Nowrosjee Wadia College, Pune.

Two Year Degree Program in Petroleum Technology

(Faculty of Science & Technology)

Revised Syllabi for

M.Sc. (Applied) Petroleum Technology

Part-I

To be implemented from Academic Year 2022-2023

Title of the Course: M.Sc. (Applied) Petroleum Technology

Course Structure

Subject Name	Year	Sem.	Course Type	**Course Code**	**Course Title**	**Credits**
Petroleum Technology	1	I	Theory Paper	PT-1	Fundamentals of Petroleum Geology	2
				PT-2	Sedimentology	4
				PT-3	Structural Geology in Petroleum Exploration	4
				PT-4	Stratigraphy and Micropalaeontology	4
			Practical Paper	PTP-1	Practicals related to PT-1 and PT - 2	3
				PTP-2	Practicals related to PT-3 and PT - 4	3
	1	II	Theory Paper	PT-5	Petroleum Geochemistry	4
				PT-6	Depositional System Analysis	4
				PT-7	Petroleum Exploration Techniques	4
				PT-8	Environmental management and Economics	2
			Practical Paper	PTP-3	Practicals related to PT-5 and PT - 6	3
				PTP-4	Practicals related to PT-7 and PT - 8	2
				FWC	Field Work Component	1

SEMESTER - I

(20 Credits)

PT-1: Fundamentals of Petroleum Geology (2 Credits) (30 Hours)

Topics	No. of Lectures
Unit I: Petroleum and its occurrence A. Petroleum: A Natural Resource i) Historical Overview of Search for Petroleum ii) Definition and Relation of Petroleum Geology to other Sciences iii) Exploration: Role of Geosciences and the major challenges for Petroleum Geology and its significance in different phases of exploration and production B. Surface Indications and direct detection of Hydrocarbons: i) Modes of surface and subsurface occurrence ii) Factors controlling the occurrence of petroleum iii) Introduction to unconventional resources of Hydrocarbons – Gas Hydrates, Shale Gas, Basin Centric Gas, Coal Bed Methane, Tight Gas Sands C. Introduction to the oil industry: i) Importance of study of reservoir rock and cap rock, abnormal pressure, basics of sample descriptions ii) Introduction to exploration techniques, rig structure and parts, job profiles on site, importance of well plan, basics of circulation rotation hoisting and well control systems iii) Introduction to QHSE, demands of the oil industry, time-bound final submissions, meeting deadlines	3 3 6
Unit II: Origin, Migration and Accumulation of Crude Oil and Natural Gas A. Origin of Petroleum: i) Theories of Organic and Inorganic origin ii) Source rock concept iii) Kerogen: Source Material and Formation, Composition and Distribution, Oil window concept B. Migration and accumulation of Oil and Natural Gas: i) Primary and Secondary Migration ii) Trapping mechanism and formation of oil and gas iii) Fields: Types of trapping mechanism (structural, stratigraphy and fluid types), traps associated with salt domes C. Porosity and Permeability: i) Types, origin and Geological factors influencing porosity and permeability ii) Inhibition and Wettability, Capillarity iii) Displacement Pressure and Relative Permeability	4 4 4
• Assessment / Presentation / Group Discussions	6
REFERENCES 1. A. L. Leverson (2nd edition, 2004) Geology of Petroleum 2. F. K. North (1985) Petroleum Geology	

3. B. G. Deshpande (1992) The World of Petroleum
4. G. D. Hobson, F L Tiratsoo (1975) Introduction to Petroleum Geology.
5. R. E. Chapman (1989) Petroleum Geology.

PT-2: Sedimentology (4 Credits) (60 Hours)

Topics	No. of Lectures
Unit I: Introduction	
A. Role of Sedimentology in Petroleum Industry.	1
B. Sedimentary Processes and Classification of Sedimentary Rocks:	3
i) Processes of sedimentation (Erosion / Weathering, Transportation and Deposition), Lithification & Digenesis.	
ii) Classification and description of some common sedimentary rocks (Conglomerate, Sandstone, Shale, Limestone).	
C. Mechanism of sediment transportation:	4
Fluid properties & fluid motion:	
i) Physical properties of fluid	
ii) Stokes Law	
iii) Reynolds number & Froude number	
iv) Laminar & Turbulent flow	
D. Modes of transportation of sediment grains and Sediment gravity flows:	4
i) Sediment grain movement.	
ii) Grainflows, Debris flows, Liquefied flows &Turbidity flows;	
iii) Deposits of sediment gravity flows.	
Unit II: Hydrodynamics of Depositional Environments (Part I)	
A. Introduction:	2
i) Physical Parameters of Depositional Environments.	
ii) Importance of study of Primary Sedimentary Structures.	
B. Hydrodynamic factors & Bed forms in water:	10
i) Concept of flow regime.	
ii) Classification & characteristics of Flow regimes.	
iii) Current ripple and its geometrical features.	
iv) Bed forms characterizing different flow regimes.	
v) Study of following bed forms based on their morphology, internal structures, genetic classification, genesis & phase diagrams:	
vi) Plane bed phase, Small ripples, Mega ripples, Giant ripples, and Antidunes.	
vii) Bed load transport: i) Migration of bed forms ii) Bed forms in relation withstream power & water depth iii) Depth-velocity-size diagram.	
Unit III: Hydrodynamics of Depositional Environments (Part II)	
A. Wave Ripples:	4
i) Symmetrical & Asymmetrical wave ripples.	
ii) Combined current / wave ripples, Isolated ripples, Wind ripples.	
B. Bedding types:	3

i) Cross bedding ii) Climbing ripple lamination iii) Flaser & Lenticularbedding iv) Graded bedding	
C. Bed forms caused by erosion of cohesive sediments	2
D. Biogenic & Organo-sedimentary structures: i) Stromatolites ii) Tracefossils	1
E. Digenetic (soft sediment) deformation structures	2
Unit IV: 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: a) Continental / Non-marine: Desert, Alluvial fans, Fluvial, Lacustrine & Glacial b) Transitional: Delta, Estuarine, Beach & Clastic shelves c) Marine: Continental shelf, slope, Abyssal plains & Pelagic B. Techniques of Environmental interpretation i) Relationship between Sedimentary Environments & Sedimentary Facies (Walther's law) Methods of Environmental diagnosis: i) Surface Environmental Interpretation: Field sedimentology & Outcrop analysis) based on: a) Geometry b) Lithology c) Syn-pre & post depositional structures d) Paleocurrent patterns e) Fossils ii) Subsurface Environmental interpretation based on: a) Core description b) Vertical grainsize profile from geophysical logs (SP& gamma logs)	6 6
• Assignments/Presentations/Evaluation	12
REFERENCES 1. R. C. Selley (2000) Applied Sedimentology. 2. Boggs, Jr, S. (2009) Petrology of Sedimentary Rocks (2nd ed.). 3. H. E. Reineck & I. B. Singh (1974) Depositional Sedimentary Environments. 4. R. Lindholm (1987) A Practical Approach to Sedimentology. 5. F. J. Pettijohn (2004) Sedimentary Rocks (3rd ed.) 6. Gary Nichols (2009) Sedimentology and Stratigraphy (2nd ed.) 7. Kölbl, L. (1967) Sedimentology and the petroleum industry. Sedimentary Geology.	

PT-3: Structural Geology in Petroleum Exploration (4 credits) (60 Hours)

Topics	No. of Lectures
Unit I: Structural Geology in Petroleum Studies A. Introduction i) Uses and Value of Structural Geology ii) Scope of Structural Geology iii) Development of Structural Geology iv) Definitions of Structural Geology v) Qualifications and Duties of a Structural Geologist vi) Types of Instruction Needed in Structural Geology	2
B. Classification of Traps for Oil and Gas Accumulation i) Stratigraphic relations of Structural traps ii) Relations of Lithologic variations in a Reservoir to closure and closed area iii) Definitions iv) Recommended classification v) Regional variations in types vi) Relation to Age and Lithology of rocks vii) Cover rocks	5
C. Structural Factors in Petroleum Prospecting i) Relative importance of structural data ii) Practical considerations in Wildcatting iii) Chances of Finding production on Untested traps iv) Nonstructural factors v) Regional structural conditions vi) Local structural conditions vii) Combination of structural and stratigraphic methods in prospecting viii) Use of structure in developing fields after discovery ix) Difficulty of finding oil x) Mental factors in Wildcatting xi) Future of Structural Geology in the Oil industry	5
Unit II: Folds and Joints A. Folds i) Characteristics and nature ii) Parts of fold iii) Types of folds iv) Mechanical adjustments v) Characteristics of folds important to petroleum geologist	10
B. Joints and Fractures i) Definitions ii) Uses and geological relations of Joints iii) Fractures as reservoir rocks	2
Unit III: Faults i) Nature ii) Fault plane	12

iii) Classification iv) Types v) Nomenclature of features associated with Fault plane vi) Structures associated with Faults vii) Recognition in the field viii) Topographic expression ix) Expression on aerial maps x) Expression on Airplane photographs xi) Expression on Structure contour and Isopach maps xii) Determining movements along faults xiii) Closure and closed area of faulted structures xiv) Reversal due to faulting xv) Relations of faults to folds xvi) Relation of faults and folds to basement structures xvii) Relation of oil and gas fields to faults	
Unit IV: Unconformities, Salt Domes and Buried Hills A. Unconformities i) Definition and types ii) Stratigraphic and structural relations iii) Recognition at the surface iv) Recognition on aerial maps v) Recognition of subsurface unconformities vi) Relation to traps for oil and gas accumulation vii) Effect on oil and gas prospects B. Salt Domes i) Importance and value ii) Geographic distribution iii) Types iv) Salt stock v) Overhang vi) Cap rock vii) Topographic expression and surface indications viii) Geologic expression ix) Residual highs and other salt structures x) Oil and gas production xi) Effect of faulting on producing reservoirs xii) Discovery methods xiii) Salt domes on Continental shelf C. Buried hills and Compaction i) Factors and processes of Compaction ii) Traps due to Compaction iii) Traps related to Buried hills	4 4 4
• Assignments/Presentations/Evaluation	12
REFERENCES 1. John G. Ramsay & Martin I. Huber (1987): The Techniques of Modern Structural Geology; Folds and Fractures Vol.2, Academic Press Publication 2. Stehen M. Rowland, Ernest M. Duebendorfer, Ilsa M. Schiefelbein (2007); Structural Analysis and Synthesis, Wiley Publication	

3. Daniel J. Tearpock, Richard E. Bischke · (1991); Applied Subsurface Geological mapping , Prentice Hall Publication, the University of California
4. Russell, W. L. (William Low). (1955). Structural geology for petroleum geologists. New York: McGraw-Hill.
5. Kent C. Condie. (1997). Plate tectonics and Crustal evolution. Elsevier Publication.
6. Valdia K.S. (1984).Aspects of tectonics: focus on south central Asia. Tata McGrew Hills, New Delhi.
7. John G.Ramsay. (1980) Structural Geology-Strain Analysis Vol.1 Academic Press Publication
8. Peter C. Badgley (2009). Structural Methods for the Exploration Geologist. New York; McGraw-Hill publication.
9. Park R.G (2013) Foundations of Structural Geology. Third edition. Routledge Publication.

PT-4: Stratigraphy and Micropalaeontology (4 credits) (60 Hours)

Topics	No. of Lectures
Unit I: Stratigraphy	
A. Introduction: Historical Development, Basic Principles of Stratigraphy, Importance of Stratigraphy, Standard Stratigraphic Classification and Nomenclature: IUGS Classification.	3
B. Elements of Stratigraphy with their Units. Description of each Unit: i) Chrono Stratigraphy: ii) Litho Stratigraphy; iii) Bio Stratigraphy; iv) Magneto Stratigraphy; v) Chemo Stratigraphy; vi) Sequence Stratigraphy; vii) Seismic Stratigraphy;	4
C. Stratigraphic Procedures: Outcrop and Sub Surface Procedures;	1
D. Stratigraphic Correlation: Types; Evidence; Inter and Intra Basinal Correlation.	2
E. Facies Concept and Lateral Variation: Litho Facies, Bio Facies; Lateral Variation with examples.	2
Unit II: Geology of India & Ostracoda	
A. Geology of India: Introduction & Tectonic Framework of India.	1
B. Cratons (Dharwar, Bastar, Singhbhum, Bundelkhand and Aravalli) Mobile Belts (Eastern Ghats, Pandyan, Satpura, Precambrian of Himalaya).	2 1
C. Proterozoic ('Purana') Sedimentary Basins (Vindhyan Basin, Chhattisgarh basin, Khariar Basin, Bastar Basins, Pranhita-Godavari Basin, Cuddapah Basin, Kaladgi Basin and Bhima Basin)	3
D. Phanerozoic - (Palaeozoic, Gondwana super group, Mesozoic, Deccan Volcanic province, Cenozoic - Tertiary, Quaternary)	3
E. Study of Ostracoda: Taxonomy, Characters: Size, Locomotion, Environment & Mode of Life; Morphology: Wall Structure, Hinge Structure, Ornamentation & Surface Texture; Orientation of Carapace. Ecology (Substrate and food, salinity, depth and temperature).	2
Unit III: Micropalaeontology	
A. Definition, Scope, branches and applications of Micropaleontology	1
B. Types of Microfossils and their morphology, ecology, range and utility of following microfossils: Acritarchs, Tasmanitids, Diatoms, Coccoliths, Silicoflagellates, Dinoflagellates, Tintinnids & Calpionellids, Radiolarians, Conodonts and Sponge Spicules.	3
C. Uses/Applications of Microfossils: In Petroleum Exploration with examples.	1
D. Study of Foraminifera: i) Taxonomy, Test Morphology: Wall Structure and composition, Chamber architecture, Apertures and foramina.	6

ii) Foraminiferal ecology: Smaller benthics (Light, food, Substrate, Salinity, Nutrients and oxygen, Temperature & Diversity) and Larger benthics. iii) Classification By Loeblich & Tappan (1987) up to level of Sub Orders. iv) Geological history of foraminifera E. Palynology: Morphology of Pollens & Spores; Distribution and ecology and Geological history	1
Unit IV: Petroliferous Basins of India A. Study of following Petroliferous basins of India with reference to geological setting, biostratigraphy, tectonics, structure and petroleum prospects: i) Bombay basin ii) Krishna-Godavari basin iii) Assam basin iv) Cauvery basin v) Rajasthan basin B. Major Oil & Gas fields of the Middle east i) Dukhan Field - Qatar ii) Yibal & Mukhaizna Field - Oman iii) Burgan field - Kuwait iv) Ghawar - Saudi Arabia v) Upper Zakum oil field - Abu Dhabi vi) South Pars/North Dome Gas-Condensate field - Qatar & Iran	8 4
• Assignments/Presentations/Evaluation	12
REFERENCES 1. Armstrong H. A. and Brasier M. D. (2005) Microfossils. Blackwell Publishing. 2. Gary Nichols (2009) Sedimentology and Stratigraphy. A John Wiley & Sons, Ltd., Publication. 3. Kumar Ravindra (2020) Fundamentals of Historical Geology and Stratigraphy of India. New Age International Private Limited. 4. M. S. Krishnan (2017) Stratigraphy of India and Burma. 6th Edition CBS Publisher. 5. Michael E. Brookfield (2003) Principles of Stratigraphy. Wiley-Blackwell Publisher. 6. Ramakrishnan and Vaidyanadhan (2010) Geology of India. Geological Society of India – Vol. 1& 2. 7. Sam Boggs Jr. (2014) Principles of Sedimentology and Stratigraphy, Fifth Edition. Pearson Education Limited. 8. Saraswati P. K. and Srinivasan M. S. (2016) Micropaleontology: Principles and Applications. Springer International Publishing Switzerland. 9. Schoch, Robert, M. (1989) Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York. 10. W. Brian Harland et. al (1989) Geological Time Scale. Cambridge University Press.	

PTP-1: (Practicals related to PT-1 and PT-2) (3 credits)

Topics
Practicals related to PT-1: 1. Determination of Shale Factor of a reservoir rock 2. Estimation of Optical Activity of an organic compound 3. Determination of Refractive Index of an organic compound using Abbey's Refractometer 4. Isopach maps 5. Porosity and Permeability measurement
Practicals related to PT-2: 1. Megascopic study of the clastic rocks with genetic significance 2. Megascopic study of the non-clastic rocks with genetic significance 3. Microscopic study of the clastic and non-clastic rocks with genetic significance. 4. Study of sedimentary structures with their environmental significance 5. Study of core samples 6. Identification and implications of heavy minerals 7. Palaeo-environmental interpretation 8. Quantitative method of estimation of roundness by Weadle's method 9. Grain morphology (chi-square test) 10. Size and Shape Analysis

PTP-2: (Practicals related to PT-3 and PT-4) (3 credits)

Topics
Practicals related to PT-3: 1. Three-point problems based on drilling data. 2. Construction, interpretation and use of cross section of Geological maps: i) Geological maps of with folds having vertical beds, ii) Geological maps of with inclined faults, dykes, unconformities etc. 3. Graphical problems related to Plunge, Rake and Bearing of linear and planar body 4. Problems related to Vertical and Inclined fault 5. Dip isogons 6. Introduction and Interpretation of Dip isogon patterns for different Ramsay's classes of folds & giving their general & diagnostic characters.
Practicals related to PT-4: 1. Stratigraphy: Exercises based on Correlation, Lithological and Palaeontological. 2. Sedimentary basins of India, brief Lithological, Structural and Palaeontological descriptions. 3. Identification of environments with RTM suborders of foraminifera. 4. Foraminifera: A. Study of Selected Genera of Foraminifera with Reference to: Classification, Description, Composition, Distribution (Environmental & Geological) and Distinguishing Features: i) Nodosarides (Lagena & others), ii) Bolivina, iii) Ammonia, iv) Elphidium, v) Quinqueloculina, vi) Globorotalia, vii) Globogerina, viii) Textularia. 5. Ostracoda: General Morphology & Orientation of Carapace. 6. Pollens & Spores: Morphology, Stain Test and Distribution

SEMESTER - II

PT-5: Petroleum Geochemistry (4 Credits) (60 Hours)

Topics	No. of Lectures
Unit I: Introduction:	
A. Introduction to Geochemistry	6
iv) Paraffins, Cycloparaffins or Naphthenes, Aromatic Hydrocarbon, Olefin Hydrocarbons	
v) Sulphur Compounds, Nitrogen Compounds, Oxygen Compounds, Organo-metallic Hydrocarbons, H/C ratio of Hydrocarbons	
vi) Kerogens: Formation, Composition and Diagenesis	
B. Oil Field Brines:	6
iv) Composition and Classification	
v) Origin and alternation of Oil Field Brines	
vi) Importance of Oil Field water analysis, effects of water circulation on Hydrocarbons	
Unit II: Properties and Thermodynamics of Hydrocarbons:	
A. Properties:	
iv) Density, Viscosity, Surface Tension, Colour, Fluorescence	7
v) Cloud Point and Pour Point, Aniline Point, Flash Point	
vi) Optical Properties, Refractive Index and Calorific Value	
B. Hydrocarbon Thermodynamics:	5
iv) Liquid Phase Behaviour, Molecular Behaviour	
v) Changes in Phases with Changes in Pressure Temperature	
vi) Pure Hydrocarbons, Hydrocarbon Mixtures, Low Shrinkage – Gas, High Shrinkage – Gas, Retrograde Condensate Gas, Wet and Dry Gas	
Unit III: Crude Oil:	
A. Classification:	6
a) Physical Classification of Crude Oil	
b) Chemical Classification of Crude Oil	
c) Genetic Classification of Crude Oil	
B. Separation Mechanism:	6
a) Distillation and Classification of Petroleum	
b) First, Second and Third Generation Petrochemicals	
c) Miscellaneous Petrochemicals	
Unit IV: Refining and Fractionation of Hydrocarbons:	
A. Refining of Hydrocarbons:	7
a) Introduction to Separation, Conversion, Treatment and Storage	
b) Processing Units and Auxiliary Facilities	
c) Crude Oil Distillation Unit and Refining End Products	
B. Fractionation of Hydrocarbons:	5

a) Relative volatility, Degree of Separation, Oil Shale-Oil Fractionation Techniques b) Fractionators and devices for Fractionation of Hydrocarbons, Crude Oil Distillation Devices and Procedures c) Natural Gas Liquids (NGL) extraction and its process	
• Assignments / Presentation / Group Discussions / Assessments	12
REFERENCES 6. An introduction to Physics and Chemistry of Petroleum - Kinghorn 7. Introduction to Petrochemicals – Sukumar Maiti 8. Geochemistry in Petroleum Explorations – D W Waples 9. Petroleum Geochemistry and Geology – John Hunt 10. Chemicals from Petroleum – A L Waddams 11. Analytical Chemistry – Day and Underwood 12. Instrumental Methods – Willard De Merit 13. Instrumental Methods of Analysis - Ewing	

PT-6: Depositional System Analysis (4 Credits) (60 Hours)

Topics	No. of Lectures
Unit I: Depositional System:	
A. Introduction: Basic concepts of: a) Depositional Systems, b) Sedimentary Environments, c) Sedimentary Facies, d) Sedimentary models, e) Walther's law.	4
B. Fluvial models: a) Basic fluvial systems / models with their Discharge Characteristics, spectral dip oriented facies types; b) Classification and sub facies of alluvial systems.	3
C. Depositional models of following fluvial systems:	5
i. Braided fluvial system	
ii. Coarse grained meander belt system	
iii. Fine grained meander system	
iv. Distributary channel	
v. Confined valley fill deposits.	
Unit II: Delta Models :	
A. Definition of Delta, Stages of development of ideal delta system and morphological units of delta: a) Progradation of delta (Mississippi, Nile and Bramhaputra delta) b) Triangular classification of deltas; c) Ancient delta deposits; d) Delta cycle: Constructional and destructional phase in delta formation.	3
B. Delta deposition: Variables involved, High constructive and High destructive deltas.	1
C. Fan delta model: Characteristics, tectonic setting and associated facies.	1
D. River dominated deltas: Elongate deltas- Example with progradation and aggradation facies.	2
E. Lobate deltas as high constructive deltas- Example with characteristic progradation and aggradationfacies.	2
F. Marine dominated deltas: Examples, characteristics and facies of:	
a) Wave dominated delta	
b) Tide dominated delta	3
G. Recognition of ancient deltas. Contemporaneous and post depositional compaction of delta sediments as a Digenetic modelin trapping of hydrocarbons.	
Unit III: Strike Systems (Non deltaic coast lines):	
A. Barrier bars: Types and facies assemblages.	2
B. Shore face facies: Geometry, boundary relationships and vertical sequence.	2
C. Strandplain Systems: processes, facies and variations.	2

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. **F. Slope and Abyssal Systems:** Definitions and general features.	2 2 2
Unit IV: Basin formation mechanisms and sedimentation: **A.** Klemme's classification of basin types; **B.** Effect of tectonism on spatial arrangement of Marginal and Cratonic basins. **C. Basin formation mechanisms**: Basins due to lithospheric stretching; Basins due to flexure, Basins associated with strike slip deformation; Basin setting and depositional style: Depositional styles of basins related to divergent motion, convergent motion and strike slip deformation.	2 3 7
• Assignments/Presentations/Evaluation	12
REFERENCES 1. Reading, H.G. (Ed.) (1996) Sedimentary Environments: Processes, Facies and Stratigraphy. 3rd Edition, Blackwell Science, Oxford, 688. 2. Miall, A.D. (1984) Depositional systems. In: Principles of Sedimentary Basin Analysis. Springer, New York, NY. 3. Brown, L. F., Jr., and Fisher, W. L., (1977) Seismic stratigraphic interpretation of depositional systems. 4. D.H. Welte, B. Horsfield & D.R. Baker (eds).(1997) Petroleum and basin evolution: Insights from petroleum geochemistry, geology and basin modeling. 5. R. C. Selley (2000) Applied Sedimentology. **6.** H. E. Reineck & I. B. Singh (1974) Depositional Sedimentary Environments**.**	

SEMESTER – I

PT-7: Petroleum Exploration Techniques (4 Credits) (60 Hours)

Topics	No. of Lectures
Unit I: Geological Exploration: **A.** Use of aerial photographs, satellite imageries, and radar imageries in structural or litho logical mapping for Petroleum Exploration. Techniques ofGeological Mapping: Surface and Sub Surface. **B. Surface Geochemistry in Petroleum Exploration:** Concepts of Micro seepage. Methods of Micro seepage detection: Direct vsIndirect. Significance of following methods in Petroleum Exploration: Radiometric, Halogens, Major and Minor elements, Microbial, Helium, Ph /Eh Methods;	6 6
Unit II: Methods used in Petroleum Exploration: **A. Magnetic Method:** Introduction, Magnetic field of the Earth, Magnetism of Rocks and Minerals, Instruments (Schmidt, 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.	6 6
Unit III: Seismic Method: **A. Basic Concepts :** 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	6 6

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.	
Unit IV: **A. 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, MultiReflected Waves, Diffracted Waves, Multifold Reflections. **B. Seismic Surveying:** Instruments for Seismic Surveying (Geophones, Hydrophones), The Seismic Cable, Marine Streamer Cables, Analog Recording Systems, DigitalRecording 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.	6 6
• Assignments / Presentation / Group Discussions / Assessments	12
REFERENCES 1. Dobrin, M. B., and Savit, C. H., 1988, Introduction to Geophysical Prospecting (Fourth Edition), Tata McGraw Hill. 2. Rao, B. S. R. and Murthy, I. V. R., Gravity and Magnetic Methods of Prospecting 3. Ramachandra Rao M. B. (1975) Outlines of Geophysical Prospecting: A Manual for Geologists.	

PT- 8: Environmental Management and Petroleum Economics

(2 Credits) (30 Hours)

Topics	No. of Lectures
Unit I: Environmental Studies:	
A. Environmental impact and management in the petroleum industry	1
B. Introduction to environmental control in the petroleum industry & Overview of environmental issues	1
C. The impact of drilling and production operations	1
D. Toxicity a. Physiological, b. asphyxiation, c. respiratory, d. skin effect of petroleum hydrocarbons	1
E. Nuclear radiation, Air pollution & Acoustic impacts	1
F. Environmental transport of petroleum wastes: a. Surface paths- b. Subsurface paths- c. Atmospheric paths, d. Planning for environmental protection.	1
G. Introduction to waste management : a. Waste treatment methods: i. Treatment of water- ii. Treatment of solids iii. Treatment of air emissions b. Wastewater disposal: i. surface disposal.	2
H. Environmental Impact Assessment: a. Introduction: Concept, Environmental Impact Assessment model and its implementation.	2
I. Case Study of Gandhar Oil Field and Enhanced Oil Recovery by Steam Injection	2

Unit II: Petroleum Production Economics: **Fundamentals of Economics & Petroleum Economics** A. Fundamentals of Economics & Economic terms B. Understanding petroleum projects, Role of the Petroleum Economist, Terms, and concepts C. Characteristics of oil and gas resources D. Mineral rights, licenses and leases, Type of oil and gas contracts E. Revenue, Costs, Profits & Cash flow F. CAPEX & OPEX, Depreciation, depletion, and amortization (Value Chain) G. Economic analysis and decision making - certainty, risk & uncertainty H. Time value of money / Profitability of a venture - Pay out (Payback) period, Net Present value (NPV), IRR, Discounted profit-to-investment ratio (DPR) I. Risk and uncertainty & Risk analysis & Decision trees analysis J. Drilling economics.	 1 1 1 1 1 1 1 2 2 1
Assignments/Presentations/Evaluation	12
REFERENCES 1. John C. Reis, (1996). Environmental Control in Petroleum Engineering, Gulf Publishing Company 2. R. Rajagopalan, (2011) Environmental Studies, 2nd Edition, Oxford University Press. 3. Paul D. Newendorp & John R. Schuyler (2000)Decision Analysis for Petroleum Exploration. Planning Pr, USA 4. Bakr A. Bakr, H.K. Abdel-Aal, M.A. Al-Sahlwai (1992) Petroleum Economics and Engineering, 2nd Edition. Marcel Dekker 5. Rebecca A. Gallun, Charlotte J. Wright, Linda M. Nichols & John W. Stevenson (2001)Fundamentals of Oil and Gas Accounting Hardcover 6. Bob Tippee (1993) Where's the Shortage? A Nontechnical Guide to Petroleum Economics. Pennwell Corp	

PTP-3: (Practicals related to PT-5 and PT-6) (3 credits)

Topics
Practicals related to PT-5: 1. Surface tension of organic fluids by traveling microscope 2. Determination of chemical composition of a binary mixture of an organic compound with help of pH meter. 3. Use of Flame photometer and determination of sodium, potassium and calcium 4. Use of viscometer and determination of chemical composition of unknown hydrocarbon mixture 5. Problems related to specific gravity of gases
Practicals related to PT-6: 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 oflithological variations in reservoir to closure & closed area.

PTP-4: (Practicals related to PT-7 and PT-8) (2 credits)

Topics
Practicals related to PT-7: 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 AnomalyMaps / Gravity data corrections. 3. Determination of depth and orientation of dyke from verticalMagnetic 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 related to PT-8: 1. Exercises related to environmental issues in the oil field. 2. Exercises related to Environmental Impact Assessment 3. Problems related to drilling & production economics. 4. Exercise related to Revenue, Costs, Profits & Cash flow 5. Exercise related to CAPEX & OPEX, Depreciation, depletion, and amortization 6. Problems related to Time value of money - Pay out (Payback) period, Net Present value (NPV) & IRR 7. Exercise on Decision tree analysis