

DEPARTMENT OF APPLIED GEOPHYSICS

INDIAN SCHOOL OF MINES

DHANBAD



BOCS and AC

Approved

COURSE STRUCTURES AND SYLLABUS OF

M. TECH. (PETROLEUM EXPLORATION)

(Implementation from 2012-2013 Academic Session onwards)

SEMESTER-I

Sl. No.	Course No.	Subject	L T P	Credit Points
1	GLC-51121	Petroleum Geology and Petroleum Geochemistry	4 0 0	8
2	GLC 51122	Tectonics and structural methods for exploration	3 0 0	6
3	GPC 51101	Petroleum Exploration Geophysics and Geophysical Modeling	4 0 0	8
4	GPC 51102	Well Logging and Electrofacies	3 0 0	6
5	PER 51101	Petroleum drilling and Production Engineering	3 1 0	7
Practicals:				
6	GLC-51221	Petroleum Geology	0 0 3	3
7	GLC 51222	Tectonics and structural methods for exploration	0 0 3	3
8.	GPC 51201	Petroleum Exploration Geophysics and Geophysical Modeling	0 0 3	3
9.	GPC 51202	Well Logging and Electrofacies	0 0 3	3
Total:			17 1 12	47

SEMESTER-II

Sl. No.	Course No.	Subject	L T P	Credit Points
1.	GLC 52123	Sedimentary environment, Sequence stratigraphy and basin analysis A. Sedimentary Environment B. Sequence Stratigraphy and Basin analysis	4 0 0	8
2.	GLC 52124	Micropaleontology in hydrocarbon exploration and Coal bed methane and Gas Hydrate Exploration	4 0 0	8
3.	MSC 52104	Project Management	3 0 0	6
4.	GPC 52103	Reflection Seismology	4 0 0	8
5.	GPE 52104 GLE 52110	Electives (any one) Reservoir geophysics and deep water imaging Geostatistical Methods	3 0 0	6
Practicals:				
6.	GLC 52223	Sedimentary Environment and Basin analysis	0 0 3	3
7.	GLC 52224	Micropaleontology	0 0 3	3
8.	GPC 52203	Reflection Seismology	0 0 3	3
Total:			18 0 9	45

SEMESTER-III

Sl. No.	Course No.	Subject	L T P	Credit Points
1	GLC-53001	Industrial training / Minor Project	0 0 0 (4)	4
2	GLC-53002	Seminar and Viva-Voce on Industrial Training	0 0 0 (2)	2
3	GLC-53501	Comprehensive Viva-Voce	0 0 0 (4)	4
4	GLC-53801	Dissertation (Interim) Fieldwork/Labwork	0 0 0 (15)	15
5	GLC-53802	Seminar and Viva-voce on Interim Dissertation	0 0 0 (10)	10
6	GLC-53003	Teaching Assignment Evaluation/ Laboratory Development Work etc.	0 0 0 (5)	5
Total:			0 0 0 (40)	40

SEMESTER-IV

Sl. No.	Course No.	Subject	L T P	Credit Points
1	GLC-54801	Dissertation	0 0 0 (20)	20
2	GLC-54802	Seminar on Dissertation	0 0 0 (5)	5
3	GLC-54803	Viva-Voce on dissertation	0 0 0 (10)	10
4	GLC-54804	Teaching Assignment Evaluation/ Laboratory Development Work etc.	0 0 0 (5)	5
Total:			0 0 0 (40)	40

GLC 51121	PETROLEUM GEOLOGY AND PETROLEUM GEOCHEMISTRY	4 0 0
------------------	---	--------------

PETROLEUM GEOLOGY:

Distribution of petroleum in earth's crust; surface manifestations; stratigraphic regularities, depth and temperature rules; coal-oil paragenesis and carbon ratio concept. Boundary conditions of origin and occurrence based on compositional and associational evidences. Organic theory and further support to it through biological markers and isotopic studies. The inorganic methane and Gold's hypothesis and limitations of other non-organic concepts. Outlines of early diagenesis, catagenesis and metagenesis. Significance of knowledge on organic origin, migration and occurrence concept to geochemical methods of exploration of oil and gas. Source and reservoir rocks.

Oil field waters: Composition and classification of dissolved organic compounds, application of oil-field water analysis in exploration.

Petroleum traps: concept and classification; different types of traps, their genesis.

Migration: concept, phases and forces of oil migration, mechanics of oil movement. Time of accumulation.

Tectonics and sedimentation history and structures of the important petroliferous basins of India. A review of the exploratory programmes carried out for oil prospects in India.

PETROLEUM GEOCHEMISTRY:

Facies controlling the amount and type and organic matter in sediments.

Kerogen: classification and evolution of Kerogen. Geochemical fossils. Timing of oil and gas generation. Source rock characterization qualitative and quantitative evaluations of source rock maturity. Correlation: oil to oil correlation and oil to source correlation.

Molecular groups in hydrocarbons, Normal-, Iso- and Cycloparaffins, Aromatics, Napthenoaromatics and NSO compounds. Composition of crude oil based on main hydrocarbon groups.

GLC 51122	TECTONICS AND STRUCTURAL METHODS FOR EXPLORATION	3 0 0
------------------	---	--------------

Brittle and Ductile deformation of rocks. Techniques of strain analysis. Concepts of plate tectonics and plate motion. Evolution of divergent boundary basins and their petro-tectonic assemblages. Evolution of convergent basins and their petro-tectonic assemblages. Evolution of strike-slip boundaries and their petro-tectonic assemblages. Plate Tectonics and mineral/ Hydrocarbon accumulation. Mapping of structural geometry: using of fence diagram, stratum contour, isopach and isochore maps. Balanced cross-section. Development of gravity induced and diapiric structures, Fracture analysis.

GPC 51101	PETROLEUM EXPLORATION GEOPHYSICS AND GEOPHYSICAL MODELING	4 0 0
------------------	--	--------------

SECTION A: PETROLEUM EXPLORATION GEOPHYSICS

Gravity Method

Acceleration of Gravity, Gravitational Potential, Potential Field Equations, Derivatives of the Potential, Unit of Gravity, Figure of the Earth, Spheroid and Geoid.

Gravimeters: Stable and Unstable Gravimeters. Principle of Worden Gravity Meters
Reduction of Gravity Data and preparation of Gravity Anomaly Map.

Magnetic Method

Basic Concept and Definitions. Units of Magnetic Fields, Elements of Earth's Magnetic Field. Variation of Earth's Magnetic Field Over the Earth. Remanent Magnetism, Magnetic Susceptibilities of Rocks and Minerals.

Magnetometers: Proton Precession Magnetometers, Gradiometers.

Field Procedure and Reduction of Magnetic Data. Land and Aeromagnetic Surveys.

Resistivity Method

DC Resistivity, Definition of apparent resistivity, various electrode configurations, Profiling and sounding.

SECTION B: GEOPHYSICAL MODELING

Fundamental concepts of geophysical Model and Modeling, relation between model and data space, Forward problems, Inverse problems, model and data covariance-understanding uncertainty and resolution.

Basic concept of Seismic methods and modeling approaches. Concept of Physical Models, Forward and Inverse Seismic Modeling, Examples of inverting geophysical data over 1D and 2D structures: Travel time inversion, velocity inversion and cross hole tomography.

Applications of gravity and magnetic methods in oil exploration, Mapping of fracture zones. Basement modeling, modeling for salt domes, stratigraphic traps, uplifted horst and graben, continental ocean boundary (COB), continental ocean transition (COT).

GPC 51102	WELL LOGGING AND ELECTROFACIES	3 0 0
------------------	---------------------------------------	--------------

Well logging Technique and its role in Hydrocarbon exploration. Borehole environment.

Application of basic Wireline logging Tool:

Open Hole Logging Tools

- a) Latero (Resistivity measurement); SP, Conductivity method (Induction)
- b) Porosity measurement tools: Density-Porosity, Neutron Porosity, Sonic Porosity
- c) Caliper and Correlation log (Gamma ray)
- d) Electrofacies analysis techniques to identify various sedimentary features (regressive, transgressive, sandbars, channels, delta deposits) and environment using various correlation techniques.
- e) Formation evaluation from open hole logs

Cased hole and production logging tools

CBL/VDL, Flowmeter, fluid density and temperature tool

Utilisation of various logs to study reservoir parameters

Detection of overpressure zone from well logs, detection of Fractures from FMS/FMI, and Dipmeter and interpretation of Dipmeter logs.

PER 51101	PETROLEUM DRILLING AND PRODUCTION ENGINEERING	3 1 0
------------------	--	--------------

SECTION A: OIL AND GAS WELL DRILLING

Well planning: Drilling planning approaches, Evaluation of pore and fracture pressure, Casing seat selection.

Rotary drilling method: Rig parts, Selection and general layout. Advancements in Rig equipment. Top drive and Bottom drive systems.

Drilling operations and Practices: Hoisting, circulation, Rotation, Power plants and Power transmission.

Drilling fluids: Types, Function, Properties, Equipment and Design

Cementing: Methods, Tools and Techniques, cementing circulations, Special cement system.

Wire Lines: Classification, Service life evaluation & precautions in handling.

Drill bits: Types and application, Selection, Design and performance.

Drill string and Casing string: Parts, functions and operations. Selection/ Design

Drilling problems, their control and Remedies: Pipe sticking, Sloughing shales, Lost circulation, Blow outs

Oil well fishing: Fish classification, tools and techniques.

Fundamentals of directional drilling

SECTION B: OIL AND GAS PRODUCTION

Well equipment: Well head assembly, Christmas tree, valves, hangers, flow control devices, packers, tabular and flow lines, safety and control systems.

Well completion: Systems, types and applications

Well perforation and well activation

Processing in oil fields: GGS/ CTF – layout, sequential treatment, separation, storage and transportation of petroleum, Demulsification and desalting

Introduction to well servicing and stimulation system: Objectives and applications.

GLC 52123	SEDIMENTARY ENVIRONMENT, SEQUENCE STRATIGRAPHY AND BASIN ANALYSIS	4 0 0
------------------	--	--------------

A. SEDIMENTARY ENVIRONMENT:

Concept of sedimentary environments. Environmental parameters and their control. Classification of environments. Facies model and environmental reconstruction.

Shallow and deep water sandstone reservoir geometry. Alluvial environments. Marginal marine and neritic environment; deltaic models, Barrier bar-lagoon, coastal (interdeltaic) model – barrier islands and lagoons, tidal channels and tidal deltas, Submarine fan. Carbonate sedimentation model, platform geometry.

Concept of tectonics and sedimentation. Role of environmental analysis in petroleum exploration.

B: SEQUENCE STRATIGRAPHY AND BASIN ANALYSIS:

1. Definitions and key concepts, base level changes, transgressions and regressions.
2. Sequence stratigraphic surfaces. Unconformity and correlative conformity.
3. Systems Tracts : Lowstand, Transgressive, Highstand, Falling stage.

4. Hierarchy of sequences and bounding surfaces
5. Definition and scope of basin analysis. Basin mapping methods: Lithofacies maps, palaeocurrent analysis, Geohistory analysis. Thermal history.
6. Tectonic classification of sedimentary basins.

GLC 52124	MICROPALEONTOLOGY IN HYDROCARBON EXPLORATION, CBM AND GAS HYDRATE EXPLORATION	4 0 0
------------------	--	--------------

A. MICROPALEONTOLOGY IN HYDROCARBON EXPLORATION

Introduction to micropaleontology, Collection, preparation and preservation of microfossils. Classification of microfossils. Classification and morphology of foraminiferas, radiolaria, ostracods, Acritarchs, and nano-fossils. Environmental significance of micro fossils. Microfossils in stratigraphy. Application of micropaleontology in petroleum exploration with special reference to oil-bearing regions of India.

B. CBM AND GAS HYDRATE EXPLORATION:

CBM:

1. Coal bed methane generation and accumulation
2. Geological and petrographic influences on coal, Pore geometry, Micropore, Mesopore and macropore, cleat system
3. Sorption – principles, sorption isotherms – types and interpretation. CO₂, CH₄ and N₂ adsorption – desorption, hysteresis, Langmuir isotherm, Swelling of coal matrix isotherm construction.
4. CH₄ content determination in coal seams.
5. Underground coal gasification, carbon dioxide sequestration

GAS HYDRATE:

1. Gas hydrate, occurrence and origin;
2. Structure of gas hydrate, Types of gas hydrate; Geological setting of Hydrate;
3. Stability of gas hydrates; Gas hydrate reservoir;
4. Geological and geophysical exploration of gas hydrate

GPC 52103	REFLECTION SEISMOLOGY	4 0 0
------------------	------------------------------	--------------

Geometry of reflection ray path and time distance relationship, seismic noise and their cause.

Methodology for 2D reflection survey: Common depth point technique. Different kinds of spread geometry, end on, split spread, crooked line profiling, linear and tapered geophone arrays, effect of arrays on the seismic response, optimization of spread geometry, offset matching, source arrays.

3D survey designing: Different 3D geometry with Swath shooting and cross spreads. Various navigation and positioning systems used for reflection 2D/3D surveys.

Seismic data processing: Introduction to seismic data processing and editing, concept of minimum and zero phase wavelet, processing sequences – preparation of processing geometry, quality checks, true amplitude recovery, deconvolution, filtering, velocity analysis, residual statics, noise elimination through multichannel filtering, parameter optimization for generation of final stacked section, DMO and migration, wavelet processing, DIH and pitfalls.

3D processing techniques – generation of time slice and stacked sections.

Interpretation: Study of seismic section and other geological aspects of prospecting, structural interpretation, Construction of isochron and isopach maps & seismic stratigraphic interpretation.

MSC 52104	PROJECT MANAGEMENT	3 0 0
------------------	---------------------------	--------------

Project Management – an Overview; Project Life Cycle, Feasibility Study; Market and Demand Analysis; Technical Analysis; Financial Analysis; Social Cost-Benefit Analysis; Detailed Project Report.

Project Planning and Scheduling: Planning Time Scales, Project Planning using Network techniques, Scheduling of Project with Limited Resources, Implementation and Control; Project Organization, Project Management Information Systems, Basics of Software Project Management.

Elective I

GPE 52104	RESERVOIR GEOPHYSICS AND DEEP WATER IMAGING	3 0 0
------------------	--	--------------

SECTION A: RESERVOIR GEOPHYSICS

Reservoir: Definition, elements and types; Petrophysics: fluid properties, stress conditions, fluid flow in two and three dimensions, radial and spherical flows, generalized Darcy's law. Introduction to multi component seismic survey.

Application of 3D and 3C seismic data in reservoir studies, Vertical Seismic Profiling: acquisition, processing and interpretation.

Use of crosshole seismic tomography and AVO in reservoir management.

Case studies of 4D seismics in reservoir management.

SECTION B: DEEP WATER IMAGING

Deepwater: Indian and World Scenario

Deepwater Depositional System, Deepwater Challenges and Strategy

Marine Controlled Source Electromagnetic (MCSEM): Introduction to Geoelectromagnetism, Physics of MCSEM, EM Boundary Condition and Attenuation, Numerical Studies and Case Studies

Sea Bed Logging, Marine Magnetotelluric

Elective II

GLE 52110	GEOSTATISTICAL METHODS	3 0 0
------------------	-------------------------------	--------------

Sampling Methods- Theory and Concepts. Classical Statistical methods: Uni-variate and Bi-variate; Exploratory data analysis. Probability distributions: (i) Continuous distributions, viz. Normal (Gaussian), and Lognormal distributions and their fit to a sample distribution; (ii) discrete distributions, viz. Binomial, Negative binomial and Poisson distributions.

Concepts of Geostatistics; Semi-variogram : definition, characteristics and properties. Computation of semi-variograms; mathematical models of semi-variogram; Techniques of semi-variogram model fit.

Extension variance and Estimation variance : definition, derivation and calculation procedures.

Kriging: introduction and definition. Linear kriging. Derivation and solving kriging system of equations for point and block. Geostatistical conditional simulation.

Practical applications of Geostatistics in geotechnical investigation, hydrocarbon exploration and reservoir modelling with case studies.

PRACTICALS

Petroleum Geology (GLC-51221)

L T P 0 0 3

Sl. No. PRACTICAL EXERCISES

- 1 Interpretation of geological structures from surface geological maps.
- 2 Interpretation of geological structures from borehole data
- 3 Reconstruction of structural developments through different time planes
- 4 Preparation of structural contours
- 5 Preparation of isopach maps of reservoir facies
- 6 Development of panel diagram from borehole data
- 7 Finding oil-water contact from borehole data
- 8 Oil field water chemistry
- 9 Calculation of oil reserves in defined structures

Petroleum Exploration Geophysics, (GPC 51201)

L T P 0 0 3/2

Gravity and magnetic Methods:

Sl. No. PRACTICAL EXERCISES

- 1 Working principle of the Worden Gravimeter
- 2 Calculation of drift correction in respect of a local gravity base in a field survey
- 3 Computation of free-air and Bouguer gravity anomalies for a set of field stations.
- 4 Geomagnetic field components, and their variation across continental India.
- 5 Working principle of Proton–precession magnetometer
- 6 Procedures for ground magnetic field surveys.
- 7 Reduction of magnetic field data

Seismic Methods:

Sl. No. PRACTICAL EXERCISES

- 1 Calculate elastic constants (K, E, μ & ν) of geologic formation from given P- and S- wave velocity data
- 2 Calculate depth of single horizontal interface using seismic refraction data
- 3 Calculation of depth of basement in a dam-site area from shallow seismic refraction survey.
- 4 Calculation of dip and vertical depth of single dipping interface using seismic refraction data.
- 5 Demonstration of geophone

6 Field operation of a seismic recording unit

Geophysical Modeling (GPC 51201)

L T P 0 0 3/2

Part I

Sl. PRACTICAL EXERCISES

No.

- 1 Interpretation of Seismic Reflection Data by Modeling
- 2 Wave equation modeling through finite-difference technique
- 3 Synthetic Seismogram generation through Seismic Unix
- 4 1D Full wave normal incidence modeling

Part II

Sl. PRACTICAL EXERCISES

No.

- 1 Modeling of Bouguer and free-air gravity anomaly using available software for petroleum exploration
- 2 Regional-residual separation of gravity anomalies using available software.
- 3 Gravity anomaly model across a vertical fault/fracture and estimation of ore mass using available software.
- 4 Model the earth's crust and thickness, define COB and COT

Well Logging and Electrofacies (GPC 51202)

L T P 0 0 3

Sl. PRACTICAL EXERCISES

No.

- 1 Study of SP and Gamma Ray logs to identify bed boundaries.
- 2 Identification of fluid types in pore spaces by resistivity logs
- 3 Insight in to the determination of formation factor in flushed and uninvaded zones
- 4 Computation of porosity of the formation using different types of input data
- 5 Computation of water saturation from resistivity logs
- 6 Correction for the bore hole mud on induction log data
- 7 Compute R_t , R_{xo} and d_i from three sets of resistivity measurements
- 8 Computation of resistivity of formation water from SP logs
- 9 Interpretation of Cross plotting techniques in Formation Evaluation
- 10 Electrofacies identification from various well log responses
- 11 Structural interpretation from Dipmeter logs

Tectonics and structural methods for exploration (GLC 51222)

L T P 0 0 3

**Construction of Isopach, Isochore, Structure, Contour maps and Crosssection.
Studies on Joint Analysis**

Sedimentary Environment and Basin Analysis (GLC 52123)

L T P 0 0 3

Sl. PRACTICAL EXERCISES

No.

- 1 Structure contour map, description of structure, profile construction, marking oil/water contact, proposal for new well.
- 2 Interpretation of geological map, reconstruction of stratigraphic succession.
- 3 Borehole litho log correlation, marking of potential oil entrapment zone.
- 4 Problem on deviation drilling
- 5 Problems on oil field water
- 6 Isopach, sand Isolith and isochore map

Micropaleontology (GLC 52224)

L T P 0 0 3

Sl. PRACTICAL EXERCISES

No.

- 1 Separation of Microfossils from Different types of sediments
- 2 Description & identification of smaller benthic foraminiferal tests up to generic level
- 3 Description & identification of planktonic foraminiferal tests up to species level
- 4 Description & identification of larger benthic foraminifera in thin sections
- 5 Description & identification of ostracodes

Reflection seismology (GPC – 52103)

L T P 0 0 3

Sl. PRACTICAL EXERCISES

No.

- 1 Study of Velocity spectrum plots & calculation of interval velocity using DIX's relation. Drawing of velocity profiles on spectrum plots.
- 2 Convolution, cross correlation, auto correlation of seismic data through FORTRAN/MATLAB programming.
- 3 Generation of variation of shot gathers for simple & complex structure using CWP seismic UNIX software.
- 4 Processing of synthetic shot records using shell scripting on CWP Seismic UNIX software
- 5 Wave equation migration schemes applied to synthetic shot gathers.
- 6 Preparation of isochron map of given prospect
- 7 Synthesis & analysis of waves using Fourier transform
- 8 Digital filtering (TVF) of synthetic shot records
- 9 Seismic attribute analysis on synthetic vibroseis data
- 10 Processing field seismic records using shell scripting on CWP Seismic UNIX software

