

**INTERINSTITUTIONAL MASTER PROGRAMME "EXPLORATION AND  
EXPLOITATION OF HYDROCARBONS"**

**COURSE CONTENT**

**1<sup>st</sup> Year – 1<sup>st</sup> Semester**

**6 Compulsory Courses**

Course: **PETROLEUM GEOLOGY**

Course code: **HGA-1Y**

Compulsory/Optional: **Compulsory**

ECTS: **7**

**Course Content:**

The basic introductory concepts of Petroleum Geology are presented together with the properties of the source rocks and "kerogen", the geochemical methods for determining their quality, the hydrocarbons migration, the characteristics of the reservoir rocks and especially their petrophysical properties (porosity, saturation, and permeability), the different cap rocks and the diagenetic phenomenon. The term "hydrocarbon reserves", the concepts of resources and reserves, and the distinction between proven reserves [1P], "probable reserves" and "possible reserves" are explained. The techniques for estimating and calculating the reserves are also presented. Examples of the various types of hydrocarbon traps of the three major categories: Structural Traps, Stratigraphic Traps and Combined Traps are described and examined. The different forms of surface manifestations of hydrocarbon seepage and micro-seepage, which have led to the development and marketing of an equally diverse number of hydrocarbon detection methods are presented.

Course: **OVERVIEW OF THE OIL AND GAS EXPLORATION PROCESSES**

Course code: **HGA-2Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

The upstream, midstream and downstream sectors of the oil industry, as well as all techniques and activities for oil and gas exploration are presented. There are three (3) primary methodologies used to find hydrocarbons in the subsurface: Geophysical, Remote Sensing, and wildcatting (exploratory drilling). The 'Mud Logging' practice, heavily related to the mud circulation system, is described in detail. 'Mud Logging' is the creation of a detailed record, the 'well log' of a borehole by examining the cuttings of rock brought to the surface by the circulating drilling mud. Information about the lithology and fluid content of the borehole while drilling is provided. Mud logging includes observation and microscopic examination of drill cuttings, and evaluation of gas hydrocarbon and its constituents, basic chemical and mechanical parameters of drilling mud, as well as compiling other information about the drilling parameters. The different technologies for the extraction of samples, or "cores", from the formation using special bits or wireline-conveyed coring tools are presented. The 'Well logging' which constitutes the practice of making a detailed record (the 'well log') of the geologic formations penetrated by a borehole is introduced.

Course: **OVERVIEW OF THE PETROLEUM SYSTEMS IN GREECE, CYPRUS AND THE SOUTH-EASTERN MEDITERRANEAN AREA**

Course code: **HGA-3Y**

Compulsory/Optional: **Compulsory**

ECTS: **4**

**Course Content:**

The geology of Prinos Oil field and South Kavala Gas field, discovered near Thassos Island in North Aegean Sea, are presented. The hydrocarbon traps are related to a fault block closure and to a salt induced structure respectively. Are also presented the geology and the hydrocarbon potential of the offshore and onshore sedimentary basins in Western Greece and Southern Crete. The Pre-Apulian and the Ionian zones, the two most external portions of the Hellenide fold-and-thrust belt, present important petroleum potential, showing similar geochemical characteristics ('analogues') with the producing fields in Italy. The active petroleum systems within the EEZ of Cyprus, the Levantine basin, and the SE Mediterranean area are presented. The impact of the Messinian Salinity Crisis (MSC) on the petroleum systems of the Eastern Mediterranean is assessed.

Course: **SEDIMENTARY BASINS – SEDIMENTS – TRANSPORTATION AND SEDIMENTATION PROCESSES – PALEOGEOGRAPHY – PALEOENVIRONMENT**

Course code: **HGA-4Y**

Compulsory/Optional: **Compulsory**

ECTS: **4**

**Course Content:**

Sea-level change – subsidence and accommodation space for sediment deposition. Mechanisms of sedimentary basin formation and their impact on basin morphology (basins due to lithosphere stretching, basins due to flexure, effects of mantle dynamics, basins associated with strike-slip deformation). Transportation and deposition of clastic sediments (processes on the continental environments, processes in lake and marine environments). Clastic sediments (conglomerates, sandstones, schists). Global palaeogeography and palaeoenvironments during Geological Time.

Course: **SEQUENCE STRATIGRAPHY OF CLASTIC AND CARBONATE SEDIMENTS**

Course code: **HGA-5Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

Principles of Lithostratigraphy and Biostratigraphy. Depositional sequence in relation to accommodation space. The climate signal in depositional sequences. Sequence Stratigraphy (a framework for interpretation of seismic stratigraphy, in relation to accommodation space and depositional processes). Sequence Stratigraphy of fluvial, coastal, continental shelf and deep-sea environments. Cyclostratigraphy of Carbonates. The Genesis of Carbonate Sediments (T-Factory, C-Factory, M-Factory). The Sequence Stratigraphy of Carbonates in tropical waters. The Sequence Stratigraphy of Carbonates in cool

waters. The Sequence Stratigraphy of Carbonates formed by microbial influence. Mixed clastic and carbonates sedimentary sequences.

Course: **ORGANIC GEOCHEMISTRY**

Course code: **HGA\_6Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

Organic Petrography/Petrology. The coal-petrography microscope. The organic matter under the microscope: maceral (in coal) and bitumen (in source rock). The maceral groups of huminite/vitrinite, liptinite, inertinite. Kerogen, migrand and pyrobitumen. Huminite/vitrinite and bitumen reflectance as measure of rank and maturation of organic matter in coal and source rock, respectively. Biomarkers. Analytical methods: Gas Chromatography, full-scan Gas Chromatography-Mass Spectrometry. The chemistry of biomarkers. Application of biomarkers in petroleum exploration. Application of biomarkers in basin analysis. The biomarkers as indicators of depositional conditions and accumulation of organic matter in source rocks. Thermal maturity assessment based on biomarker analysis. The biodegradation process. MP1 index and its relation to VRo. The palaeo-pasturization effect. Petroleum age and biomarkers. Examples of biomarker analysis from Greek and international hydrocarbon fields.

**1<sup>st</sup> Year – 2<sup>nd</sup> Semester**

**6 Compulsory Courses + 1 Elective Course (*out of two*)**

Course: **NON SEISMIC METHODS IN HYDROCARBONS EXPLORATION**

Course code: **HGB\_1Y**

Compulsory/Optional: **Compulsory**

ECTS: **3**

**Course Content:**

The course covers the basic theory and practice of the main non seismic geophysical methods which are used detecting Hydrocarbon resources. These are usually employed at the initial stages of the exploration process. Gravity, magnetic and electromagnetic (EM) prospecting methods are presented. The specific topics covered are:

1. Basic theory of the Earth's gravity field, density of rocks and minerals, quantities measured in a gravity survey, instruments for measuring the gravity field, data collection and relevant corrections, data reduction, regional - residual filed separation.
2. Basic theory of the Earth's magnetic field, measured quantities, magnetic susceptibility and remnant magnetization, instruments, techniques for land, off shore and airborne data collection, techniques for the reduction of the magnetic readings, data processing.
3. Basic concepts of EM prospecting methods, the magneto-telluric method, controlled source EM methods, transient EM methods.

4. Introduction to complex functions, potential fields' theory, field transformations, signal complex attributes interpretation of gravity and magnetic field anomalies, methods for automatic interpretation.
5. Case studies of application of non-seismic methods to Hydrocarbon Exploration.

Course: **SEISMIC SURVEYS AS A TOOL IN OIL AND GAS EXPLORATION**

Course code: **HGB\_2Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

Elastic Medium, properties, elastic constants (Young Modulus, Bulk Modulus, Rigidity or Shear Modulus, Poisson Ratio). Seismic Waves [Body Waves (P & S Waves), Surface Waves (Rayleigh Waves, Love Waves)]. Seismic Velocity of seismic waves in various rock formations. Seismic Wave-front and seismic rays, Huygens Principle, Fermat Principle, Snell Law, Seismic Impedance, Reflection Coefficient. Propagation of seismic waves in time, distance and depth. Direct, reflection and refraction waves. Seismic Sources [Dynamite (Pulse shape and Amplitude Analysis), Vibroseis (Cross Correlation, Auto Correlation), Weight Drop, Seismic Hammer, P & S wave Seismic Hydraulic Hammer, Land Airgun, Marine Airgun]. Geophones. Hydrophones. Land Seismic survey (acquisition design). Marine Seismic Survey (vessels, streamers, acquisition design, OBS, OBN). Reflection Seismics Basic factors for Data Acquisition: *Geology of the survey area* (Depth of interest, slope of layer interfaces, thickness and acoustic impedance variation, seismic bandwidth, vertical and lateral resolution), *Transmissivity of the Earth* (Spherical divergence or geometrical spreading {A}, Partitioning of energy at an interface {A,  $\varphi$ }, Reflection interference {A}, Scattering {A,  $\varphi$ , B}, Absorption {A,  $\varphi$ , B}), *Data and Noise* [Source generated noise, Ambient Noise, Coherent Noise (Surface waves, Shear and converted waves, scattered waves, Airwave), Random Noise, Multiples, Noise Reduction (Frequency and/or velocity filtering), Reduction of Coherent Noise (arrays of sources and/or receivers in the field {velocity filtering}, Frequency and/or velocity, Common Mid-Point (CMP) stacking)]. Seismic Refraction. MASW.

Course: **SEISMIC DATA PROCESSING**

Course code: **HGB\_3Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

Fourier series and Transform (FT), DFT, FFT, Convolution, correlation. Moving average (MA), Autoregressive (AR) and ARMA models. Power spectrum estimators. Convolutional model in seismic reflection, Wiener filters, Deconvolution. Seismic velocity analysis, interval, Root Mean square (RMS). Normal Moveout Correction (NMO), Static corrections, Stacking. Migration, Kirchhoff, phase-shift migration. Amplitude Versus Offset (AVO) analysis.

Course: **INTERPRETATION OF SEISMIC REFLECTION DATA**

Course code: **HGB\_4Y**

Compulsory/Optional: **Compulsory**

ECTS: 5

**Course Content:**

The basic principles of the interpretation of two- and three-dimensional seismic lines from a variety of geological-tectonic environments are presented. At a second stage the interpreted sections are used to construct three-dimensional models of the subsurface and these models are evaluated in view of crude oil and natural gas bearing structures. The course includes: the basic principles of seismic data interpretation, simulations, synthetic data, seismic ray tracing methods, the seismic forward and inverse problem, inversion methods, adjusting seismic data interpretation on the basis of the different processing used, identification of common basic stratigraphic and tectonic structures in the Mediterranean, the estimation of the oil potential of an area based on interpretations as well as extensive practice with real seismic lines.

Course: **GEOSTATISTICS - OIL AND GAS RESERVES ESTIMATION METHODS**

Course code: **HGB\_5Y**

Compulsory/Optional: **Compulsory**

ECTS: 4

**Course Content:**

The aim of the course is to present the mathematical tools of geostatistics in order to prepare students for the development of static and dynamic reservoir models. The course includes a brief introduction to probability, the theory of random functions, spatial correlation analysis, spatial and spatio-temporal interpolation, joint interpolation of multiple variables using the linear coregionalization model, methods for the spatial analysis of categorical variables, methods for spatial simulation including sequential indicator simulation and Gaussian simulation.

Course: **WELL LOGGING**

Course code: **HGB\_6Y**

Compulsory/Optional: **Compulsory**

ECTS: 4

**Course Content:**

The aim of this course is to present the 'Well Logging' technique which continuously measures formation properties with electrically powered instruments. Measurements include electrical properties (resistivity and conductivity at various frequencies), sonic properties, active and passive nuclear measurements, dimensional measurements of the wellbore, formation fluid sampling, formation pressure measurement, wireline-conveyed sidewall coring tools, and others allowing the determination of such important elements as, for example, full lithostratigraphic profile of the well, sedimentary rock depositional environment, the oil-water contact, percentage share of particular minerals, mechanical modulus, porosity, permeability or hydrocarbon content in prospective zones.

<b>ELECTIVE COURSES – 2<sup>nd</sup> SEMESTER (1 out of 2) (4 ECTS)</b>
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**(1)**

Course: **APPLIED PETROLEUM SEDIMENTOLOGY**

Course code: **HGB\_1E**

Compulsory/Optional:

ECTS: **4**

**Course Content:**

The aim of this course is to develop practical geological skills applicable to the oil and natural gas industry, embracing the sub-disciplines of clastic and carbonate sedimentology, stratigraphy, and diagenesis. Sedimentological and stratigraphic knowledge is crucial in both exploration and development activities, and is fundamental in making predictive models. A practical knowledge of depositional environments which form hydrocarbon reservoirs, linking these together using the techniques of sequence stratigraphy is given. Physics in sedimentology (settling of sediment grains, dimensionless transformations, Reynolds and Froude numbers, laminar and turbulent flow), depth dependent algorithms for simulation of sedimentation in marine environments, as well as existing computer packages for forward modeling of sequence stratigraphy (SEDFLUX, etc) are taught. Examples of sedimentary sequences simulation of coastal, continental shelf and deep-sea environments are presented. The course also includes grain identification under stereoscopic microscope, observation of drill cuttings, sedimentary analysis techniques, petrophysical properties determination, and field exercise of borehole coring, core logging and macroscopic examination and description of the cores.

**(2)**

Course: **PERFORMANCE ASSESMENT AND MANAGEMENT**

Course code: **HGB\_2E**

Compulsory/Optional: **Compulsory**

ECTS: **4**

**Course Content:**

This course deals with the fundamentals of the industrial project performance assessment in hydrocarbon exploration and operation companies and projects. Based on process engineering concept, the widest used methods to measure, review, monitor, control and management of a complicated industrial or/and infrastructure project are discussed. Through numerical applications and case studies, the key issues on project control, supply chain management and management performance monitoring are discussed, and by case studies and referred applications some best practices are highlighted.

The course fundamentals could be, briefly, summarized to:

- Performance management principles and outputs,
- Performance management assessment methods and techniques,
- Development and review of performance indexes,
- Performance monitoring, control and management process,
- Case studies on project performance assessment and management,
- Best practices and practical guidelines.

Course: **DRILLING ENGINEERING**

Course code: **HGC-1Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

Overview of well drilling and relevant equipment. Well planning. Geomechanics and Geopressures. Drill bits and Rock interaction. Drilling fluids. Drill string design. Casing design, Cementing, Completion and Perforation. Deviated and Horizontal wells. Safety, Well control and blowout prevention. Drilling economics and Cost analysis.

Course: **RESERVOIR ENGINEERING AND RESERVOIR FLUIDS/SAMPLING AND ANALYSIS**

Course code: **HGC-2Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

Reservoir fluids thermodynamics, Gas mixture properties, Volumetric PVT parameters, Oil mixture properties, Phase behavior, EOS, Reservoir fluids sampling, PVT laboratory experiments and data analysis, Material balance, Secondary recovery-Water flooding, CMG tutorial.

Course: **HYDROCARBON FLOW IN POROUS MEDIA**

Course code: **HGC-3Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

The graduate course of flow in porous media deals with the concepts, theories, and laboratory procedures as related to the porous rock properties and their interactions with hydrocarbon fluids. The properties of porous subsurface rocks and the fluids they contain, govern the rates of fluid flow and the amounts of residual fluids that remain in the rocks. In order to establish the basis for the study of rock properties and rock-fluid interactions, the analysis begins with the two rock properties that are the most important for petroleum reservoirs, the porosity and permeability and we establish the porosity-permeability correlations. The theories and applications of capillary pressure and wettability to various phenomena associated with fluid-saturated rocks, such as residual saturations due to fluid trapping, variations of relative permeability and their effects on production are then studied. Their experimental determinations of these parameters are then described theoretically. It is explained that with the use of the capillary pressure, the mean pore size distribution, the wettability as well as the water distribution within the reservoir can be determined. After the explanation of the properties and variables affecting the transport phenomena the analysis turns to the applications of the Darcy's Law in linear and radial flows under laminar conditions as it governs the rates of hydrocarbon production. Finally, the multiple variations of permeability and porosity in relation with the rock mechanics properties like deformation and compressibility are discussed.

The effect of stresses on the porosity and permeability is analyzed so as to explain various problems in petroleum geomechanics.

Course: **PRODUCTION ENGINEERING & WELL PERFORMANCE**

Course code: **HGC-4Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

Inflow and outflow performance, production analysis of subsurface systems, well completion methods and procedures, perforating techniques, formation damage, flow restrictions, fracturing process, sand control methods, producing bottom hole pressure (BHP), tubing selection, design, and installation, single and multi-phase flow in piping, gas lift, electrical submersible pump (ESP), hydraulic pumping, cavity pumping (PCP), plunger lift. Well testing methods, stimulation. Work-over and Well Interventions.

Course: **HYDROCARBONS MARKET AND VALUATION**

Course code: **HGC-5Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

The International Monetary System historical review. Foreign exchange market. Determination of exchange rates - Long-run. Determination of exchange rates - Short-run (Foreign exchange return model). Financial Derivatives (Forwards - Fixed-term purchases, Futures - Futures contracts, Options - Options, Swaps - Exchanges. Efficient Market Hypothesis (EMH). Uncovered interest rate parity. Covered interest rate parity. International trade. Valuation of fixed income securities. Measures of Returns (interest rates). Bonds. Modern Portfolio Theory - Portfolio Management Theory. Balance of Payments.

Course: **HEALTH, SAFETY AND RISK MANAGEMENT**

Course code: **HGC-6Y**

Compulsory/Optional: **Compulsory**

ECTS: **5**

**Course Content:**

The aim of the course is to introduce the students to the health and safety as well as to the risk management process for the exploration and exploitation of hydrocarbons. The main concepts, definitions and relevant indices that describe H&S issues are presented, while the main types, causes and consequences of accidents and failures are analyzed. Key risk assessment methodologies are analyzed and illustrated under various techniques (e.g. Fault Trees, Event Trees, Monte Carlo probabilistic modeling), the acceptable risk and potential mitigation measures are identified. Finally, techniques for the optimal decision making under uncertainty are presented with the use of decision trees.

**Course: ENVIRONMENTAL PLANNING, IMPACT ANALYSIS AND RISK ASSESSMENT**

Course code: **HGD-1Y**

Compulsory/Optional: **Compulsory**

ECTS: **2**

**Course Content:**

This course deals with the environmental planning and risk assessment concept, principles, methodologies, processes and outputs. The sustainable development concept for a project is analyzed, providing the framework of the environmental planning to manage, control and mitigate the environmental risks and improve the socioeconomic effects. Key objective is to present key methodologies and applications on environmental planning, impact analysis and risk assessment such as the cost-benefit analysis, socio-economic econometric assessment modeling, impact analysis, quantitative and qualitative risk assessment, gap analysis and the multi-criteria analysis. Through dedicated case studies and applications, some best practices and key guidelines to balance the industry and management expectations and the social values are highlighted.

The course key objectives could be summarized to:

- Definitions on sustainable development and environmental management,
- Environmental planning principles,
- Environmental assessment fundamentals,
- Methodologies and applications on environmental planning, management and assessment,
- Case studies and best practices on environmental assessment.

**Course: GREEK LEGISLATION AND REGULATORY FRAMEWORK ON HYDROCARBONS**

Course code: **HGD-2Y**

Compulsory/Optional: **Compulsory**

ECTS: **2**

**Course Content:**

In this course all relevant issues concerning legislation and regulatory framework on the prospecting, exploration and exploitation of hydrocarbons, Exclusive Economic Zones (EEZs), the status of the hydrocarbon discoveries in Greece as well as the economic, political, and technical issues will be presented. Will also be presented the three different forms under which the Hellenic Republic grants E&P rights for block areas [*Open Door Invitation, License Rounds or Individual Initiative*], the invitation to tender (ITT), which is the initial step in competitive tendering including terms, conditions, and evaluation criteria as well as the "*Biddable Items*".

Course: **FORECASTING THE HYDROCARBONS MARKETS**

Course code: **HGD-3Y**

Compulsory/Optional: **Compulsory**

ECTS: **2**

**Course Content:**

Introduction to the Markets (General introduction to the functions of markets, Factors that affect the demand and supply of goods and services). Money and Capital Markets (Introduction to the operation of modern financial systems and money, capital markets. Bonds, interest rates, money markets). The oil markets (Exchange rates and their importance in the oil market, the structure of oil markets, Similarities and differences with other financial markets). Forecasting (The problem of prediction in general, Predictive direction, Point forecasts, Static forecasts, Dynamic forecasts, and Forecast evaluation). Forecasting Models (Univariate and multivariate models, Autoregressive models, Structural models, Hypothesis testing, Statistical significance of models, Practical use of forecasts). State-of-the-Art Models [Markets and RandomWalks, Random walk with drift, Univariate regressions, Multivariate regressions, Logit Regression, Probit Regression, Vector Auto-regressions, Support Vector Machines binary, Support Vector Regression, Machine learning applications (Neural Neighborhood Classifiers), Econometric Software, Graph Theory and Threshold-Minimum Dominating Set, Deep Learning].

Course: **OIL & GAS SOFTWARE TRAINING** (*Schlumberger's Donation*)

Course code: **HGD-4Y**

Compulsory/Optional: **Compulsory**

ECTS: **4**

**Course Content:**

The course provides a technical training for the E&P industry. The course includes introductory to advanced training in key disciplines including Geology, Geophysics, Petrophysics, Drilling, Reservoir, Production, Facilities, Management, and Economics using Schlumberger's software tools including *Petrel*, *Techlog*, *GeoX*, *PetroMod*, *ECLIPSE*, *Merak*, *Petrel GPM Carbonate Simulator* and *Petrel GPM Clastic Simulator*.

Course: **MASTER DISSERTATION PROJECT**

Course code: **HGD-5Y**

Compulsory/Optional: **Compulsory**

ECTS: **20**

**Description:** The project provides students with the opportunity to study in depth a particular aspect of petroleum geoscience, thereby expanding the knowledge they have acquired during the taught courses. Students are expected to demonstrate independent thinking, critical and creative analysis, and sound technical judgment in their project work, and to manage both the technical analysis and time-management aspects of the project. In short, the independent project should represent the pinnacle of a student's knowledge and ability over the duration of the MSc course.

**Assessment:** Oral presentation and written Thesis [More detailed instructions, including guidelines for report and oral presentation design, are given to students at the appropriate time].