

**UNIVERSITY OF PUNE**

**M.Sc (Applied) PETROLEUM TECHNOLOGY**

(w.e.f. June 2008 for semester 1 and 2 and June 2009 for semester 3 and 4)

**Semester I:**

PT	1	Fundamentals of Petroleum Geology
PT	2	Principles of Sedimentology
PT	3	Interpretative Micropalaeontology & Stratigraphy
PT	4	Structural Techniques in Petroleum Exploration
PTP	1	Practical

**Semester II:**

PT	5	Fundamentals of Petroleum Geochemistry
PT	6	Depositional System Analysis and Petroliferous Basins of India
PT	7	Petroleum Exploration
PT	8	Environmental Management and Economics
PTP	2	Practical

**Semester III :**

PT	9	Reservoir Dynamics
PT	10	Formation Evaluation I
PT	11	Drilling and Well Completions
PT	12	Fundamentals of Computer and Applications ( Departmental Course )
PTP	3	Practical

**Semester IV :**

PT	13	Reservoir Performance
PT	14	Formation Evaluation II
PT	15	Production Operations
PTP	4	Practical
PTP	5	Practical

- Note :**
1. Practical Examinations will be conducted at the end of each semester.
  2. Their will be Four Theory and One Practical course in semester I, II and III.
  3. Semester IV consists of Three Theory and Two Practical courses.
  4. Practical PTP-4 is based on two theory courses ( Reservoir Performance And Production Operations) of semester IV.
  5. Practical PTP-5 consists of Practicals based on Formation Evaluation along with software applications and Project work .
  6. Each Theory Course will be of 48 Hours duration and Practical of 90 Hours.
  7. Each External theory Paper( University and Departmental ) will be of 80 marks and 20 marks for internals.
  8. The Internal marks will be given on the basis of continues assessment of students which will be in the form of tutorials, seminars, tests, attendance etc.
  9. The PTP-5 practical consists of Practicals based on Formation Evaluation and Project work of Minimum three weeks. The external examiners will conduct the Viva Voce and assess the project work for 50 marks and 30marks will be for Practicals based on Formation Evaluation and 20 internal marks will be assessed based on the performance at the project sites and Presentation .

## PT-1. Fundamentals of Petroleum Geology

Unit No	Title	No. of Lectures
1.	Introduction	03
2.	Occurrence of Petroleum	06
3.	Origin of Crude Oil and Natural Gas	09
4.	Migration and Accumulation of Oil and Natural Gas	08
5.	Reservoir Rocks	09
6.	Reservoir Fluids	09
7.	Distribution of Oil And Gas	04
	<b>Total</b>	<b>48</b>

### **Unit 1. Introduction:**

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.

### **Unit 2. Occurrence of Petroleum:**

#### **Surface manifestation:**

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.

### **Unit 3. Origin of Crude Oil and Natural Gas:**

Origin of Petroleum : Theories of Organic and Inorganic Origin  
Source Rock concept  
Kerogen : Source Material and Formation, Composition and Distribution.  
Oil window concept

### **Unit 4. 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.

### **Unit 5. Reservoir Rocks :**

Classification, Nomenclature, Fragmental Reservoir Rocks, Sand stone, Carbonate, Fractured Reservoir rocks and Miscellaneous.

**Unit 6. 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  
Porosity and Permeability: Types, Origin and geological Factors influencing  
Porosity and Permeability  
Imbibation and Wettability, Capillarity, Displacement Pressure and Relative  
Permeability

**Unit 7. Distribution of oil and Gas**

Geographic and Stratigraphic distribution of Oil and Gas.  
An Overview of Global and Indian Petroleum Industry

**REFERENCE BOOKS**

**Name of the Authors**

- |                                      |               |
|--------------------------------------|---------------|
| 1. Geology of Petroleum              | A.L.Leverson  |
| 2. Petroleum Geology                 | F.K.North     |
| 3. The world of Petroleum            | B.G.Deshpande |
| 4. Introduction to Petroleum Geology | G.D.Hobson    |
|                                      | E.L.Tiratsoo  |
| 5. Petroleum Geology                 | R.E.Chapman   |
| 6. Principles of Petroleum Geology   | W.L. Russle   |

**PT- 2. Principles of Sedimentology**

Unit No	Title	No. of Lectures
1.	<b>Introduction</b>	(01)
2.	<b>Origin of sedimentary grains</b>	(02)
3.	<b>Sediment transport by fluid flow</b>	(02)
4.	<b>Hydrodynamics of Depositional Environments</b>	(19)
5.	<b>Biological &amp; Chemical processes</b>	(02)
6.	<b>Diagenetic changes in the sediments</b>	(02)
7.	<b>Classification / petrography &amp; origin of sedimentary rocks</b>	(04)
8.	<b>Geometry of sedimentary bodies</b>	(02)
9.	<b>Techniques of Environmental interpretation</b>	(02)
10.	<b>Chemical, mineralogical &amp; biological factors making depositional environments</b>	(02)
11.	<b>Importance of sequence in environmental interpretation</b>	(02)
12.	<b>Sedimentary facies &amp; Sedimentary environments</b>	(04)
13.	<b>Sedimentological controls of reservoirs &amp; reservoir properties</b>	(04)
	<b>TOTAL</b>	<b>48</b>

**Unit 1. Introduction to Sedimentology:**

Definition & branches of Sedimentology  
Methodology  
Application in Petroleum Exploration

**Unit 2. Origin of Sedimentary grains:**

**Origin of terrigenous clastic grains:**

- a) Importance of water in rock decay
- b) Oxidation-Reduction & Eh-Ph diagrams
- c) Weathering of rock forming minerals
- d) Products of rock breaking & new mineral formation
- e) Mechanical weathering & resultant sediments
- f) Clastic grains & identification of parental rocks
- g) Source lands & Plate tectonics

**Origin of CaCO<sub>3</sub> grains:**

- a) Marine carbonate sediments of recent age
- b) Fresh water Vs Sea water
- c) Primary Carbonate precipitation
- d) Biologically originated carbonate grains
- e) Aragonite muds- skeletal origin
- f) Micrites, intraclasts, pellets, peloids, ooliths & Grapestones
- g) Polygenetic carbonate grains
- h) Carbonates from shallow temperate water
- i) Dissolution of CaCO<sub>3</sub> grains in deep ocean water

**Origin of evaporites, biogenic silica & phosphates :**

**Sediment grain parameters:**

- a) Grain size- definition, size ranges & grain size distribution
- b) Grain populations & their characteristics
- c) Size parameters & distributions
- d) Grain abrasion & breakage
- e) Grain shape & form
- f) Grain aggregates & their bulk properties
- g) Grain fabric

**Unit 3. Sediment transport by fluid motion:**

**Fluid properties & fluid motion:**

- a) Physical properties of fluid
- b) Stream lines & flow visualization
- c) Reynolds number & Froude number
- d) Laminar & Turbulent flow
- e) Flow separation & secondary currents

**Modes of transportation of sediment grains :**

**Sediment gravity flows:**

- a) Grain flows, Debris flows, Liquefied flows & Turbidity flows
- b) Deposits of sediment gravity flows

**Unit 4. Hydrodynamics of Depositional Environments:**

**Sedimentary Environments-** Erosional & Depositional.

**Outline of recognition / reconstruction of ancient depositional environments .**

**Limitations of reconstruction of ancient depositional environments .**

**Importance of inorganic primary sedimentary structures & sedimentary textures in interpretation of hydrodynamic conditions of depositional environments .**

**Sediment grain movement & modes of sediment transport .**

**Hydrodynamic factors & Bed forms in water:**

- a) Concept of flow regime
- b) Classification & characteristics of Flow regimes
- c) Bed forms characterizing different flow regimes
- d) Study of following bed forms based on their morphology, internal structures, genetic classification, genesis & phase diagrams:
  - i) Plane bed phase
  - ii) Small ripples
  - iii) Mega ripples
  - iv) Giant ripples
  - v) Antidunes
  - vi) Sandwaves
  - vii) Symmetrical & Asymmetrical wave ripples
  - viii) Current ripples
  - ix) Combined current / wave ripples
  - x) Isolated ripples
  - xi) Wind ripples
- e) Bed load transport:

- i) Migration of bed forms
  - ii) Bed forms in relation with stream power & water depth
  - iii) Depth-velocity-size diagram
- f) Bed forms caused by erosion of cohesive sediments:
  - i) Water erosion of cohesive beds
  - ii) Erosion by 'tools'
- g) Biogenic & organo-sedimentary structures:
  - i) Stromatolites
  - ii) Trace fossils & rates of deposition
- h) 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
- i) Bedding types:
  - i) Cross bedding
  - ii) Climbing ripple lamination
  - iii) Flaser & Lenticular bedding
  - iv) Graded bedding

**Unit 5. Biological & Chemical processes:**

**Biological processes:**

- a) CaCO<sub>3</sub> skeletons secreted by organism
- b) Formation of debris by degradation of CaCO<sub>3</sub> skeletons
- c) Trapping of sedimentary particles by organisms
- d) Pelletization, burrowing & effect of microorganism

**Chemical processes:**

- a) Dissolution & precipitation of CaCO<sub>3</sub>
- b) Inorganic chemical processes & formation of minerals

**Unit 6. Diagenetic changes in the sediments:**

**Compaction & solution :**

**Carbonate cementation:**

- a) Lithification of marine carbonate sediments by fresh water
- b) Lithification by sea water

**Sandstone cementation:**

- a) Lithification by Calcite & by silica
- b) Differential fractionation of stable isotopes of C & O as evidence

**Unit 7. Classification / petrography & origin of sedimentary rocks:**

**Conglomerates:** Definition, description, origin, texture (size distribution), composition, fabric, imbrication, stratification, grading, classification & nomenclature

**Sandstones:** Definition, description, origin, texture, size distribution, mineral & chemical composition, structures, maturity, diagenesis, classification & nomenclature

**Siltstones, mudstones, claystones & shales:** Definition, description, origin, texture, structures, clay mineral composition, classification & nomenclature

**Volcanoclastic rocks:** Coarse grained & fine grained, structure, composition, origin, classification & nomenclature

**Limestones & Dolomites:** Definition, description, nomenclature, texture, mineral composition, origin, Allochem types & forms, diagenetic fabric, sedimentary structures, classification & nomenclature

**Evaporites:** Definition, description, origin, mineral composition, crystal sizes & forms, diagenetic fabric, sedimentary structures, classification & nomenclature

**Classification & origin of other sedimentary rocks:**

- a) Siliceous rocks
- b) Carbonaceous rocks
- c) Sedimentary ironstones
- d) Phosphorites

**Unit 8 Geometry of sedimentary bodies:**

**Sandstone Geometry**

Sandstone dykes, sills & auto intrusions

**Carbonate Rock Geometry :**

Salt dome stalks & anticlines

Filled cavities & sinks

**Miscellaneous sedimentary bodies**

**Unit 9 Techniques of Environmental interpretation:**

**Sedimentary Environments & Sedimentary Facies :**

**Relationship between Sedimentary Environments & Sedimentary Facies (Walther's law)**

**Methods of Environmental diagnosis :**

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 logs (SP & gamma logs)
- c) Use of dipmeter in subsurface facies analysis

**Unit 10 Chemical, mineralogical & biological parameters making depositional environments :**

- a) Oxidation-reduction potential
- b) Acidity-alkalinity (pH)
- c) Salinity
- d) Temperature

- e) Index minerals
- f) Colour
- g) Trace elements
- h) Outline of biological parameters

**Unit 11 Importance of sequence in environmental reconstruction :**

**Unit 12 Sedimentary Facies & Sedimentary Environments :**

**Sedimentary Facies:**

- a) Concept of Sedimentary Facies
- b) Diagnosis of Sedimentary Facies
- c) Facies model

**Sedimentary Environments:**

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

**Sedimentological criteria to distinguish above Sedimentary Environments**

**Unit 13 Sedimentological controls of reservoir & reservoir properties:**

- i) Impact of Sedimentary processes on distribution of reservoirs & reservoir properties
- ii) Impact of clastic & carbonate diagenesis on reservoir properties
- iii) Porosity Evolution in diagenesis of limestones & sandstones
- iv) Pore geometry & performance of reservoir rocks
- v) Depositional facies variability, diagenetic processes & reservoir quality
- vi) Main clastic & Carbonate depositional environments
- vii) Depositional Environments & development of reservoirs
- viii) Characteristic reservoir morphology of sandstone bodies from different sedimentary environments
- ix) Reservoir Heterogeneity
- x) Petrophysical analysis of reservoirs using logs

**REFERENCE BOOKS**

**Name of the Authors**

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

**PT- 3 – Interpretative Micropalaeontology & Stratigraphy**

Unit No	Title	No. of Lectures
	<b>STRATIGRAPHY</b>	<b>18</b>
1	<b>Introduction</b>	<b>01</b>
2	<b>Standard Stratigraphic classification and nomenclature</b>	<b>01</b>
3	<b>Elements of stratigraphy with their Units</b>	<b>05</b>
4	<b>Stratigraphic procedures</b>	<b>02</b>
5	<b>Stratigraphic Correlation</b>	<b>02</b>
6	<b>Facies concept and lateral Variation</b>	<b>02</b>
7	<b>Geo Tectonic Classification and Distribution of Petroliferous Basins in Geological Time and study of Indian Sedimentary Basins</b>	<b>05</b>
	<b>INTERPRETATIVE MICROPALAEONTOLOGY</b>	<b>30</b>
7	<b>Definition, Scope , branches and applications of Micropaleontology</b>	<b>01</b>
8	<b>Types of Microfossils, their size, characters and range.</b>	<b>02</b>
9	<b>Uses of Microfossils in geological operations</b>	<b>02</b>
10	<b>Study of selected groups of microfossils; Foraminifera and Ostracoda</b>	<b>13</b>
11	<b>Palynology</b>	<b>03</b>
12	<b>Biostartigraphy of Petroliferous basins of India with reference to Foraminifera, Ostracoda</b>	<b>06</b>

**STRATIGRAPHY**

- Unit 1. Introduction:**  
Evolution, scope and Importance of Stratigraphy
- Unit 2. Standard Stratigraphic Classification and Nomenclature:**  
IUGS Classification
- Unit 3. Elements of Stratigraphy with their Units**  
Description of Each Unit:  
a) ChronoStratigraphy ; b) LithoStratigraphy ; c) BioStratigraphy ;  
d) Magneto Stratigraphy; e) Chemo Startigraphy ; f) Sequence  
Stratigraphy ; g) Seismic Stratigraphy;
- Unit 4. Stratigraphic Procedures :**  
Outcrop and Sub Surface Procedures;
- Unit 5. Stratigraphic Correlation :**

- Types; Evidence ; Inter and Intra Basinal correlation;
- Unit 6. Facies Concept and Lateral Variation:**  
Litho Facies, Bio Facies ; Lateral Variation with Examples:
- Unit 7. Geo Tectonic Classification and Distribution of Petroliferous Basins in Geological Time with tectonic set up , statistics environments and traps of each era. Study of Indian Sedimentary Basins with Classification and Examples.**

### INTERPRETATIVE MICROPLALAEONTOLOGY

- Unit 1. Definition, Scope , Branches and application of Micro Palaeontology;**
- Unit 2. Types pf Micro Fossils :**  
Brief Study of Acritarchs, Tasmanitids, Spores, Pollens, Silicoflagellates, Diatoms, Coccoliths, Dinoflagellates, Tintinnids & Calpionellids, Radiolarians, Conodonts, Sponge Spicules;
- Unit 3. Uses Of Microfossils :**  
In Petroleum Exploration with examples.
- Unit 4. Study of selected groups of microfossils:**  
**A) Foraminifera :**  
Taxonomy, Structure Of Living Foraminifera Cell Size, Culture; Test: Wall Structure & Composition , Chamber Development, Chamber Architecture & Shape , Apertures & Foramina Sculpture , Test Function  
Identification Of Environment- Fresh Water, Brackish Water, Marsh, Estuarine, Lagoonal, Bay, Oceanic.  
Foraminiferal Ecology:  
(Physical, Chemical, Biological Characters, Food, Predation, Substrate, Light, Temp , Oxygen, Salinity, CaCo<sub>3</sub>.)  
Statistical Treatment- Species Index, Specific Diversity, Diversity Index, Cluster Analysis, Value Of Alpha.  
Palaeoecological & Palaeoenvironmental Studies-: P/B Ratio, Nature of the shell, Planktic Forams, % of Calcareous Forams , Symbiont Larger Forams;  
Brief outline of High resolution Stratigraphy.  
Biostratigraphic Significance in : Zones, Range Zones, Acme Zones, Lineage Zones.  
D.S.D.P-: Brief out line  
Classification By Loeblich & Tappan(1987) up to level of Sub Orders:  
Distribution In Geological Time(General History Of Foraminifera)  
(Evolution Of Planktic Forams During U. Jurassic)

**Applications Of Foraminifera-: (Biostratigraphy, Age, Environment, In Oil Exploration)**

**B) Ostracoda:**

1. Taxonomy-
2. Characters-Size, Locomotion, Environment & Mode Of Life, Morphology: Wall Structure, Hinge Structure, Ornamentation & Surface Texture, Orientation Of Carapace.
3. Classification (by Benson 1961, Scott 1961, Van Morkhove 1963)
4. Identification Of Environment- ( Fresh Water, Brackish & Marine Environment)
5. Ecology- (Food, Substrate, Salinity, Depth, Temp.)
6. Biostratigraphic Significance-
7. Use Of Ostracods In Oil Exploration-

**Unit : 5 Palynology :**

Morphology Of Pollens & Spores; Importance In Biostratigraphy.  
Source Rock Potential & Thermal maturation Study.  
Significance Of Palynodebries Data For Palaeoenvironmental Analysis.

**Unit 6 Biostratigraphy Of Petroliferous Basins Of India With Reference To Two Major Groups of Fossils, Forams And Ostracod**

1. Cambay Basin
2. Bombay Offshore Basin
3. Cauvery Basin
4. Krishna-Godaverri Basin
5. Assam-Arakan Basin
6. Jaisalmer Basin

## REFERENCE BOOKS

	<u>Name of the Authors</u>
1. Foraminifera	J.R.Haynes
2. Marine Geology	I. P.Kennett
3. Introduction to Micro fossils	D.B.Brasier
4. Introduction to Micro Palaeontology	Daniel Jones
5. Distribution and Ecology of Living Benthic Foraminifers	J.W.Murray
6. Classification of Plant Derived Organic Matter in sediments	T.C. Masran & S.A.J.Pococa
7. Micropaleontology in Petroleum Exploration	J.R. Wynn
8. Elements of Micropaleontology	G.Bignot
9. Calcareous Algae	John Wray
10. Palynology in Hydro Carbon Exploration ( India Scenario) Memoir 48 (Part 1)	Mehrotra et.al
11. Stratigraphic Principles and Practices	Weller
12. Stratigraphy and Sedimentary Rocks	Krumbein And Sloss
13. Geological Time Scale	B. Harland
14. Recent Researches in Qualitative Stratigraphic Correlation	F.P.Agtebero
15. Stratigraphy of India and Burma	M.S.Krishnan
16. History of Earth	B. Kummel
17. Global Geological History and Distribution Of Hydrocarbon Reserves	C.Bois et.al
18. Principles of Stratigraphic Analysis	Blart et.al
19. An overview of Litho, Bio and Chrono Sequence Stratigraphy and Sea level changes of Indian Sedimentary Basins	D.S.N.Raju et.al
20. Stratigraphy of Indian Petroliferous Basins	Jagdish Pandey et.al

### PT: 4 - Structural Techniques in Petroleum Exploration

<b>Unit No</b>	<b>Title</b>	<b>No. of Lectures</b>
1.	<b>Introduction</b>	<b>03</b>
2.	<b>Application of Structural data and techniques in discovery and development of oil and gas fields</b>	<b>05</b>
3.	<b>Classification and study of traps for oil and gas accumulation</b>	<b>10</b>
4.	<b>Maps and Cross sections</b>	<b>04</b>
5.	<b>Folds</b>	<b>07</b>
6.	<b>Faults</b>	<b>06</b>
7.	<b>Joints and fractures</b>	<b>03</b>
8.	<b>Unconformities</b>	<b>03</b>
9.	<b>Salt domes</b>	<b>04</b>
10.	<b>Oil and gas fields associated with buried hills</b>	<b>03</b>
	<b>Total</b>	<b>48</b>

#### **Unit 1. Introduction:**

- a) Uses and value of Structural Geology to Petroleum Geologist .
- b) Development of Structural Geology / Structural data:
  - i) Collection of field data
  - ii) Developing generalizations
  - iii) Testing of theories
- c) Scope of Structural Geology
- d) Qualifications and duties of Structural Geologist or Structural work of Petroleum Geologist.

#### **Unit 2. Application of structural data and techniques in discovery and development of oil and gas fields:**

- a) Relative importance of structural data
- b) Practical consideration in wildcatting: Economic aspect of the structures
- c) Chances of finding oil production on untested traps.
- d) Nonstructural factors
- e) Regional structural conditions:
  - i) Regional structural conditions affecting the prospects for production in a structural trap.
  - ii) Significance of position
  - iii) Regional alterations- causes and structural significance of physical and chemical changes during regional alterations of the sediments
  - iv) Local structural conditions
  - v) Oil and gas production in relation to closure and closed areas of folds
- h) Closure and thickness of productive zone

- i) Factors affecting prospects for production on local structural traps
- j) Difficulty in finding trap of oil / gas accumulation
- k) Mental factors in wildcatting

**Unit 3. 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) Cover rocks

**Unit 4. Maps and Cross sections:**

- a) Importance of maps and cross sections in Petroleum Geology
- b) General characteristics of maps
- c) Characteristics of following maps:
  - i) Base maps
  - ii) Topographic maps
  - iii) Photo geological maps
  - iv) Geologic and areal maps
  - v) Palaeogeologic and palaeoareal maps
  - vi) Palinspastic maps
  - vii) Equal value maps
  - viii) Structure contour maps
  - ix) Reconnaissance and details maps
- d) Structural contouring- inter conversions of structure contours and dip- strike readings
- e) Phantom horizons
- f) Representation of uncertain structures
- g) Strike lines and form lines
- h) Construction of uncertain structures
- i) Construction of isopach maps
- j) Construction, interpretation and use of cross sections
- k) Three dimensional models, block diagrams and their use
- l) Graphical determination of attitude of formations

## **Unit 5. Folds**

- a) 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

## **Unit 6. Faults:**

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

**Unit 7.**

**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 favoring production
  - iii) Oil and gas production from basement rocks
  - iv) Structural conditions favoring 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

**Unit :8**

**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 areal maps
- c) Recognition of subsurface unconformities
- d) Effects of unconformities on oil and gas prospects

**Unit :9**

**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 bounicy, 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

**Unit :10 Oil and gas fields associated with 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**

**Name of the Authors**

1. Techniques of modern Structural Geology: Folds and Fractures	John G. Ramsay
2. A) Structural Analysis and Synthesis	Stephen M Rowland, Ernest M 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 Asia	K.S.Valdiya
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 edition.	Park R.G

**PRACTICAL COURSE FOR M.SC.-1**  
**SEMESTER-1**  
**PTP-1**  
**( 15 Practicals of 6 Hrs Each )**

**SEDIMENTOLOGY**

- 1) Megascopic and Microscopic study of the clastic and non clastic rocks with genetic significance.
- 2) Study of sedimentary structures with their environmental significance.
- 3) Study of core samples .
- 4) Identification and Implication of Heavy minerals.
- 5) Calculation of moment measure.
- 6) Grain morphology ( chi square test )
- 7) Mann- Whitney “U” Test.
- 8) Palaeo–environmental Interpretation.
- 9) Sieve Analysis.
- 10) Quantitative method of estimation of roundness by weadle’s method.

**MICROPALAENTOLOGY**

Separation of Micro Fossils from the Matrix of sedimentary rocks.(Lab techniques)

Separation of Micro Fossils from :-

- (1) Shale.
- (2) Clay Stones.
- (3) Limestones.
- (4) Chert - Dolomite.
- (5) Coal – Shales for Pollens & Spores.

Separation, picking & mounting of microfossils :

- (1) Accessory required – Types of Microfaunal Slides.
- (2) Hand Picking Method – Mounting of Microfossils.

**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.
  - (a) Nodosarides ( Lagena & others)
  - (b) Bolivina
  - (c) Ammonia
  - (d) Elphidium
  - (e) Quinqueloculina
  - (f) Globorotalia
  - (g) Globogerina

(h) Textularia.

### **Ostracode**

- (a) General Morphology & Orientation of Carapace.
- (b) Candona –Morphology,Composition,Distribution ( Environmental & Geological )
- (c) Any other identified genus.

### **Radiolarians –**

Morphology,Composition, Distribution (Environmental & Geological )  
Pollens , Spores :- Morphology ,Stain Test, Distribution.

## **STRATIGRAPHY**

Exercises based on Correlation , Lithological and Palaeontological.

### **Environmental studies**

Identification of environments with RTM suborders of foraminifer..  
Sedimentary basins of India , brief Lithological , Structural and Palaeontological descriptions.

## **PETROLEUM GEOLOGY**

- 1. Determination of bulk porosity of reservoir rock with single pan balance.
- 2) Determination of shale factor of a reservoir rock.
- 3) Estimation of optical activity of a organic compound.
- 4) Determination of refractive index of an organic compound using Abbey's refractometer.
- 5) Isopach maps and Panel diagrams.

### **Structural techniques in Petroleum Exploration.**

#### **(I) Application of technique of Descriptive Geometry in solving Structural Problems:**

- a) Problems involving attitudes (Heights) / depths of exposures of top and bottom Bedding planes of the formation, true / apparent thickness /dip /width of Outcrop and vertical thickness of formation.
- b) Problems related to planer features containing linear features ( single and Intersecting planar features ) and determination of bearing ,plunge and rake of Line of intersection of planer features (Attitude readings measured at same and At different elevation )
- c) Three point problems based on drilling data
- d) Vertical fault problems (with translational movements only )

Determination of net slip, relative movement and type of fault based on separation data of two horizons off set by the fault.

Locating counter part of third disrupted horizon.

- e) Inclined fault problems ( with translational movements only)

Determination of net slip, relative movement and type of fault based on separation

Data of two horizons off set by the fault.

Locating counterpart of third disrupted horizon.

**(II) Using stereographic net in solving structural problems :-**

a) Problems involving strike, true dip and apparent dip of planar features .

b) Problems involving planer features containing linear features (single and Intersecting planer features ) and determining bearing ,plunge and rake of line of intersection of planar features.

**Geological Field work**

**Minimum two weeks in different sedimentary Terrains of India.**

## PT- 5. Fundamentals of Petroleum Geochemistry

Unit No	Title	No. of Lectures
1.	Composition of Petroleum	08
2.	Classification of Crude Oils	04
3.	Oil Field Brines	04
4.	Properties of Hydrocarbons	08
5.	Hydrocarbon Thermodynamics	10
6.	Analytical Techniques	06
7.	Separation of Crude Oil	05
8.	Scenario of Petrochemical Industry In India	03
	<b>Total</b>	<b>48</b>

**Unit 1. Composition:**

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 Diagenesis.

**Unit 2. Classification of Crude Oils:**

Physical, Chemical and Genetic Classification of crude oil

**Unit 3. Oil Fields Brines:**

Composition, Classification, Origin and alteration of Oil Field Brines; Importance of Oil Field water analysis, Effects of water circulation on Hydrocarbons

**Unit 4. Properties of Hydrocarbons :**

Density, Viscosity, Surface Tension, Color, Fluorescence, Cloud Point And Pour Point, Aniline Point, Optical Properties, Flash Point, Refractive Index and Calorific Value.

**Unit 5. Hydrocarbon Thermodynamics:**

Liquid Phase Behavior, Molecular Behavior; 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.

**Unit 6. Analytical Techniques:**

Quantitative and Qualitative Steps in Analysis of Petroleum;  
Analytical Methods in Geochemistry for Reservoir Rocks and Fluids;

**Unit 7. Separation Of Crude Oil:**

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

**Unit 8. Petrochemical Industry In India;**

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

**REFERENCE BOOKS**

**Name of the  
Authors**

- |   |                            |
|---|----------------------------|
| <b>1. An Introduction to Physics and chemistry of Petroleum</b> | <b>Kinghorn</b>            |
| <b>2. Introduction to Petrochemicals</b>                        | <b>Sukumar Maiti</b>       |
| <b>3. Geochemistry in Petroleum Exploration</b>                 | <b>D.W.Waples</b>          |
| <b>4. Petroleum Geochemistry and Geology</b>                    | <b>John Hunt</b>           |
| <b>5. Chemicals from Petroleum</b>                              | <b>A.L.Waddams</b>         |
| <b>6. Analytical Chemistry</b>                                  | <b>Day &amp; Underwood</b> |
| <b>7. Instrumental Methods</b>                                  | <b>Willard De Merit</b>    |
| <b>8. Instrumental Methods of Analysis</b>                      | <b>Ewing</b>               |

**PT- 6 Depositional System Analysis and Petroliferous Basins of India**

<b>Unit No</b>	<b>Title</b>	<b>No. of Lectures</b>
1.	<b>Introduction</b>	<b>03</b>
2.	<b>Fluvial models</b>	<b>08</b>
3.	<b>Delta models</b>	<b>10</b>
4.	<b>Sedimentary and tectonic factors in Fluvial / Deltaic Systems</b>	<b>04</b>
5.	<b>Basin formation mechanisms and sedimentation</b>	<b>04</b>
6.	<b>Strike Systems (Non deltaic coast lines</b>	<b>02</b>
7.	<b>Carbonate / Evaporite Shoreline / Shelf Systems and reefs</b>	<b>02</b>
8.	<b>Slope and Abyssal Systems</b>	<b>04</b>
9.	<b>Sequence Stratigraphy in Environmental reconstruction</b>	<b>02</b>
10.	<b>Seismic Stratigraphic interpretation in Petroleum Exploration</b>	<b>04</b>
11	<b>Petroliferous Basins of India</b>	<b>05</b>
	<b>Total</b>	<b>48</b>

**Unit 1. Introduction:**

- i) Basic concepts : Study of concepts of :
  - a) Depositional Systems
  - b) Sedimentary Environments
  - c) Sedimentary facies
  - d) Sedimentary models
  - e) Walther's law

**Unit 2. Fluvial models :**

- a) Basic fluvial systems / models with their discharge characteristics, spectral dip oriented facies types.
- b) Classification and sub facies of alluvial systems
- c) Depositional models of following fluvial systems:
  - i) Braided fluvial system
  - ii) Coarse grained meander belt system
  - iii) Fine grained meander system
  - iv) Distributary channel
  - v) Confined valley fill deposits

**Unit 3. Delta models :**

- a) 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 aggradation facies .
- k) Marine dominated deltas: Examples, characteristics and facies of:
  - i) Wave dominated delta
  - ii) Tide dominated delta
- l) Recognition of ancient deltas

**Unit 4. Sedimentary and tectonic factors in fluvial / deltaic systems:**

- a) Effect of tectonism in sedimentary basins on fluvial / deltaic systems
- b) Klemme's classification of basin types
- c) Effect of tectonism on spatial arrangement of Marginal and Cratonic basins
- d) Recognition of effects of tectonism on ancient delta systems
- e) Contemporaneous and post depositional compaction of delta sediments as a
  - digenetic model in trapping of hydrocarbons

**Unit 5. Basin formation mechanisms and sedimentation:**

- a) Basin formation mechanisms
  - i) Basins due to lithospheric stretching
  - ii) Basins due to flexure
  - iii) 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.

**Unit 6. 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:
  - i) Structural shelf and Physiographic shelf
  - ii) Shelf environment and processes
  - iii) Shelf depositional models-tide dominated, wave dominated, biogenic and carbonate shelf

**Unit 7. Carbonate / Evaporite shore line / Shelf systems and reefs:**

**Unit 8. Slope and Abyssal Systems (Deep sea environments) :**

- a) Status of deep water 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:
  - i) Traction Vs Suspension transport
  - ii) Mass gravity movement
  - iii) Turbidity flow and turbidites
  - iv) Grain and shear flow, Bottom hugging traction flow
  - v) Suspension and pelitic-pelagic deposits (Basinal / Abyssal)
  - vi) Contour / Geostrophic currents and contourites
  - vii) Cloudy (nepheloid) suspension currents
  - viii) Bioturbation
- d) Brief description of processes and sediments
- e) Submarine fan: Principle processes and sediments
- f) Slope stratigraphic units:
  - i) Offlap, onlap and uplap
  - ii) Depositional significance of slope geometry
  - iii) Depositional phases: Constructional, Destructional and Repetitive
- g) Conceptual Depositional models: Study of uplap, offlap and onlap Slope Systems

**Unit 9. Sequence stratigraphy in environmental reconstruction :**

**Unit 10. Seismic stratigraphic interpretation in petroleum exploration:**

- a) Seismic stratigraphy
- b) Seismic reflection parameters used in seismic stratigraphy and their geological significance
- c) Procedures during seismic stratigraphic interpretation
- d) Recognition and discrimination of depositional sequences in seismic stratigraphic interpretation
- e) Outlines of stratigraphic interpretation of seismic facies

**Unit 11 Petroliferous Basins of India :**

Study of following petroliferous basins of India with reference to geological setting, tectonics, structure and petroleum prospects:

- i) Bombay basin
- ii) Krishna-Godavari basin
- iii) Assam basin
- iv) Cauvery basin
- v) Rajasthan basin

### **REFERENCE BOOKS**

- |  | <b><u>Name of the Authors</u></b>  |
|--|--|
| 1. <b>Basin Analysis: Principles and Applications- Instructor's manual.</b>  | <b>Philip A. Allen, John R. B Sc Allen</b>   |
| 2. <b>Sedimentary Environments: Processes, Facies and Stratigraphy</b>   | <b>Reading H. G.</b>   |
| 3. <b>Sedimentary Basins: Evolution, Facies and Sediment budget..</b>  | <b>Gerhard Einsele</b>   |
| 4. <b>The three dimensional Facies architecture of Terrigenous clastic sediments.</b>  | <b>Andrew D Miall</b>  |
| 5. <b>Sedimentation and Basin Analysis in siliciclastic rock sequences :1( Ige series)</b>   | <b>Amer Geophysical Union, June 1989.</b>  |
| 6. <b>Salt and Sediment dynamics</b>   | <b>Ian Lerche, Kenneth Petersen CRC Press Aug 1995</b>   |
| 7. <b>Principles of Sedimentary Basin Analysis</b>   | <b>A.D. Miall</b>  |
| 8. <b>Petroleum and Basin Evaluation: Insights from Petroleum Geochemistry, Geology and Basin modeling</b>                                       | <b>D. H. Welte etal Springer. Verlag Berlin and Heidelberg Gmbh and Co. K.</b>   |
| 9. <b>Basin Analysis and Seismic Stratigraphy</b>  | <b>W. L. Fisher and L. F. Brown, Jr.</b>   |
| 10. <b>Petroliferous Basins of India Voll,II and III,</b>  | <b>O.N.G.C.</b>  |
| 11. <b>Depositional Sedimentary Environments second edition,</b>   | <b>1980 Rineck Singh</b>   |
| 12. <b>Recent Researches in Sedimentary Basins- Implications in the Exploration of Natural Resources: Proceedings of the National Symposium.</b> | <b>edited by R.N.Tiwari, Dehradun, Indian Petroleum Publishers 1998.</b>   |
| 13. <b>Basin Analysis, Sedimentary Geology, Sedimentology.</b>   | <b>Proceedings of 30<sup>th</sup> International GeologicalCongressVol.8 Nakayama K.1987 Jan. University of South Carolina, Columbia.</b> |
| 14. <b>Two dimensional basin analysis for petroleum exploration</b>  | <b>Paul G. Teleki, Robert E. Mattck</b>  |
| 15. <b>Basin Analysis in Petroleum Exploration-A case study from Bekes Basin, Hungary</b>  | <b>A.M.Akramkhodzhaev,etal</b>   |
| 16. <b>Geology and Exploration of oil and gas-Bearing Ancient Delta</b>  |  |
| 17. <b>Sedimentary basins and Petroleum Geology of the Middle East</b>   | <b>A.S. Alsharhan, AEM Nairn, Amsterdam, NEW York: Elsevier, 1997.</b>   |
| 18. <b>Sedimentary Basins Evolution, Facies and Sediment Budget. Springer Verlag</b>   | <b>Einsele, G. 1992</b>  |

## PT-7 – PETROLEUM EXPLORATION

Unit No	Title	No. of Lectures
1.	<b>Geological Exploration</b>	<b>08</b>
2.	<b>Surface Geo chemistry in Petroleum Exploration</b>	<b>16</b>
3.	<b>Geophysical Methods used in Petroleum Exploration</b>	<b>24</b>
	<b>Total</b>	<b>48</b>

**Unit 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.

**Unit 2. Surface Geochemistry in Petroleum Exploration :**

Concepts of Micro seepage .

Methods of Micro seepage detection : **Direct vs Indirect.**

Radiometrics , Halogens, Major & Minor elements, Microbial Methods, Helium, Ph / Eh Methods;

**Unit 3. Geophysical Methods used in Petroleum Exploration :**

**Magnetic Method :**

Introduction, Magnetic field of the Earth Magnetism of Rocks and Minerals, Instruments( Schimdt, Flungate 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.

**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 Modeling ( Gravity Anomalies with simple Geometrics, Models using Semi-infinte slab approximations), Gravity Anomaly Maps, Interpretations, Applications in Petroleum Explorations with Indian Examples.

**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 (Compress ional, 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.

**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

**Reflected Seismic Waves and Earth Structure:**

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.

**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.

**Seismic Reflection Data Processing and Interpretation**

**REFERENCE BOOKS**

**Name of the Authors**

- |   |                                 |
|---|---------------------------------|
| 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<br>R.W.Kiefer |
| 4. Surface Geochemistry in Petroleum<br>Exploration   | S.A.Tedesco                     |
| 5. Whole Earth Geo Physics                            | Robert J. Lillie                |
| 6. Basic Exploration Geo Physics                      | Edwin S. Robinson et.al         |
| 7. Applied Geo Physics                                | Telford et.al                   |
| 8. Introduction to Geo physical Prospecting           | Dobrin and Savit                |
| 9. Petroleum Exploration and Exploration<br>Practices | Bhagwan Sahey                   |

## PT-8 : Environmental Management and Economics

Unit No	Title	No. of Lectures
	<b>Environmental Management</b>	
1.	<b>Pollution Assessment &amp; Management</b>	<b>25</b>
2.	<b>Environmental Impact Assessment</b>	<b>06</b>
3.	<b>Environmental Management</b>	<b>02</b>
4.	<b>Energy Resources</b>	<b>02</b>
	<b>TOTAL</b>	<b>35</b>
	<b>Economics</b>	
5.	<b>Prices and Market Forces</b>	<b>02</b>
6.	<b>Production</b>	<b>02</b>
7.	<b>Firms and Market</b>	<b>02</b>
8.	<b>Pricing Decisions</b>	<b>01</b>
9.	<b>Petroleum Production Economics</b>	<b>05</b>
10.	<b>Risk and Uncertainty in Hydrocarbon Exploration</b>	<b>01</b>
	<b>TOTAL</b>	<b>48</b>

### Environmental Management

#### **Unit 1. Pollution Assessment & Management :**

- i) Introduction :
- ii) Types of Pollution : Air, Water, Soil and Noise Pollution, during Exploration , Drilling, Production , Transportation and Refining.
- A) 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.
- B) Noise Pollution :**
  - i) Introduction : Concept, Sources, Noise standards, Effects of Noise on Human Health, Control of Noise Pollution.

**C) Water Pollution :**

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

**D) Soil Pollution:**

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

**Unit 2. Environmental Impact Assessment :**

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

**Unit 3. Environmental Management :**

- i) Introduction : Concept, Environmental Management of the Offshore Oil and Gas Industry;

**Unit 4. Energy Resources :**

- i) Introduction : Concept, Sources and World Scenario;

## **Economics**

**Unit 5. 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.

**Unit 6. 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;

**Unit 7. Firms and Market :**

- i) Introduction : Definition and types of Market( Perfect competition, Monopoly and Monopolistic competition)
- ii) Price determination under the above mentioned markets.

**Unit 8. Pricing Decisions :**

- i) Break even analysis, Pricing selling cost under monopolistic competition and Profits.

**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 & it's advantages , preferences theory  
concept, Concept of depreciation & depletion, etc.: Drilling  
economics.

**Unit 10 Risk and Uncertainty in Hydrocarbon Exploration :**

i) Introduction : Defintion and concept

ii) Different Types : Geological, Price , Political, Macro Economic,  
Business , Environment and Project Risk.

**REFERENCE BOOKS**

**Name of the Authors**

- |  |   |
|--|---|
| 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. Concept of Ecology  | Edward. J. Kormondy                           |
| 5. Fundamentals of Ecology                                   | Engene. P. Odum                               |
| 6. Environmental Impact of The Offshore Oil and Gas Industry | Stanislav Patin                               |
| 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. |
| 11. Fundamentals of Oil and Gas Accounting                   | Gallun, R.A, Stevenson, Z.W, Nicols, L.M.     |
| 12. New Technical Guide to Petroleum Economics               | Tippee, B.                                    |

**PRACTICAL COURSE FOR M.SC.-1  
SEMESTER-II  
PTP-2  
( 15 Practicals of 6 Hrs Each )**

**GEOCHEMISTRY**

- 1) Surface tension of organic fluids by traveling microscope.
- 2) Use of Flame photometer and determination of sodium, potassium & calcium.
- 3) Use of viscometer and determination of chemical composition of unknown hydrocarbon mixture.

**Depositional Systems Analysis**

- I) Interpretation of structure contour maps.
  - a) Determination of closure of folds, faults, intersecting faults and faulted structures from structure contour maps.
  - b) Determination of reversals of structures from structure contour maps.
  - c) Determination of order of priority to drill the various structures for oil and gas based on structure contour maps.
- (II) Removal of regional tilt of the area and locating pre-tilt crest of the structure and determining the amount of per-tilt closure from structure contour map.
- (III) Interpretation of Isopach maps.
- (IV) Maps showing relations of lithological variations in reservoir to closure and closed area.
- (V) Geological maps and cross sections :-
  - (1) Geological maps of highly deformed strata with folds having vertical beds, inclined faults dykes and unconformities.
  - (2) Description of topography and geology of the area.
  - (3) Commenting on shapes and topographic expressions of folds.
  - (4) Drawing vertical sections of geological maps in desired directions.
- (VI) Completion of outcrop patterns with the help of given data.
- (VII) Dip isogons :-
  - (1) Definition, drawing and significance of dip isogons.
  - (2) Ramsay's classification of folds based on stacking of folded surfaces.
  - (3) Drawing dip isogons for different Ramsay's classes of folds.
  - (4) Interpretation of dip isogon patterns for different Ramsay's classes of folds and giving their general and diagnostic characteristics

**Petroleum Exploration**

- i) Determination of True Resistivity and thickness of beds from the Resistivity data from VES.
- ii) Determination of depth of ore bodies from Gravity data / Identification of sub surface structures from Bouger Anomaly Maps / Gravity data corrections.
- iii) Determination of depth and orientation of dyke from vertical

- Magnetic intensities, by drawing a Magnetic Anomaly curve
- iv) Drawing of Seismic Section from Seismic data :
    - a) Finding depth of refracting surveys two layers and three layers from Seismic Refraction data.
    - b) Computer Analysis of Seismic data.

**Environmental Management and Economics**

- 1) Decision Tree Analysis
- 2) Problems on Production Economics
- 3) Problems related to Air, Sound Water And Soil Pollutions