BSc in Petroleum Engineering

Course block: Major Core Course

SMG 100 - Introduction to Natural Resource Extraction

This is an introductory course to natural resources extraction and research methods. The course is designed to provide students with an overview of geology, mining and petroleum engineering, and their significance for the society. The course will equip the students with the fundamental knowledge of geological processes and mining and petroleum operations covering areas across the entire mineral industry value chain. This includes exploration, evaluation of assets, main components of mining and petroleum operations, post-processing, operational health and safety, risk assessment, environmental impact, and the latest technological advancements towards more efficient and sustainable operations. In addition, the course will introduce students to research methodology considering ethical principles. By the end of the course, the students are expected to acquire essential knowledge towards undertaking comprehensive studies in their selected program of study related to natural resource extraction industries.

Course learning outcomes
1. Characterize the basic concepts of geological processes and mineral exploration.
2. Classify best practices in mining operations across the entire value chain, mineral processing, mine health and safety and risk assessment, and sustainability and efficiency of mining operations.
3. Acquire knowledge of petroleum systems and E&P best practices, including differentiation of rock classifications, reservoirs, reservoir fluids, and recovery mechanisms.
4. Contrast the interplay between exploration, production, and mid-stream operations.
5. Outline the research process, research methodology, research methods, and research ethics.

GEOL 101 - Fundamentals of Geology

This introductory course to Geology will cover the following topics: the Solar System; formation, differentiation, and present structure of the Earth; the mantle, the oceanic crust and plate tectonics; the continental crust; rivers and oceans; origins and evolution of life; climate change; natural resources. Important minerals, rocks, and fossils will be progressively introduced in the course with respect to their geologic context.

Course learning outcomes
1. Outline Earth history, structures and describe various physical and geomorphological processes using plate tectonic theory.
2. Explain the basic concepts of stratigraphy and interpret maps with geological and structural information included.
3. Classify and identify types of minerals and rocks igneous, sedimentary and metamorphic rocks in nomenclature, composition and formation.
4. Describe the geology and resources of Kazakhstan.

PETE 201 - Fluid Mechanics and Thermodynamics

This course aims to introduce students to the fundamentals of fluid mechanics and its applications in petroleum/mining engineering and basis of engineering thermodynamics and its application to a range of problems of relevance to practical engineering. Basic principles of static and dynamics of fluid such as pressure calculation, principles and governing equations of fluid flow, Bernoulli equation, fluid flow in pipes, and dimensional analysis are covered in the fluid mechanics part. In the thermodynamics part, the nature and operating principles of energy flow in systems encountered in engineering, basic thermodynamic principles and laws of physics to analyze and predict performance of idealized forms of thermodynamic systems, and principles of phase equilibrium in two-component and multiple-component systems are discussed and covered.

Course learning outcomes
1. Use properties of substances and basic concepts of thermodynamics and fluid mechanics.
2. Derive conservation equations of mass, momentum, and energy.
3. Apply conservation equations to solve complex engineering problem.
4. Solve fluid flow in pipes complex engineering problems.

PETE 202 - Transport Phenomena

The physical processes of momentum, heat and mass transfer will be covered under the term Transport Phenomena. The focus of this course is momentum transfer, mass transfer, and energy transfer. Differential and integral balance equations for conservation of mass, energy and momentum will be derived and used to solve a wide range of fluid flow problems.

Course learning outcomes
1. Solve fluid dynamics problem.
2. Solve shell balance equations for momentum, mass, and energy.
3. Derive and apply differential conservation equations for mass and momentum.
4. Derive macroscopic balance equations for mass and momentum, and energy.

PETE 204 - Reservoir Rock and Fluid Properties with Laboratories

Basic petrophysical properties of reservoir rocks are covered including porosity, permeability, fluid saturation, electrical conductivity, mechanical properties, capillary pressure, and relative permeability. Applications of Darcy's law to flow in porous media are also presented. Laboratory experiments illustrate measurement of various rock properties. The phase behavior of hydrocarbon systems as related to petroleum recovery is introduced. The course includes ideal and real gas behavior, single and multi-component two-phase systems, and properties of reservoir fluids under various conditions of pressure and temperature. Laboratory tests include determination of various properties of oil and gas mixtures.

Course learning outcomes
1. Describe fundamental rock and fluid properties required for characterization of reservoir systems.
2. Apply equations and correlations to solve complex engineering problems in various petroleum reservoirs.
3. Measure reservoir rock and fluid properties using various laboratory methods.

PETE 203 - Drilling Engineering with Laboratories

The course begins with basic petroleum unit conversions, understanding of drilling rigs and its mechanism, and well control and monitoring system. Then, the students will be introduced to laboratory works relate fluid properties to the fluid formulation and to measure drilling fluid, well control and cement slurry rheological properties. The course also covers; concepts of formation pressures (pore pressure and fracture pressure) and well control. Students will also be exposed to Describe different mathematical models related to drilling hydraulics and drill bit selection and evaluation.

Course learning outcomes
1. State the drilling rigs and its mechanism and well control and monitoring system.
2. Evaluate drilling fluid and cement slurry rheological properties.
3. Relate fluid properties to the fluid formulation.
4. Analyse pore pressure and fracture pressure related to the mud and casing design.
5. Describe different mathematical models related to drilling hydraulics and drill bit selection and evaluation.

PETE 303 - Well Logging and Formation Evaluation

The course introduces various well logs and well logging methods and covers most conventional open-hole

and their interpretation methods. It also covers the concepts of formation evaluation and well logging. It also includes the physical principles of the tools used in logging and characterizes the formation based on interpretation of well logs. The objective is to provide insight into the basic well logging methods that are employed to derive petrophysical properties for hydrocarbon exploration and production. Discussions also touch on concepts of logging program design are presented with examples of applications. All concepts covered are demonstrated through practical log interpretation sessions. Graphical and analytical methods will be developed to allow the student to better visualize the reservoir, its contents and it potential for production. Computerized well logging approaches will be used to handle data, create graphs and log traces, and make computations of reservoir parameters.

Course learning outcomes
1. Interpret various open hole logs.
2. Apply various conventional logs to identify reservoirs non-reservoir rocks, and determine mineralogy, porosity, and saturation in various lithologies.
3. Explain the physics behind various conventional logs and list limitations and advantages of each logging method.

PETE 301 - Numerical Methods for Petroleum Engineers

This course covers the introduction of numerical methods and their applications in solving petroleum engineering problems. Topics cover numerical solutions of linear and nonlinear equations, ordinary differential equations, systems of equations, various solution techniques, interpolation and curve fitting, computer applications, numerical differentiation and integration, the principles of finite difference method to ordinary differential equations, and error and stability analyses. Upon successful completion of this course, students will be able to set up mathematical models for typical petroleum engineering problems with certain complexity and solve them numerically with MATLAB®.

Course learning outcomes
1. Better comprehend the role of mathematics, linear algebra, and numerical methods in petroleum engineering.
2. Become familiar with various numerical methods commonly used in petroleum engineering.
3. Understand the mathematics and corresponding numerical techniques used in petroleum engineering.
4. Formulate and apply numerical techniques to solve mathematical equations for typical petroleum engineering problems.
5. Develop hands-on programming skills using MatLab®.
6. Demonstrate ability to solve a complex petroleum engineering related problem using numerical methods.

PETE 302 - Reservoir Engineering I with Laboratories

Reservoir Engineering overview (petroleum systems, reservoir types, reservoir fluids and compositions, drive mechanisms, basic rock properties like porosity and permeability). Darcy law and its application. Basic definition of reserves, petroleum resources management system, methods of estimating reserves. Predicting hydrocarbons in place (volumetric and material balance methods, water influx). Material balance considerations (equations for gas, gas condensate, black oil, and volatile oil reservoirs). Definition and classification of aquifers, Steady-state models, Unsteady-state models, Pseudosteady-state models.

Course learning outcomes
1. Assess the initial hydrocarbon in place using different reservoir engineering concepts.
2. Analyze the reservoir performance.
3. Evaluate the water influx and its impact on reservoir performance.

PETE 304 - Well Completion and Stimulation

This course focuses on well completion and stimulation technique. The following item will be covered: Well completion and design scenarios such as designing various types of bottom hole completion technique and

completion string component. Formation damage during the various phases of oil and gas recovery from subsurface reservoirs including production, drilling, stimulation techniques and work over operations. Matrix acidizing and acid fracturing, Modern stimulation techniques, Perforating techniques and sand control and Hydraulic fracturing.

Course learning outcomes
1. Examine well completion techniques and production string design.
2. Perform well stimulation technique such as matrix acidizing and hydraulics fracturing design.
3. Design methods to control sand problems.
4. Design optimum perforating system.

PETE 306 - Reservoir Engineering II

Concepts and importance of water flooding, theories and derivations of fractional flow equations from Darcy's law for two-phase flow, theories and derivations of frontal advance equations from continuity equations for water displacing oil, water flooding patterns and characteristics, areal sweep efficiency and influential factors, well injectivity calculation, reservoir heterogeneity and its impact on water flooding processes, vertical and volumetric sweep efficiency, water flooding performance assessment, oil recovery calculations, water flooding design, and strategy optimization.

Course learning outcomes
1. Relate the significance of water flooding for reservoir engineering practice.
2. Apply water flooding schemes for improved oil recovery.
3. Identify water flooding problems and solutions using the learned theories and skills.
4. Assess different water flooding case studies.

PETE 305 - Well Test Analysis

Well testing is a powerful tool to assess the reservoir and well performance. Analysis and evaluations of well conditions and reservoir characterization by using different well testing techniques are the main focus of this course. To be familiar with this subject, both the theory and field examples will be covered in the course content.In summary, this course will include an introduction to well testing, the diffusivity equation for radial flow, transient pressure analysis,gas deliverability testing and derivative-type curves. Learners will further develop their knowledge and skills in petroleum engineering and apply the knowledge they gain in critical relation to the study of petroleum engineering. Furthermore, the course aims to develop lifelong learning skills of independent learning and study concerning Petroleum Engineering.

Course learning outcomes
1. Examine well testing technology and its significance.
2. Analyze pressure data from different well tests.
3. Evaluate formation producibility and underlying reasons for well performance.

PETE 307 - Production Engineering

This core course focuses on basic applications of production engineering to design, estimate, and optimize production from oil and gas wells. Reservoir performance and wellbore performance will be discussed for different types of reservoirs, and interaction between wellbore and reservoir will be investigated to estimate the deliverability of oil and gas. Methods to improve production, such as artificial lift approaches, are discussed. Surface related issues, such as surface facilities and flow assurance, will be also covered in this course to enhance the ability of students to design and control production systems in the most efficient manner This course is designed to make students capable to improve performance and result in higher production rates and/or reduced operating costs.

Course learning outcomes
1. Critically evaluate the production system from reservoir to surface, including Inflow Performance and

Outflow Performance Relationships for oil and gas wells.
2. Evaluate well deliverability under different operating conditions.
3. Optimize a production system (select flowlines, tubing size, chokes, sensitivities, etc.) based on IPR and the principles of multiphase flow in wells.

PETE 311 - Reservoir Simulation

Numerical simulation principles and tools for hydrocarbon reservoir modeling.

Course learning outcomes
1. Understand the advantages and disadvantages of numerical reservoir simulation concepts, and different error sources within numerical simulation.
2. Build input data sets (rock and fluid properties) to run reservoir simulation case studies.
3. Develop formulation of basic equations for single Phase Flow for different conditions.
4. Understand the importance and applying gridding and well modeling.
5. Incorporate advanced elements in reservoir simulation, such as horizontal wells, fault, SAGD, geological map, and fractured reservoir.
6. Conduct an integrated reservoir simulation study to develop a comprehensive understanding of reservoir simulation techniques and their applications in the oil and gas industry through a teamwork.

GEOL 401 - Petroleum Geology and Geochemistry

This course introduces the petroleum system concept (source rocks, migration, entrapment), petroleum physical properties and chemical composition including biomarkers, methods of petroleum exploration, reservoir architecture and characterization, and critically discusses geological controls on recovery method. In the 2nd part of the course petroleum bearing basins of Kazakhstan are studied in details.

Course learning outcomes
1. Define the types of sedimentary basins and petroleum system elements.
2. Discuss the geological processes involved in the formation, migration and accumulation of petroleum.
3. Interpret the chemical composition of petroleum in terms of thermal maturity, water-washing or bacterial degradation.
4. Describe reservoir architecture and its role on entrapment and production strategy.
5. Demonstrate a clear understanding of the geoscience tools used in petroleum exploration and development.
6. Get familiar with petroleum bearing basins of Kazakhstan.

PETE 405 - Enhanced Oil Recovery

Mechanisms involved during different enhanced oil recovery techniques are discussed in this course. Also different methods such as gas injection, thermal methods, chemical EOR, low salinity water flooding, mobility control methods, and nanofluid injection are explained and analyzed in this course.

Course learning outcomes
1. Analyze macroscopic and microscopic sweep efficiency parameters in porous media.
2. Analyze different mechanisms affecting fluid sweep efficiencies in porous media.
3. Evaluate parameters affecting the success of EOR methods in oil fields.
4. Design an EOR model using research techniques and innovative software implementation to predict oil production.

SMG 200 - Resource Economics

Economic analysis presents a structured approach to understanding natural resource industries. The focus of this course is on the market mechanism and its demand-supply model. Students learn both the theory and its applications to analyzing natural resource markets. Specifically, topics include market equilibrium, prices,

costs, and government regulation. Students apply economic models to understand how resource markets are impacted by the business cycle, economic growth, emerging technologies, and climate policies.

Course learning outcomes
1. Analyze resource consumers, producers, and markets.
2. Assess the influence of costs and market structure on resource prices and profits.
3. Evaluate economic impacts of new technologies and climate policy on resource industries.

PETE 404 - Petroleum Geomechanics

Principles of rock mechanics and its application and role in petroleum exploration, drilling, completion, and production engineering. Rock deformation and mechanical behavior, stress-strain relationships, elastic moduli, in situ stresses, stress magnitude and orientation and field determination methods, pore pressure, strength and fracture gradient, introduction to drilling geomechanics and wellbore stability analysis, hydraulic fracturing geomechanics, and reservoir geomechanics.

Course learning outcomes
1. Identify major geomechanics processes and risks involved in design of petroleum development projects.
2. Evaluate petroleum related rock mechanics aspects of petroleum development operations for their optimal design, monitoring, and development.
3. Formulate schemes to address rock mechanics related aspects of petroleum development operations via using proper theoretical, filed, and laboratory methods, tools, and data.
4. Synthesize and present a term paper on a petroleum geomechanics topic.

Course block: Research Component

The Capstone Design Project I is intended to be a team final year project along with the Capstone Design Project II. It provides a team of senior year students with the opportunity to conduct research work where students will implement, and integrate their previously learned skill-sets and techniques from the petroleum engineering curriculum to execute a research study related to their interest under the supervision of one faculty member in the department. The capstone project will be examined by a faculty team.

Course learning outcomes
1. Propose Research Methodology.
2. Design a field facility, a field operation, or a reservoir development scheme within a set of constrains.
3. Analyze and process the data to investigate design performance with due consideration of economic and health and safety issues.
4. Write a detailed engineering report and make an oral presentation about the project.

PETE 407 - Capstone Design Project II

This is the continuation of the final year group project, which started with the Capstone Design Project I. A student team employs experimental and/or theoretical approaches with possible application of computer techniques to integrate various components of the curriculum in a comprehensive engineering design experience. Under the supervision of a faculty member, the team develops a complete project including identification of a problem, formulation of design, preparation of specifications, and consideration of alternative feasible solutions, both technically and economically. The student team has to submit a detailed final project report and present their work to an examining committee.

Course learning outcomes
1. Implement Research Methodology.
2. Utilize petroleum engineering theories and techniques to design a research or field facility, a field operation, or a reservoir development scheme within a set of constrains.
3. Design a model or a process to solve the defined problem.
4. Analyze and process the data and to investigate design performance with due consideration to economic

and health and safety issues.
5. Compose a detailed engineering report and deliver an oral presentation about the project.

Course block: Elective Course

Elective Courses of Year 4 - Fall. Please take one elective course (6 ECTS) from the provided list of the elective courses or any other electives offered by the School of Minings and Geosciences upon agreement with the Program Coordinator

PETE 408 - Gas Engineering

This elective course focuses on basic applications of reservoir and production engineering of gas fields. Definition and components, properties of natural gases, hydrate formation, and inhibition, equation of states (EoS), and special topics in gas reservoirs will be covered. Drilling and well completion of gas wells, well flow performance and recovery, problems in gas wells, natural gas processing, gas gathering and transport, underground gas storage, and health and safety (HSE) regulations in gas fields will also be discussed.

Course learning outcomes
1. Predict the performance, properties, and PVT behavior of natural gases.
2. Identify technical solutions for gas field problems in accordance with production and drilling plans.
3. Plan contemporary aspects of gas fields in accordance with the industry by appropriate research methods.
4. Assess major hazards and potential H.S.E solutions for gas field operations.

PETE 409 - Surface Facilities

This elective course focuses on basic applications of oil and gas surface production facilities. The first part of the course covers the basic concepts and techniques necessary to specify, size, and manage oil field surface production facilities. It clearly introduces the equipment and processes used in joint separation, such as two-phase oil and gas or oil and water, oil and water and produced-water treating systems, and the selection of piping and pumps. The second part of the course focuses on areas that primarily concern gas handling, conditioning, and processing facilities. Specific areas included are the process of dehydration, acid gas treatment, the mechanical design of pressure vessels, compressors, and pressure relief. Safety analysis techniques for production facilities are also covered.

Course learning outcomes
1. Identify the equipment and processes used in joint separation, such as two-phase oil and gas or oil and water, oil and water treating systems, and the selection of piping and pumps.
2. Design, specify, and manage oil field surface production facilities for compressors and pressure drop-in piping.
3. Identify the process of dehydration, acid gas treatment, gas processing, and selection of compressors.
4. Design the mechanical pressure vessels, pressure relief concept, and safety analysis for production facilities.

Course block: Elective Course

Elective Courses of Year 4 - Spring. Please take one elective course (6 ECTS) from the provided list of the elective courses or any other electives offered by the School of Mining and Geosciences upon agreement with the Program Coordinator

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1. Identify the equipment and processes used in joint separation, such as two-phase oil and gas or oil and water, oil and water treating systems, and the selection of piping and pumps.
2. Design, specify, and manage oil field surface production facilities for compressors and pressure drop-in piping.
3. Identify the process of dehydration, acid gas treatment, gas processing, and selection of compressors.
4. Design the mechanical pressure vessels, pressure relief concept, and safety analysis for production facilities.

SMG 400 - Engineering Economics

Economic analysis presents a structured approach to understanding natural resource industries. The focus of this course is on the market mechanism and its demand-supply model. Students learn both the theory and its applications to analyzing natural resource markets. Specifically, topics include market equilibrium, prices, costs, and government regulation. Students apply economic models to understand how resource markets are impacted by the business cycle, economic growth, emerging technologies, and climate policies.

1. Assess a project using the discounted cash flow model.
2. Analyze alternatives on a before-tax and after-tax basis.
3. Appraise projects considering inflation, exchange rates, and uncertainty.