvial, Lacustrine & Glacial
 - Transitional: Delta, Estuarine, Beach & Clastic shelves
 - Marine: Continental shelf, slope, Abyssal plains & Pelagic

b) Techniques of Environmental interpretation:**i) Sedimentary Environments & Sedimentary Facies:**

Relationship between Sedimentary Environments & Sedimentary Facies (Walther's law) Methods of Environmental diagnosis:

- ii) Data acquisition & interpretation:
 - **Surface Environmental interpretation**
 Field sedimentology & Outcrop analysis) based on: a) Geometry b)

Lithology c) Syn-pre & post depositional structures

d) Palaeocurrent patterns e) Fossils

- **Subsurface Environmental interpretation based on:**

a) Core description b) Vertical grainsize profile from geophysical log P& gamma logs) c) Use of dipmeter in subsurface facies analysis.

c) Chemical, mineralogical & biological parameters making depositional environments:

i)Oxidation-reduction potential.

ii)Acidity-alkalinity (pH).

iii) Salinity.

iv)Temperature.

v) Index minerals.

vi) Colour.

vii) Trace elements.

viii) Outline of biological parameters

REFERENCE BOOKS

- 1) Applied Sedimentology Selley, R.C.
- 2) Petrology of sedimentary rocks Boggs, Jr.
- 3) Physical processes of sedimentation Allen, J.R.L
- 4) Sedimentology. Principles of sedimentology Chamley, H Friedman, G.M.and Sanders, J.E
- 5) Practical Sedimentology Lewis, D.W.
- 6) A practical approach to sedimentology Lindholm, R.C.
- 7) Sedimentary rocks (3rd ed.) Pettijohn, F.J.
- 8) Sand and sandstone (2nd ed.) Pettijohn, J.F., Potter,
- 9) Techniques in Sedimentology Tucker, M. (ed.), Reservoir Sandstones Berg, R.R. 11 Carbonate Reservoirs Moore, C. H.
- 10) Sandstone Petroleum Reservoir Barwis, J.H.
- 11) Sedimentology and Stratigraphy 2nd ed Gary Nichols
- 12) Stratigraphic Principles and Practices Weller
- 13) Startigraphy and Sedimentary Rocks Krumbein and Sloss

PT 114 P: (Practicals related to PT 111T, PT 112T, PT 113T) (4 credits)**Practicals for PT 111**

- 1) Determination of shale factor of a reservoir rock.
- 2) Isopach maps.
- 3) Panel diagrams
- 4) Surface tension of organic fluids by travelling microscope.
- 5) Use of viscometer and determination of chemical composition of Unknown hydrocarbon mixture.
- 6) Problems related to Specific gravity of gases

Practicals for PT 112

- 1) Three point problems based on drilling data
- 2) Geological maps: Geological maps of highly deformed strata with folds having vertical beds, inclined faults, dykes, unconformities etc
- 3) Photo Geological Map
- 4) Structural Contour Map
- 5) Dip isogons: Introduction and Interpretation of dip isogon patterns for different Ramsay's classes of folds & giving their general & diagnostic characters.

Practicals for PT 113

- 1) Megascopic study of the clastic and non-clastic rocks with genetic significance.
- 2) Microscopic study of the clastic and non-clastic rocks with genetic significance.
- 3) Study of sedimentary structures with their environmental significance.
- 4) Study of core samples.
- 5) Palaeo–environmental Interpretation.
- 6) Size analysis and Shape analysis.

PTE 111 T: Stratigraphy**(2 credits)****Credit 1: Stratigraphy:**

- a) **Introduction:** Evolution, scope and Importance of Stratigraphy
Standard Stratigraphic Classification and Nomenclature: IUGS Classification
- b) **Elements of Stratigraphy with their Units**
Description of Each Unit:
a) ChronoStratigraphy; b) LithoStratigraphy; c) BioStratigraphy;
d) Magneto Stratigraphy; e) Chemo Stratigraphy; f) Sequence Stratigraphy; g) Seismic Stratigraphy;
Stratigraphic Procedures: Outcrop and Sub Surface Procedures;
Stratigraphic Correlation: Types; Evidence; Inter and Intra Basinal Correlation.
- c) **Facies Concept and Lateral Variation:**
Litho Facies, Bio Facies; Lateral Variation with Examples:

Credit 2: Sequence Stratigraphy**a) Introduction:**

Concepts of sequence stratigraphy: definition and terminologies (accommodation space, Absolute and relative sea level fluctuation, surfaces system tracts, sequence, parasequences etc.) Methods of Sequence Stratigraphic Analysis (Introduction facies analysis, outcrops, core and modern analogues, well logs, seismic data, Age determination, age determination techniques, workflow of sequence stratigraphic analysis)

- b) **Sequence Models:** Introduction and Types of stratigraphic sequences in fluvial and carbonate system

REFERENCE BOOKS

- 1 Geological Time Scale B. Harland
- 2 Recent Researches in Qualitative Stratigraphic Correlation
F.P. Agtebero
3. Stratigraphy of India and Burma M.S. Krishnan
4. History of Earth B. Kummel
5. Global Geological History and Distribution Of Hydrocarbon Reserves C. Bois et.al
6. Principles of Stratigraphic Analysis Blart et.al
7. An overview of Litho, Bio and Chrono Sequence Stratigraphy and Sea level changes of Indian Sedimentary Basins D.S.N. Raju et.al
8. Stratigraphy of Indian Petroliferous Basins Jagdish Pandey et.al

PTE 111 T: Coal Geology**(2 credits)****Credit 1: Geology and Physico-Chemical Composition of Coal**

- a) Types of Coal: peat, lignite, bituminous and anthracite coal etc.
- b) Mode of Occurrences
- c) Coal and its properties
- d) Concept of coal maturity; origin of coal, coalification process
- e) Coal Petrography: lithotypes, microlithotypes and maceral groups of coal
- f) CBM

Credit 2: Exploration and Distribution of Coal in India:

- a) Proximate and ultimate analysis
- b) Exploration of coal
- c) Distribution of coal

REFERENCE BOOKS**PTE 112 P: Hydrodynamics of Depositional Environment****(2 credits)****Credit 1: Sediment grain movement & modes of sediment transport. Hydrodynamic factors & Bed forms in water:**

- i) Concept of flow regime
- ii) Classification & characteristics of Flow regimes
- iii) Bed forms characterizing different flow regimes
- iv) Study of following bed forms based on their morphology, internal structures, genetic classification, genesis & phase diagrams: Plane bed phase, Small ripples, Mega ripples, Giant ripples, Antidunes, Sand waves, Symmetrical & Asymmetrical wave ripples, Current ripples, Combined current / wave ripples, Isolated ripples, Wind ripples.
- v) Bed load transport: i) Migration of bed forms ii) Bed forms in relation with stream power & water depth iii) Depth-velocity-size diagram
- vi) Bed forms caused by erosion of cohesive sediments: i) Water erosion of cohesive beds ii) Erosion by 'tools'
- vii) Biogenic & organo-sedimentary structures: i) Stromatolites ii) Trace fossils rates of deposition
- viii) Diagenetic (soft sediment) deformation structures: i) Reduction of sediment strength; ii) Liquefaction & water escape structures; iii) Liquefaction & current drag structures; iv) Diapirism & differential loading structures v) Slides, growth faults & slumps; vi) Desiccation & syneresis shrinkage structures;
- ix) Bedding types:
 - i) Cross bedding ii) Climbing ripple lamination iii) Flaser & Lenticular bedding iv) Graded bedding.

PTE 112 P: Field Sedimentology

(2 credits)

- 1) Field Sedimentology: Field Equipment, Field Studies: Mapping and Logging
- 2) Graphic Sedimentary logs
- 3) Presentation of Graphic Sedimentary
- 4) Sketches and Photographs
- 5) Study of Provenance
- 6) Description of core samples
- 7) Concept of Facies
- 8) Reconstructing Palaeo-environments in space and time

SEMESTER – II**(22 Credits)****PT 121 T: Depositional System Analysis****(4 Credits)****Credit 1: Depositional System**

Introduction: Basic concepts of: a) Depositional Systems, b) Sedimentary Environments, c) Sedimentary Facies, d) Sedimentary models, e) Walther's law

Fluvial models: a) Basic fluvial systems / models with their Discharge Characteristics, spectral dip oriented facies types; Classification and sub facies of alluvial systems; Depositional models of following fluvial systems:- Braided fluvial system; Coarse grained meander belt system; Fine grained meander system; Distributary channel; Confined valley filldeposits.

Case studies in oil and gas fields in fluvial reservoirs

- a) Messla Field, Libya
- b) Little Creek Field, Mississippi
- c) Red wash field Utah, USA

Credit 2: Delta models:

- d) Definition of Delta, Stages of development of ideal delta system and morphological units of delta ; b) Progradation of delta (Mississippi, Nile and Bramhaputra delta) c) Triangular classification of deltas; d) Ancient delta deposits; e) Delta cycle: Constructional and destructional phase in delta formation; f)Delta deposition: Variables involved, High constructive and High destructive deltas; g) Fan delta model: Characteristics, tectonic setting and associated facies; h) Composition and recognition of ancient fluvial / deltaic systems; i) River dominated deltas: Elongate deltas- Example with progradation and aggradation facies; j) Lobate deltas as high constructive deltas- Example with characteristic progradation and aggradationfacies; k) Marine dominated deltas: Examples, characteristics and facies of: i) Wave dominated delta; ii) Tide dominated delta;
 - l) Recognition of ancient deltas. m) Contemporaneous and post depositional compaction of delta sediments as a Digenetic model in trapping of hydrocarbons.

Credit 3: Basin formation mechanisms and sedimentation:

- A) Basin formation mechanisms:** Basins due to lithospheric stretching; Basins due to flexure, Basins associated with strike slip deformation; b) Basin setting and depositional style: Depositional styles of basins related to divergent motion, convergent motion and strike slip deformation.
- B) Strike Systems (Non deltaic coast lines):** a) Barrier bars: Types and facies assemblages; b) Shore face facies: Geometry, boundary relationships and vertical sequence; c) Strandplain Systems: processes, facies and variations; d) Tidal flat Systems: Tidal inlet processes and facies; e) Terrigenous Shelf Systems:- Structural shelf and Physiographic shelf; Shelf environment and processes; Shelf depositional models-tide dominated, wave dominated,

biogenic and carbonate shelf.

Credit 4: Carbonate / Evaporite Shoreline/ Shelf Systems and reefs/ Slope and Abyssal Systems:

a) Status of deepwater studies in construction of deep-water environment; b) Slope and Abyssal Systems: Definitions and general features; c) Depositional processes and Slope / Abyssal sediments:

Study of following processes: Traction Vs Suspension transport; Mass gravity movement; Turbidity flow and turbidites Grain and shear flow, Bottom hugging traction flow; Suspension and pelitic-pelagic deposits (Basinal / Abyssal); Contour /Geostrophic currents and contourite; Cloudy (nepheloid) suspension current; Bioturbation; d) Brief description of processes and sediments; e) Submarine fan: Principle processes and sediments; f) Slope stratigraphic units: - Offlap, onlap and uplap; Depositional significance of slope geometry; Depositional phases: Constructional, Destructional and Repetitive g) Conceptual Depositional models: Study of uplap, offlap and onlap Slope Systems

REFERENCE BOOKS

1. Analysis: Principles and Applications-Instructor's manual. Philip A. Allen, John R. B;ScAllen
2. The Geology of Fluvial Deposits, Sedimentary Facies, Basin Analysis, and Petroleum Geology 4th by Andrew D. Miall
3. Sedimentary Environments: Processes, Facies and Stratigraphy Reading H. G.
4. Sedimentary Basins: Evolution, Facies and Sediment budget. Gerhard Einsele
5. The three dimensional Facies architecture of Terrigenous clastic sediments. Andrew D Miall
6. Sedimentation and Basin Analysis in siliciclastic rock sequences :1(Ige series) Amer Geophysical Union, June 1989.
7. Salt and Sediment dynamics Ian Lerche, Kenneth, Petersen CRC Press Aug
8. Principles of Sedimentary Basin Analysis A.D. Miall
9. Petroliferous Basins of India Vol.I, II and III, O.N.G.C.
10. Depositional Sedimentary Environments second edition, 1980 Rineck & Singh.
11. Recent Researches in Sedimentary Basins- Implications in the Exploration of Natural Resources: Proceedings of the National Symposium. R.N.Tiwari (ed), Dehradun, Petroleum Publishers 1998.
12. Basin Analysis, Sedimentary Geology, Sedimentology. Proceedings of 30th International Geological Congress Vol.8
13. Two dimensional basin analysis for Nakayama K. 1987 Jan. petroleum Exploration University of South Carolina, Columbia.
14. Basin Analysis in Petroleum Exploration-A case study from Bekes Basin, Hungary. Paul G. Teleki, Robert E. Mattck
15. Geology and Exploration of oil and gasbearing ancient delta. A.M.Akramkhodzhaev, etal
16. Sedimentary basins and Petroleum Geology of the Middle East (1987) A.S. Alsharhan, AEM Nairn, Amsterdam, NEW York: Elsevier,
17. Sedimentary Basins Evolution, Facies and Sediment Budget. Springer Verlag Einsele, G. 1992

PT 122 T: Petroleum Exploration Techniques**(4 Credits)****Credit 1: Geological Exploration:**

Use of aerial photographs, satellite imageries, and radar imageries in structural Or litho logical mapping for Petroleum Exploration. Techniques of Geological Mapping: Surface and Sub Surface.

a) Surface Geochemistry in Petroleum Exploration:

Concepts of Micro seepage. Methods of Micro seepage detection: **Direct vs Indirect**. Significance of following methods in Petroleum Exploration: Radiometric, Halogens, Major and Minor elements, Microbial, Helium, Ph / Eh Methods

Credit 2: Methods used in Petroleum Exploration**a) Magnetic Method**

Introduction, Magnetic field of the Earth, Magnetism of Rocks and Minerals, Instruments (Schimdt, Fluxgate, Torsion Magnetometers), Field Procedures, Reduction of Magnetic Anomaly Maps and Profiles , Airborne Magnetometers (Constructions and working principles), Interpretations, Applications in Petroleum Explorations with Indian examples.

b) Gravity Method

Introduction, Gravitational field of the Earth, Densities of Rocks and Minerals, Measurement of Gravity (Absolute and Relative), Instruments (Pendulum measurements, Spring Gravimeters, Vibrating Spring Gravimeters), Field Procedures, Reduction of Gravity Data, Gravity Modelling (Gravity Anomalies with simple Geometrics, Models using Semi-infinite slab approximations), Gravity Anomaly Maps, Interpretations, Applications in Petroleum Explorations with Indian Examples.

Credit 3: Seismic Methods used in Petroleum Exploration**a) Seismic Method**

General Principles, Seismology and Seismic Prospecting, Elastic Properties of rocks, Refraction and Reflection of seismic waves, general scheme of Seismic Prospecting; Seismic Body Waves (Compressional, Shear, Body Waves), Refractions and Reflections of Seismic Body Waves, Rays and Wave Fronts, Wave Conversions, Snell's Law, Critical Refraction, Paths of Seismic Body Waves), Seismic Surface Waves (Raleigh and Love Waves), Waveguides, Seismograms, The source Wavelets, Geometrical Spreading and Absorption, Transmission and Reflection Coefficients, Vibrations at a Receiver, Recording Seismic Waves.

b) Refracted Seismic Waves and Earth Structure

The Single- layer Refraction Problem, Critical Refraction, Preparing a Travel Time Curve, Measuring Seismic Wave Velocities, Calculating Layer

Thickness, Relationships Between Intercept Time and Crossing Distance Application, Refracted Waves in Multilayered Structures, The Ray Parameter, Wave Fronts and Rays, Travel Time and Layer Thickness, Features of Reversed Travel Time Curves, Calculating Velocity, Thickness and Dip, Application, Refraction Along a Discontinuous Boundary, Some Limitations of Seismic Refraction Survey, Static Corrections, Inspection of Travel Time Curves, The Plus – Minus Method, The Wave Front Method, Applications of Seismic Refraction Surveying.

Credit 4: Reflected Seismic Waves and Earth Structure

- a) Reflection from a Single Horizontal surface, The Reflection Travel Time Curve, Reflection Arrival Time, Normal Move – out, Measuring Velocity and Reflection Depth, reflected waves and Direct waves, Reflection from a sloping surface, Paths of Reflected Waves, Reflected Travel Time, Reflector Depth and Dip, Alternate Analysis, Three – Dimensional Dip Calculations. Reflected Waves in a Multi – Layered Structure, Average Velocities, Root- Mean- Square (RMS) Velocities, Layer Thickness and Velocity, Reflector Depth, Practical Example, Multi Reflected Waves, Diffracted Waves, Multifold Reflections.
- b) Seismic Surveying
Instruments for Seismic Surveying (Geophones, Hydrophones), The Seismic Cable, Marine Streamer Cables, Analog Recording Systems, Digital Recording Systems, Seismogram Displays, Impulsive Sources, Non-Impulsive Energy Source, The Seismic Crew, Field Operations, Basic Spreads, Single-Coverage Reflection Profiling, Common Depth Point (CDP) Reflection Profiling, Marine Seismic Profiling, Noise Control, Noise Problem at Sea, Vibroseis, CDP Profiling in wells, Three Dimensional Reflection Acquisition, Crooked Line Reflection Surveying.

REFERENCE BOOKS

1. Principles and applications of Photo Geology S.N.Pandey
2. Remote sensing, Principles and Interpretation F.F.Sabins, Jr.
3. Remote sensing, and Image Interpretation T.M.Lillesand and R.W.Kiefer
4. Surface Geochemistry in Petroleum Exploration S.A.Tedesco
5. Whole Earth Geo Physics Robert J. Lillie
6. Basic Exploration Geo Physics Edwin S.Robbinson et.al
7. Applied Geo Physics Telford et.al
8. Introduction to Geo physical Prospecting Dobrin and Savit
9. Petroleum Exploration and Exploration Practices Bhagwan Sahey

PT 123 T: Environmental Management**(2 Credits)****Credit 1: Types of Pollution and Assessment**

i) Introduction: ii) Types of Pollution: Air, Water, Soil and Noise Pollution, during exploration, Drilling, Production, Transportation and Refining.

Air Pollution: i) Introduction: Concept, Sources, Types of Pollutants, Precautionary Measures, Case study of Oil Field air pollution in Upper Assam. ii) Flaring : Definition, Diversity in Flaring, Concept of Smoke less Flare, Environmental factors associated with flaring Operations, Precautionary Measures, Case Study; iii) Emissions: During Drilling, Production, Storage and LPG plant operations.

a) Noise Pollution: i) Introduction: Concept, Sources, Noise standards, Effects of Noise on Human Health, Control of Noise Pollution.

b) Water Pollution

i) Introduction: Concept, Sources, Standards and Types (Fresh water, Marine water and Ground Water), Oil Spill (Control and Prevention), Case Study.

c) Soil Pollution: i) Introduction: Concept, Sources, Effects on Human Health and Control of Soil Pollution, Case Study;

d) Environmental Impact Assessment: Introduction: Concept, Environmental Impact Assessment model and its implementation. Case Study of Gandhar Oil Field and Enhanced Oil Recovery by Steam Injection;

Credit 2: Environmental Management and Energy Resources

a) Environmental management: Introduction: Concept, Environmental Management of the Offshore Oil and Gas Industry;

b) Energy Resources: Introduction: Concept, Sources and World Scenario;

REFERENCE BOOKS

- 1 Environmental Management In Petroleum Industry Wahi, Agnihotri and Sharma
- 2 Environment Technology in The Oil Industry S.T.Orszulik
- 3 Principles of Ecology P.S.Varma and V.K.Agarwal
- 4 Fundamentals of Ecology Engene. P. Odum
- 5 Environmental Impact of The Offshore Oiland Gas Industry Stanislav Patin
- 6 Concept of Ecology Edward. J. Kormondy
- 7 Environmentally Safe Drilling Practices (Manual) Pennwell Books
- 8 Text Book of Environmental Studies Barucha E
- 9 Decision Analysis for Petroleum exploration Paaul Newendorp and John Schuyler 10 Petroleum Economics and Engineering Abdel Al, H. K, Bakr, A.B, Al – Sahlawi, M.A.

PT 124 P (Practicals related to PT 121 T, PT 122T, PT 123 T) (4 Credits)**Practicals for PT 121 T**

- 1) Interpretation of Structure contour maps:
- 2) Determination of closure of folds, faults, intersecting faults & faulted structures from structure contour maps
- 3) Determination of reversals of structures from structure contour maps
- 4) Determination of order of priority to drill the various structures for oil & gas based on structure contour maps
- 5) Removal of regional tilt of the area & locating pre-tilt crest of the structure & determining the pre-tilt closure from the structure contour maps.
- 6) Interpretation of Isopach maps & maps showing relations of lithological variations in reservoir to closure & closed area.

Practicals for PT 122 T

- 1) Determination of True Resistivity and thickness of beds from the Resistivity data from VES.
- 2) Determination of depth of ore bodies from Gravity data / Identification of sub surface structures from Bouger Anomaly Maps / Gravity data corrections.
- 3) Determination of depth and orientation of dyke from vertical Magnetic intensities, by drawing a Magnetic Anomaly curve
- 4) Drawing of Seismic Section from Seismic data
- 5) Finding depth of refracting surveys two layers and three layers from Seismic Refraction data.
- 6) Seismic Reflection Data Interpretation.

Practicals for PT 123 T

- 1) Decision tree analysis
- 2) Problems on production economics.
- 3) Problems related to air, sound, water & soil pollution

PTE 121 T: Micropalaeontology**(2 credits)****Credit 1: Introduction to Micropalaeontology:**

- b) Definition, Scope, branches and applications of Micropalaeontology**
Types of Microfossils, their size, characters and range. Uses of Microfossils in geological operations
- c) Types of Micro Fossils :Their morphology,ecology and range and utility**
Brief Study of Acritarchs, Tasmanitids, Spores, Pollens, Silicoflagellates, Diatoms, Coccoliths, Dinoflagellates, Tintinnids & Calpionellids, Radiolarians, Conodonts, Sponge Spicules
- d) Study of Foraminifera and Ostracoda:**
Taxonomy, Structure and composition, characters. Classification, ecology and Biostratigraphic significances, Environments, Uses/ Applications in oil exploration.

Credit 2: Environmental studies:

- a)** Identification of environments with RTM suborders of foraminifer. Sedimentary basins of India, brief Lithological, Structural and Palaeontological descriptions
- b) Foraminifera :** (1) General Morphology, Coiling, Arrangement of Chambers, Ornamentation. (2) Study of Selected Genera of Foraminifera with Reference to:- Classification, Description, Composition, Distribution (Environmental & Geological), Distinguishing Features of following selected genera: Nodosarides (Lagena& others), (b) Bolivina, (c) Ammonia, (d) Elphidium, (e) Quinqueloculina, (f) Globorotalia, (g) Globogerina, (h) Textularia
- c) Ostracode :**(a) General Morphology & Orientation of Carapace. (b) Candona – Morphology, Composition, Distribution (Environmental & Geological) (c) Any other identified genus.
- d) Radiolarians** – Morphology, Composition, Distribution (Environmental & Geological)
Pollens, Spores: - Morphology, Stain Test, Distribution

REFERENCE BOOKS

- 9) Foraminifera J.R.Haynes
- 10) Marine Geology I. P.Kennett
- 11) Introduction to Micro fossils D.B.Brasier
- 12) Introduction to Micro Palaeontology Daniel Jones
- 13) Distribution and Ecology of Living Benthic Foraminifers
J.W.Murray
- 14) Classification of Plant Derived Organic Matter in sediments
T.C.Masran & S.A.J.Pococa
- 15) Micropalaeontology in Petroleum Exploration J.R.Wynn

PTE 121 T: Petroleum Production Economics**(2 credits)**

- a) **Prices and Market Forces:** i) Introduction: Definition, nature of Economics and Economic problems. Meaning of demand and supply. ii) Concept of Elasticity of demand & supply. iii) Price determination-a general equilibrium analysis.
- b) **Production :** i) Factors of production & their characteristics (land & labour); ii) Law of variable proportion; iii) Concepts of Costs, Total cost, Average cost, Marginal cost, Fixed & Variable costs;
- c) **Firms and Market:** i) Introduction: Definition and types of Market (Perfect competition, Monopoly and Monopolistic competition), ii) Price determination under the above mentioned markets.
- d) **Pricing Decisions:** i) Break even analysis, pricing selling cost under monopolistic competition and Profits.
- e) **Petroleum Production Economics:** i) Introduction : New income projects, Present Day Value (PDV) concept, Effect of PDV on project analysis; Rate of Return; Acceleration projects, Long term capital expenditures etc. Measures of profitability;
 - ii) Decision tree Analysis, Definition of decision node, Chance node, outcomes & probabilities, conditional monetary values and EMV; iii) Solving of decision tree & its advantages, preferences theory concept, Concept of depreciation & depletion, etc.:
 - iii) Drilling economics.

REFERENCE BOOKS

- 1) Fundamentals of Oil and Gas Accounting Gallun, R.A, Stevenson, Z.W, Nicols, L.M.
- 2) New Technical Guide to Petroleum Economics Tippee, B

PTE 122 P: Petroliferous Basins of India**(2 credits)**

- a) Klemme's classification of basin types
- b) Effect of tectonism on spatial arrangement of Marginal and Cratonic basins
- c) Study of following petroliferous basins of India with reference to geological setting, tectonics, structure and petroleum prospects:
 - 1. Bombay basin
 - 2. Krishna-Godavari basin
 - 3. Assam basin
 - 4. Cauvery basin
 - 5. Rajasthan basin.

PTE 122 P: Interpretation of Structural Maps

- 1) Geological maps: Geological maps of highly deformed strata with folds having vertical beds, inclined faults, dykes, unconformities etc
- 2) Structural Countour Maps
- 3) Bathymetric Maps