Petroleum Engineering

Program Description

The primary objectives of petroleum engineering are the safe and environmentally sound exploration, evaluation, development, and recovery of oil, gas, geothermal, and other fluids in the earth. Skills in this branch of engineering are needed to meet the world's ever-increasing demand for hydrocarbon fuel, thermal energy, and waste and pollution management.

Graduates of our program are in solid demand, with the petroleum industry offering a wide range of employment opportunities for Petroleum Engineering students during summer breaks and after graduation. Exciting experiences range from field work in drilling and producing oil and gas fields, to office jobs in small towns or large cities. Worldwide travel and overseas assignments are available for interested students.

One of our objectives in the Petroleum Engineering department is to prepare students to succeed in an energy industry that is evolving into an industry working with many energy sources. In addition to developing technical competence in petroleum engineering, you will learn how your education can help you contribute to the development of alternative energy sources such as geothermal and carbon sequestration. Alternative careers exist outside of the petroleum industry too and many petroleum engineering graduates find rewarding careers in the environmental arena, law, medicine, business, and many other walks of life.

The department offers semester abroad opportunities through formal exchange programs with the Petroleum Engineering Department at the Montanuniversität Leoben in Austria, Technical University in Delft, Holland, King Fahd University of Petroleum Minerals (KFUPM) in Dhahran, Saudi Arabia and the Petroleum Institute in Abu Dhabi, UAE. Qualified undergraduate and graduate students from each school can attend the other for one semester and receive full transfer credit back at the home university.

The Bachelor of Science in Petroleum Engineering is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org/, under the commission’s General Criteria and Program Criteria for Petroleum Engineering.

Graduate courses emphasize the research aspects of the profession, as well as advanced engineering applications. Qualified students may continue their education and earn a Master of Science, Master of Engineering, and Doctor of Philosophy degrees.

To facilitate classroom instruction and the learning experience, the Petroleum Engineering faculty recommend that all petroleum engineering students have notebook computers. Recommended specifications for the computer can be obtained from the CSM Academic Computing & Networking webpage.

The Petroleum Engineering Department encourages student involvement with the Society of Petroleum Engineers, the American Association of Drilling Engineers, and the American Rock Mechanics Association. The department provides some financial support for students attending the annual technical conferences for these professional societies.

Marquez (pronounced "Marcus") Hall is home to the Petroleum Engineering Department. A prominent campus landmark, Marquez Hall showcases Mines’ long-standing strengths in its core focus areas and our commitment to staying at the forefront of innovation. The building is designed using aggressive energy saving strategies and is LEED certified. Marquez Hall is the first building on the Colorado School of Mines Campus that is funded entirely by private donations.

Available laboratory and computer equipment include:

Computer Laboratory

This computer laboratory is available for general use and classroom instruction. It is continuously open for student use. Software includes more than $5 million in donated industry software used by oil and gas companies and research labs around the world.

Drilling Simulator Laboratory

Rare on university campuses, this lab contains an up-to-date computer controlled, full-scale, graphic-intensive drilling rig simulator. It includes drilling controls that can be used to simulate onshore and offshore drilling operations and well control situations. This lab also has three small-scale drilling rig simulators, identical to those used in industrial well control training facilities.

Reservoir Characterization Laboratory

Rock properties are measured that affect economic development of reservoir resources of oil and gas. Measured properties include permeability, porosity, and relative permeability. Hands on experiences with simple and sophisticated equipment are provided.

Drilling Fluids Laboratory

Modern equipment found on drilling rigs worldwide enables students to evaluate and design fluid systems required in drilling operations.

Fluids Characterization Laboratory

A variety of properties of fluids from oil and gas reservoirs are measured for realistic conditions of elevated temperature and pressure. This laboratory accentuates principles studied in lectures.

Petroleum Engineering Summer Sessions

Two summer sessions, one after the completion of the sophomore year and one after the junior year, are important parts of the educational experience. The first is a session designed to introduce the student to the petroleum industry. Various career opportunities are highlighted as well as showing petroleum field and office operations and geology. In addition, students are indoctrinated in health, safety, and environmental awareness. Petroleum Engineering, a truly unique and exciting engineering discipline, can be experienced by visiting petroleum operations. Historically, the areas visited have included Europe, Alaska, Canada, the U.S. Gulf Coast, California, the Midcontinent, the northeast U.S., and the Rocky Mountain Region.

The second two-week session after the junior year is an in-depth study of the Rangely Oil Field and surrounding geology in Western Colorado. The Rangely Oil Field is the largest oil field in the Rocky Mountain region and has undergone primary, secondary, and enhanced recovery processes. Field work in the area provides the setting for understanding the complexity of geologic systems and the environmental and safety issues in the context of reservoir development and management.

Other Opportunities

It is recommended that all students considering majoring or minoring in Petroleum Engineering sign up for the Introductory course PEGN201,

Petroleum Engineering Fundamentals, as soon as possible in their schedules. Also, seniors may take 500-level graduate courses that include topics such as drilling, reservoir, and production engineering; reservoir simulation and characterization, and economics and risk analysis with instructor concurrence (see the CSM Graduate Catalog for course offerings).

Program Educational Objectives (Bachelor of Science in Petroleum Engineering)

The Mission of the Petroleum Engineering program continues to evolve over time in response to the needs of the graduates and industry; in concert with the Colorado School of Mines Institutional Mission Statement and the Profile of the Future Graduate. The Mission of the Petroleum Engineering Program is:

Our mission is to provide the necessary skills at the undergraduate, graduate, and continuing education levels to serve the world in developing conventional and unconventional hydrocarbon resources, water resources, and geothermal energy, while promoting cutting-edge research to improve resource recovery, advancing technologies to combat environmental problems, such as carbon sequestration and other earth disposal processes, and to foster the socially responsible development of Earth's resources.

As part of that process, the faculty of the department has objectives that they want to see their alumni accomplish within three to five years from graduation. The Petroleum Engineering department's faculty and other constituents have affirmed the following Program Educational Objectives:

- Obtain an industry, government, or academic position in petroleum engineering, or a related field, or be pursuing a graduate education in petroleum engineering or in a related field.
- Demonstrate advancement in their chosen careers and exercising leadership in the area of petroleum engineering.
- Continue to develop personally and professionally, and serve others, through continuing education, professional societies, educational institutions, community groups, and other organizations.
- Identify the ethical implications and social impacts of engineering decisions.

To accomplish these objectives, the Petroleum Engineering program has, in addition to the school's graduate profile and the overall objectives, certain student objectives particular to the department and based on the ABET Student Outcomes including:

- an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- an ability to communicate effectively with a range of audiences
- an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

These program educational objectives and student outcomes can be found on the Petroleum Engineering Department's webpage under the Colorado School of Mines website. These are also found publicly posted in the ABET bulletin board outside the department offices.

Curriculum

All disciplines within petroleum engineering are covered to great depth at the undergraduate and graduate levels, both in the classroom and laboratory instruction, and in research. Specific areas include fundamental fluid and rock behavior, drilling, formation evaluation, well completions and stimulation, well testing, production operations and artificial lift, reservoir engineering, supplemental and enhanced oil recovery, economic evaluation of petroleum projects, environmental and safety issues, and the computer simulation of most of these topics.

The Petroleum Engineering student studies mathematics, computer science, chemistry, physics, general engineering, geology, the humanities, technical communication (including researching subjects, report writing, oral presentations, and listening skills), and environmental topics. A unique aspect is the breadth and depth of the total program structured in a manner that prepares each graduate for a successful career from the standpoints of technical competence, managerial abilities, and multidisciplinary experiences. The needs for continued learning and professionalism are stressed.

The strength of the program comes from the high quality of students and professors. The faculty has expertise in teaching and research in all the major areas of petroleum engineering listed above. Additionally, many of the faculty members have significant industrial backgrounds that lead to meaningful design experiences for the students. Engineering design is taught throughout the curriculum including a senior design course on applying the learned skills to real world reservoir development and management problems.

The department is constantly updating the instructional facilities and equipment for laboratory instruction and experimental research. To maintain leadership in future petroleum engineering technology, decision making, and management, computers are incorporated into every part of the program, from undergraduate instruction through graduate student and faculty research.

The department is close to oil and gas field operations, petroleum companies, research laboratories, and geologic out-crops of nearby producing formations. There are many opportunities for short field trips and for summer and part-time employment in the oil and gas industry.

Degree Requirements (Petroleum Engineering)

Freshman				
Fall		**lec**	**lab**	**sem.hrs**
CSM101	FRESHMAN SUCCESS SEMINAR			1.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS			4.0

MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
HASS100	NATURE AND HUMAN VALUES			3.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
PHGN100	PHYSICS I - MECHANICS			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125			4.0
CSCI128	COMPUTER SCIENCE FOR STEM			3.0
CSM202	INTRODUCTION TO STUDENT WELL-BEING AT MINES			1.0
				16.0

Sophomore

Fall		**lec**	**lab**	**sem.hrs**
CEEN241	STATICS			3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS			4.0
PEGN201	PETROLEUM ENGINEERING FUNDAMENTALS			3.0
EDNS151	CORNERSTONE - DESIGN I			3.0
				17.0
Spring		**lec**	**lab**	**sem.hrs**
PEGN251	FLUID MECHANICS			3.0
PEGN308	RESERVOIR ROCK PROPERTIES			3.0
PEGN282	PROFESSIONAL SKILLS 1			1.0
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
HASS200	GLOBAL STUDIES			3.0
EBGN321	ENGINEERING ECONOMICS*For the 2023 Catalog EBGN321 replaced EBGN201 as a Core requirement. EBGN321 was added to the core, but has a prerequisite of 60 credit hours. Students whose programs that required EBGN201 the sophomore year may need to wait to take EBGN321 until their junior year. For complete details, please visit: https://www.mines.edu/registrar/core-curriculum/			3.0
				16.0
Summer		**lec**	**lab**	**sem.hrs**
PEGN315	SUMMER FIELD SESSION I		1.0	1.0
				1.0

Junior

Fall		**lec**	**lab**	**sem.hrs**
PEGN311	DRILLING ENGINEERING			3.0
PEGN312	PROPERTIES OF PETROLEUM ENGINEERING FLUIDS			3.0
PEGN382	PROFESSIONAL SKILLS 2			1.0
GEOL315	SEDIMENTOLOGY AND STRATIGRAPHY			3.0
CEEN311	MECHANICS OF MATERIALS			3.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
				16.0
Spring		**lec**	**lab**	**sem.hrs**
PEGN361	COMPLETION ENGINEERING			3.0
PEGN411	MECHANICS OF PETROLEUM PRODUCTION			3.0
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION			3.0
PEGN438	PETROLEUM DATA ANALYTICS			3.0
PEGN482	PROFESSIONAL SKILLS 3			1.0
GEOL308	INTRODUCTORY APPLIED STRUCTURAL GEOLOGY			3.0
S&W	SUCCESS AND WELLNESS			1.0
				17.0
Summer		**lec**	**lab**	**sem.hrs**
PEGN316	SUMMER FIELD SESSION II		2.0	2.0
				2.0

Senior

Fall		**lec**	**lab**	**sem.hrs**
PEGN423	PETROLEUM RESERVOIR ENGINEERING I			3.0
PEGN422	ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS			3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective			3.0
FREE	Free Elective			6.0
				15.0
Spring		**lec**	**lab**	**sem.hrs**
PEGN424	PETROLEUM RESERVOIR ENGINEERING II			3.0
PEGN426	FORMATION DAMAGE AND STIMULATION			3.0
PEGN439	MULTIDISCIPLINARY PETROLEUM DESIGN			3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) 400-Level Restricted Elective			3.0

ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective	3.0
		15.0

Total Semester Hrs: 131.0

Major GPA

During the 2016-2017 academic year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- PEGN100 through PEGN599 inclusive

Five-Year Combined Baccalaureate and Master's Degree

The Petroleum Engineering Department offers the opportunity to begin work on a Master of Engineering or Master of Science Degree while completing the requirements for the bachelor's Degree. These degrees are of special interest to those planning on studying abroad or wanting to get a head start on graduate education.

Students enrolled in Mines' combined undergraduate/graduate program may double count up to six credits of graduate coursework to fulfill requirements of both their undergraduate and graduate degree programs. These courses must have been passed with "B-" or better, not be substitutes for required coursework, and meet all other University, Department, and Program requirements for graduate credit.

Students are advised to consult with their undergraduate and graduate advisors for appropriate courses to double count upon admission to the combined program.

The Petroleum Engineering Department offers the following minor programs:

1. Petroleum Engineering
2. Petroleum Data Analytics

Petroleum Engineering Minor

The PE Department tailors the student's minor to correlate with their interests in the petroleum industry. There are several paths students can take according to their interests. The core set of required courses for a PE minor are as follows:

PEGN201	PETROLEUM ENGINEERING FUNDAMENTALS	3.0
PEGN308	RESERVOIR ROCK PROPERTIES	3.0

The remaining 12 credits can be satisfied by any combination of PEGN courses. Students must consult with the Department to have their sequence of courses approved before embarking on a minor program.

Minor in Petroleum Data Analytics

Program Advisor: Serveh Kamrava

The purpose of this minor is to enhance data analysis skills and to show potential opportunities of data, give students the skill set to manage and analyze the data and use their knowledge of petroleum engineering to make petroleum resource acquisition more economical, safe, and environmentally sound.

Objectives:
By the end of the minor program, students will be able to:
• Collect and pre-process typical petroleum data and to rearrange for use in analysis
• Apply standard probability and statistics methodology to various data constructs
• Analyze data to determine which various regression and prediction techniques would be applicable and to use that analysis process
• To build system algorithms for data information insight
• Use various data analytics analysis and visualization software for the petroleum industry

Minor Requirements

To obtain a Petroleum Data Analytics Minor, students must take a minimum of 18 credits related to Data Analytics. Seven courses (18 credits) are required, which includes one 3-credit course from a list of technical electives. Petroleum Engineering students can use any of their free elective classes and take PEGN438 as part of the normal PEGN credit requirements. See CSM minor requirements here. Students should begin their classes for this minor by the fall semester of their junior year in order to graduate in four years.

Prerequisite classes

The following classes are required before the students can take Petroleum Data Analytics Minor:
• MATH112. CALCULUS FOR SCIENTISTS AND ENGINEERS II or

• MATH122. CALCULUS FOR SCIENTISTS AND ENGINEERS II HONORS

• EBGN201. PRINCIPLES OF ECONOMICS

Required Courses (18 credits)

Required Courses		
MATH201	INTRODUCTION TO STATISTICS	3.0
CSCI128	COMPUTER SCIENCE FOR STEM	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
PEGN440	INTRODUCTION TO THE DIGITAL OILFIELD	3.0
Required PE Major Courses		
PEGN438	PETROLEUM DATA ANALYTICS	3.0
Choose one Technical Elective - All 3-credit courses		
EBGN461	STOCHASTIC MODELS IN MANAGEMENT SCIENCE	3.0
GEGN475	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0

Courses

PEGN198. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only

once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

PEGN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

PEGN201. PETROLEUM ENGINEERING FUNDAMENTALS. 3.0 Semester Hrs.
This course provides an introduction to the oil and gas industry and the various areas associated with petroleum engineering. Topics covered include exploration, development, drilling, production, stimulation, reservoir management, processing, transportation, engineering ethics and professionalism. This course is required for petroleum engineering majors and is open to those interested in petroleum engineering as a minor, and for any other interested students.
Course Learning Outcomes

- Distinguish the fundamental segments of the petroleum project life cycle: acquisition, exploration, exploitation, development, and abandonment/decommissioning and the oil and gas industry components of upstream, midstream and downstream.
- Distinguish the areas of drilling, completion, production, and reservoir and relate them to each other.
- Practice using petroleum engineering language derived from testing data, engineering drawings, specifications and other technical information.
- Analyze equitable and ethical working conditions for all personnel in the field of petroleum engineering.
- Analyze issues of health, safety, environment, social responsibility, economics, and sustainability as applied to the oil and gas industry.

PEGN251. FLUID MECHANICS. 3.0 Semester Hrs.
Introductory and fundamental course in engineering fluid flow. Properties of fluids and fluid flow, fluid statics, mass and momentum balance, differential equations, dimensional analysis, laminar and turbulent flow in pipes, and two-phase flow. Lecture format with demonstrations and practical problem solving. May not also receive credit for MEGN351 or CEEN310. Prerequisite: CEEN241.
Course Learning Outcomes

- No change

PEGN282. PROFESSIONAL SKILLS 1. 1.0 Semester Hr.
This course is the first in a three-course series designed for petroleum engineering students to develop skills in oral and written communication, professionalism, diversity and ethics. The course is designed as a discussion based seminar course and will focus on critical thinking and problem solving. Assignments will be based on technical and non-technical material relating to earth, energy, and the environment. Students will work individually and in multicultural teams on assignments throughout the semester.
Course Learning Outcomes

- Develop critical thinking skills around topics of earth, energy, and environment
- Demonstrate critical reading skills in field specific research and technical reports
- Work effectively in multicultural teams
- Analyze issues of health, safety, environment, social responsibility and sustainability as applied to the oil and gas industry.

PEGN298. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

PEGN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

PEGN305. COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING. 2.0 Semester Hrs.
This course is an introduction to computers and computer programming applied to petroleum engineering. Emphasis will be on learning Visual Basic programming techniques to solve engineering problems. A toolbox of fluid property and numerical techniques will be developed. 2 hours lecture; 2 semester hours. Prerequisite: MATH213.
Course Learning Outcomes

- same

PEGN308. RESERVOIR ROCK PROPERTIES. 3.0 Semester Hrs.
(WI) Introduction to basic reservoir rock properties and their measurements. Topics covered include: porosity, saturations, volumetric equations, land descriptions, trapping mechanism, pressure and temperature gradient, abnormally pressured reservoirs. Darcy's law for linear horizontal and tilted flow, radial flow for single phase liquids and gases, multiphase flow (relative permeability). Capillary pressure and formation compressibility are also discussed. Co-requisites: CEEN241, PEGN251, PEGN201. 2 hours lecture; 3 hours lab; 3 semester hours.
Course Learning Outcomes

- same

PEGN311. DRILLING ENGINEERING. 3.0 Semester Hrs.
Study of drilling operations, rig equipment and procedures, wellbore construction processes and planning, drilling fluid design, hydraulics, well control, bit selection and drill string design, directional drilling, and completion equipment. Prerequisite: PEGN251 with a grade of C or higher, PEGN315, CEEN241. Co-requisite: PEGN305.
Course Learning Outcomes

- same

PEGN312. PROPERTIES OF PETROLEUM ENGINEERING FLUIDS. 3.0 Semester Hrs.
(WI) Properties of fluids encountered in petroleum engineering including reservoir, drilling, and completion fluids, and oilfield waters. Phase behavior, density, viscosity, interfacial tension, and composition of oil, gas, and brine systems. Interpreting lab data for engineering applications. Flash calculations with k-values and equation of state. Introduction to fluid properties software. Laboratory experimentation of fluid properties. Prerequisites: PEGN308 (C or better), CHGN209 (C or better). 2 hours lecture; 3 hours lab; 3 semester hours.
Course Learning Outcomes

- 1. Use the IUPAC rule to name alkane, alkene, alkyne and cycloaliphatic hydrocarbons.
- 2. Use phase diagrams of pure substances and mixtures to calculate physical properties of gases and liquids.
- 3. Use equations of state for ideal and real gases to calculate relationships between volume, pressure and temperature of a gas.
- 4. Describe the five types of reservoir fluids: black oils, volatile oils, retrograde gases, dry gas, and wet gas.
- 5. Use laboratory analysis to identify reservoir fluid type.
- 6. Estimate values of dry and wet gas properties using correlations.
- 7. Describe physical properties of black oils (formation volumes factor, solution gas-oil ratio, total formation volume factor, coefficient of isothermal compressibility, and oil viscosity).
- 8. Identify physical properties of black oils from a reservoir fluid study.
- 9. Apply black oil correlations to determine physical properties.
- 10. Describe properties of oilfield waters
- 11. Analyze the conditions of hydrate formation.
- 12. Conduct and design laboratory experiments related to fluid properties; analyze results and interpret data.

PEGN315. SUMMER FIELD SESSION I. 1.0 Semester Hr.
This 8 day course taken after the completion of the sophomore year is designed to introduce the student to oil and gas field and other engineering operations. Engineering design problems are integrated throughout the 8 day session. On-site visits to various oil field operations in the past included the Rocky Mountain region, the U.S. Gulf Coast, California, Alaska, Canada and Europe. Topics covered include drilling, completions, stimulations, surface facilities, production, artificial lift, reservoir, geology and geophysics. Also included are environmental and safety issues as related to the petroleum industry. 3 hours lab; 1 semester hour. Prerequisite: PEGN308 (grade C or better).
Course Learning Outcomes

- n/a

PEGN316. SUMMER FIELD SESSION II. 2.0 Semester Hrs.
This two week course is taken after the completion of the junior year. Emphasis is placed on the multidisciplinary nature of reservoir management. Field trips in the area provide the opportunity to study eolian, fluvial, lacustrine, near shore, and marine depositional systems. These field trips provide the setting for understanding the complexity of each system in the context of reservoir development and management. Petroleum systems including the source, maturity, and trapping of hydrocarbons are studied in the context of petroleum exploration and development. Geologic methods incorporating both surface and subsurface data are used extensively. 6 hours lab; 2 semester hours. Prerequisite: PEGN315, PEGN419, GEOL308, and GEOL315.
Course Learning Outcomes

- same

PEGN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

PEGN350. GEOTHERMAL ENERGY. 3.0 Semester Hrs.
Students will learn geothermal energy resources and their utilization based on geoscience and engineering perspectives. Geoscience topics include world distribution of geothermal resources and their classification, heat and mass transfer, geothermal reservoirs, hydrothermal geochemistry, exploration methods, and resource assessment. Engineering topics include thermodynamics of geothermal fluids, power cycles, electricity generation, drilling and well measurements, reservoir-surface engineering, and direct utilization. Economic and environmental considerations and case studies on social acceptance with community are also presented.

PEGN361. COMPLETION ENGINEERING. 3.0 Semester Hrs.
(WI) This class is a continuation from drilling in PEGN311 into completion operations. Topics include casing design, cement planning, completion techniques and equipment, tubing design, wellhead selection, and sand control, and perforation procedures. 3 hours lecture; 3 semester hours. Prerequisite: PEGN311 and CEEN311.
Course Learning Outcomes

- Unchanged

PEGN382. PROFESSIONAL SKILLS 2. 1.0 Semester Hr.
This course is the second in a three-course series designed for petroleum engineering students to develop skills in oral and written communication, professionalism, diversity and ethics. The course is designed as a discussion based seminar course and will focus on oral and written communication skills. Assignments will be based on technical and non-technical material relating to earth, energy, and the environment. Students will work individually and in multicultural teams on assignments throughout the semester. Prerequisite: PEGN282.
Course Learning Outcomes

- Practice using petroleum engineering language derived from testing data, engineering drawings, specifications and other technical information.
- Write and present technical reports for engineering and management personnel using petroleum engineering terminology.
- Collaborate with multicultural team members to solve operational problems in petroleum engineering.

PEGN398. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

PEGN399. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

PEGN411. MECHANICS OF PETROLEUM PRODUCTION. 3.0 Semester Hrs.
Nodal analysis for pipe and formation deliverability including single and multiphase flow. Natural flow and design of artificial lift methods including gas lift, sucker rod pumps, electrical submersible pumps, and hydraulic pumps. 3 hours lecture; 3 semester hours. Prerequisite: PEGN251, PEGN308 (grade of C or better), PEGN311, and PEGN312.
Course Learning Outcomes

- same

PEGN414. WELL TESTING AND ANALYSIS. 3.0 Semester Hrs.
Solution to the diffusivity equation. Transient well testing: build-up, drawdown, multi-rate test analysis for oil and gas. Flow tests and well deliverabilities. Type curve analysis. Super position, active and interference tests. Well test design. Prerequisites: MATH225 and PEGN419. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- No change

PEGN419. WELL LOG ANALYSIS AND FORMATION EVALUATION. 3.0 Semester Hrs.
Equivalent with GPGN419,
(II) An introduction to well logging methods, including the relationship between measured properties and reservoir properties. Analysis of log suites for reservoir size and content. Graphical and analytical methods will be developed to allow the student to better visualize the reservoir, its contents, and its potential for production. Use of the computer as a tool to handle data, create graphs and log traces, and make computations of reservoir parameters is required. Prerequisites: GEOL315, PHGN 200 (grade of C or better). 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- Learn basic petrophysics in open hole logs
- Understand theoretical fundamentals of logs
- Ability to calculate and interpret petrophysical properties
- Ability to interpret well logs

PEGN422. ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS. 3.0 Semester Hrs.
Project economics for oil and gas projects under conditions of certainty and uncertainty. Topics include time value of money concepts, discount rate assumptions, measures of project profitability, costs, taxes, expected value concept, decision trees, gambler?s ruin, and Monte Carlo simulation techniques. 3 hours lecture; 3 semester hours.

PEGN423. PETROLEUM RESERVOIR ENGINEERING I. 3.0 Semester Hrs.
Data requirements for reservoir engineering studies. Material balance calculations for normal gas, retrograde gas condensate, solution-gas and gas-cap reservoirs with or without water drive. Primary reservoir performance. Forecasting future recoveries by incremental material balance. 3 hours lecture; 3 semester hours. Prerequisite: PEGN419, PEGN316 and MATH 225 or MATH235.
Course Learning Outcomes

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PEGN424. PETROLEUM RESERVOIR ENGINEERING II. 3.0 Semester Hrs.
Reservoir engineering aspects of supplemental recovery processes. Introduction to liquid-liquid displacement processes, gas-liquid displacement processes, and thermal recovery processes. Introduction to numerical reservoir simula tion, history matching and forecasting. Prerequisite: PEGN423 and PEGN438. 3 hours lecture; 3 semester hours.

PEGN426. FORMATION DAMAGE AND STIMULATION. 3.0 Semester Hrs.
Skin damage associated with formation damage, well deviation, and perforating. Formation damage mechanisms and causes. Stimulation techniques, including acidizing and fracturing. Calculation of matrix and fracturing rates and pressures. Design of matrix acidizing treatments. Selection/determination of hydraulic fracturing components including rock mechanical properties, in-situ stresses, proppants, fluid types, and diversion. Reservoir considerations in fracture propagation and design. Stimulation diagnostics and their application. Prerequisite: PEGN361 and PEGN411.
Course Learning Outcomes

- unchanged

PEGN428. ADVANCED DRILLING ENGINEERING. 3.0 Semester Hrs.
Rotary drilling systems with emphasis on design of drilling programs, directional and horizontal well planning. This elective course is recommended for petroleum engineering majors interested in drilling. Prerequisite: PEGN311, PEGN361. 3 hours lecture; 3 semester hours.

PEGN430. ENVIRONMENTAL LAW AND SUSTAINABILITY. 3.0 Semester Hrs.
(WI) In this course students will be introduced to the fundamental legal principles that are relevant to sustainable engineering project development. General principles of United States (U.S.) environmental regulation pertaining to air quality, water quality, waste management, hazardous substances remediation, regulation of chemical manufacture and distribution, natural resources, and energy will be discussed in parallel with international laws pertaining to environmental protection and human rights. In the context of engineering project design, students will explore legal, societal, and ethical risks, and risk mitigation methodologies. 3 hours lecture; 3 semester hours. Prerequisites: HASS100. Corequisites: HASS200.
Course Learning Outcomes

- Demonstrate knowledge and understanding, verbally and in writing, of domestic and international environmental law and applicable administrative and judicial procedure.
- Write persuasively and effectively through a variety of formal and informal writing exercises and independent research of environmental law, social responsibility, and sustainability issues.
- Apply knowledge of environmental law, social responsibility, and sustainability in the design and implementation of a team project that promotes just and sustainable engineering solutions.

PEGN438. PETROLEUM DATA ANALYTICS. 3.0 Semester Hrs.
Introduction to elementary probability theory and its applications in engineering and sciences; discrete and continuous probability distributions; parameter estimation; hypothesis testing; linear regression; spatial correlations and geostatistics with emphasis on applications in earth sciences and engineering. 2 hours lecture; 3 hours lab; 3 semester hours. Prerequisite: MATH112 and CSCI128.
Course Learning Outcomes

- unchanged

PEGN439. MULTIDISCIPLINARY PETROLEUM DESIGN. 3.0 Semester Hrs.
Equivalent with GEGN439,GPGN439,
(WI) This is a multi-disciplinary design course that integrates fundamentals and design concepts in geology, geophysics, and petroleum engineering. Students work in integrated teams consisting of students from each of the disciplines. Multiple open-ended design problems in oil and gas exploration and field development, including the development of a prospect in an exploration play and a detailed engineering field study are assigned. Several detailed written and oral presentations are made throughout the semester. Project economics

including risk analysis are an integral part of the course. Prerequisites: GEOL308, PEGN316. Co-requisites: PEGN426. 2 hours lecture, 3 hours lab; 3 semester hours.

Course Learning Outcomes

- same

PEGN440. INTRODUCTION TO THE DIGITAL OILFIELD. 3.0 Semester Hrs.

Capstone course for Petroleum Data Analytics minor. The course starts with an introduction to data analysis and visualization packages. The course then has three projects to include drilling, production, and reservoir data analysis along with data visualization techniques. The student will be required to prepare both oral and written and oral project updates and final results. Prerequisite: PEGN438.

Course Learning Outcomes

- Prepare and analyze data from various petroleum data streams including drilling, completions, stimulation, production, and reservoir management.
- Design petroleum engineering projects that satisfy relevant technical, professional, and societal constraints. These projects will incorporate other associated disciplines and will require Use industry analytical graphical software.
- Apply statistical methods to derive insights into petroleum data sets.
- Interpret petroleum data and derive useful conclusions.
- Independent research (prior knowledge, skills attained in previous courses, original ideas, etc.)
- Build a project business plan. Plan will apply project management skills (schedule, budget, tasks, deliverables, resource utilization, internal milestones, Gantt charts, people, and other available tools)
- Demonstrate professionalism through attendance, demeanor, participation, exhibiting integrity, accepting responsibility, taking initiative, team participation and providing leadership as necessary to ensure project success.
- Create formal and informal communications for individual, team, and industry/company use that document and facilitate progress and enhance the impact of the final design.

PEGN450. ENERGY ENGINEERING. 3.0 Semester Hrs.

Energy Engineering is an overview of energy sources that will be available for use in the 21st century. After discussing the history of energy and its contribution to society, we survey the science and technology of energy, including geothermal energy, fossil energy, solar energy, nuclear energy, wind energy, hydro energy, bio energy, energy and the environment, energy and economics, the hydrogen economy, and energy forecasts. This broad background will give you additional flexibility during your career and help you thrive in an energy industry that is evolving from an industry dominated by fossil fuels to an industry working with many energy sources. Prerequisite: MATH213, PHGN200. 3 hours lecture; 3 semester hours.

PEGN460. FLOW IN PIPE NETWORKS. 3.0 Semester Hrs.

This course will provide an introduction to single and two phase hydraulics phenomena and modeling approaches to calculate pressure/temperature profile, losses along and flow rates along a production system. Furthermore, topics related to pipeline flow control and maintenance such as leak detection, damage prevention, integrity and pipe repairs will be covered. Finally, Federal Pipeline Safety Regulations and Health, Safety, and the Environment (HSE) regulations for the transportation of gas and hazardous liquids by pipeline will be discussed. In addition, this course will provide an introduction in transient theoretical modeling and design applications. OLGA transient multiphase flow simulator will be introduced and used to complete homework and final project. Industrial practices and operational problem related to transient production design will be covered. Prerequisites: PEGN251, CHGN209 , MATH225, and PEGN305. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- 1.Estimate local rates, pressure and temperature drops on individual sections of a given pipeline network for single and two-phase flow system under steady state condition.
- 2. Apply required criteria to select required pipe specifications.
- 3. Establish understanding about flow control and pipeline maintenance.
- 4. Understand HSE regulations to transport gas and hazardous liquids.
- 4.Understand and evaluate different transient flow conditions existing in the oil and natural gas industry.
- 5. Use prediction tools to identify and mitigate transient conditions and flow assurance problems for a given production system.
- 6. Provide solutions to eliminate, mitigate or remediate operational problems in a production system.

PEGN461. SURFACE FACILITIES DESIGN AND OPERATION. 3.0 Semester Hrs.

This course will cover surface facilities typically required in the oil and gas industry. The course provides basic operation, design and evaluation of individual equipment such as Control equipment (control valve, pressure/level/flow rate/temperature), Liquid/gas Separators, Flowmeters, Boosting Equipment (pumps, compressors), Heaters, and Storage. Basic principles are described to design and evaluate different midstream processes such as Oil/water treating, Gas/liquid and liquid/liquid separation, Crude oil stabilization, Gas handling facilities, Dehydration, Gas Sweetening, Liquefied Natural Gas (LNG), Gas to Liquids (GTL). Furthermore, potential operation problems and piping and instrumentation diagram/drawing (P&ID) related to this processes will be discussed. Calculation examples and a design project can be given to integrate all acquired knowledge. Furthermore, ASME and API norms related to material selection, equipment selection, operation and maintenance will be discussed. Finally, Health, Safety, and the Environment (HSE) regulations for midstream operations will be discussed. Course objectives include learning how to select and operate different surface equipment required in the oil and natural gas industry, learning how to monitor, troubleshoot and optimize the operation of different surface equipment required in the oil and natural gas industry. Prerequisites: PEGN251, CHGN209, MATH225, PEGN305. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- 1. Select different surface equipment, typically required for oil and natural gas production, treatment and transportation, based on expected operating conditions.
- 2. Monitor, troubleshoot and optimize the operation of different surface equipment required in the oil and natural gas industry.
- 3.Design oil, water and gas handling facilities based on the expected operation requirements.

PEGN462. FLOW ASSURANCE. 3.0 Semester Hrs.

This course will cover hydrocarbon production including design and operational issues. Major subjects to be covered include the prediction of hydrates formation, paraffin, asphaltene, scale and sand deposition, and remedial actions. In addition, operational problems such as slugging,

emulsions and corrosion will be covered. This course will provide to student's strong background on hydraulic modeling. Prerequisites: PEGN251, CHGN209, MATH225, and PEGN305. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- The student outcome are the abilities to understand and evaluate different flow assurance problems existing in the oil and natural gas industry. Furthermore, use prediction tools to identify flow assurance problems for a given production system; provide solutions to eliminate, mitigate or remediate flow assurance problems encountered in production systems.

PEGN463. PETROLEUM MIDSTREAM DESIGN. 3.0 Semester Hrs.
This course will cover the development of an integrated project in the midstream area. In this the students will integrate the knowledge from the midstream classes to solve a given problem with consideration of social responsibility and societal impacts. The objective is to work with several companies from the midstream sector to solve field problems. Furthermore, in this class, we will have some classes to cover more specific subjects with different presenters (i.e. safety, regulations, marketing, environment, new technologies for pipe repairs or inspections, software, process to sell/buy oil, etc), field visits, etc. 3 hours lecture; 3 semester hours. Prerequisite: PEGN460, PEGN461, PEGN462. Co-requisite: PEGN460.

Course Learning Outcomes

- TBD

PEGN481. PETROLEUM SEMINAR. 2.0 Semester Hrs.
(I) (WI) Written and oral presentations by each student on current energy topics. This course is designated as a writing intensive course (WI). Prerequisite: none. 2 hours lecture; 2 semester hours.

PEGN482. PROFESSIONAL SKILLS 3. 1.0 Semester Hr.
This course is the third in a three-course series designed for petroleum engineering students to develop skills in oral and written communication, professionalism, diversity and ethics. The course is designed as a discussion based seminar course and will focus on oral and written communication skills, professionalism, diversity and ethics. Assignments will be based on technical and non-technical material relating to earth, energy, and the environment. Students will work individually and in multicultural teams on assignments throughout the semester. Prerequisite: PEGN382.

Course Learning Outcomes

- Adapt communications to various audiences and stakeholders (e.g., managers, community members, regulators, technicians).
- Design equitable and ethical working conditions for all personnel in the field and implement diversity strategies for a common goal.
- Write a professional and/or technical paper or report and present to various stakeholders.

PEGN490. RESERVOIR GEOMECHANICS. 3.0 Semester Hrs.
The course provides an introduction to fundamental rock mechanics and aims to emphasize their role in oil and gas exploration, drilling, completion and production engineering operations. Deformation as a function of stress, elastic moduli, in situ stress, stress magnitude and orientation, pore pressure, strength and fracture gradient, rock characteristic from field data (seismic, logging, drilling, production), integrated wellbore stability analysis, depletion and drilling induced fractures, compaction and associated changes in rock properties, hydraulic fracturing and fracture stability are among the topics to be covered. Pre-requisites: CEEN311. 3 hours lecture; 3 hours lab, 3 semester hours.

PEGN498. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

PEGN499. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Professors

Hossein Kazemi, Chesebro' Distinguished Chair

Jennifer L. Miskimins, Department Head, F.H. "Mick" Merelli/Cimarex Energy Distinguished Department Head

Erdal Ozkan

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