

# Petroleum Engineering

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## 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. 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, the University of Adelaide, Adelaide, Australia, 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 program leading to the degree of Bachelor of Science in Petroleum Engineering is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

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 web site.

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.

In the fall of 2012, the new Petroleum Engineering building, Marquez (pronounced "Marcus") Hall, was opened. The new home for the Petroleum Engineering Department is a prominent campus landmark, showcasing Mines' longstanding strengths in its core focus areas and our commitment to staying at the forefront of innovation. The new 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.

New laboratory and computer equipment added to Marquez Hall 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 \$5.0 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 world-wide 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 US, 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 elective course PEGN102, Introduction to the Petroleum Industry in the spring semester. 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.mines.edu/graduate/thegraduateschool](http://catalog.mines.edu/graduate/thegraduateschool)) 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; and in recognition of accreditation requirements specified by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. The Mission of the Petroleum Engineering Program is:

To educate engineers for the worldwide petroleum industry at the undergraduate and graduate levels, perform research that enhances the state-of-the-art in petroleum technology, and to serve the industry and public good through professional societies and public service. This mission is achieved through proactive leadership in providing a solid foundation for both the undergraduate and graduate programs. Students are well prepared for life-long learning, an international and diverse career, further education, and public service. The program emphasizes integrated and multi-disciplinary teamwork in classroom instruction and in research, and actively pursues interdisciplinary activities with many other CSM departments, particularly the Earth Science/Engineering programs.

As part of the that process, the faculty of the department has objectives that they want to see their alumni accomplish within three to five years from graduation. Therefore, the Petroleum Engineering Department's faculty has affirmed the following Program Educational Objectives as follows:

- Our Alumni will practice their professions in an ethical, social, and environmentally responsible manner.
- Our Alumni will serve society and individuals through professional societies, educational institutions, and governmental organizations.
- Our Alumni will have a high-level competency in engineering principles and practices.
- Our Alumni will pursue successful and diverse professional careers, or will continue education in the US or abroad.
- Our Alumni will work on multidisciplinary teams across multitude of cultures.
- Our Alumni will be effective communicators.

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. These include:

- A broad education, based on science, technology, engineering, and mathematics basics, effective communication skills, the skills necessary for diverse and international professional career, and the recognition of need and ability to engage in lifelong learning.
- A solid foundation in engineering principles and practices, based upon the Society of Petroleum Engineer's ABET Guidelines, a strong petroleum engineering department faculty with diverse backgrounds, and various technical seminars, field trips, and our field sessions.
- Applying problem solving skills, as demonstrated by designing and conducting experiments, analyzing and interpreting data, developing

problem solving skills in engineering practice by working real world problems.

- An understanding of ethical, social, environmental, and professional responsibilities as demonstrated by following established department and Colorado School of Mines honor codes, integrating ethical and environmental issues into real world problems, and developing an awareness of health and safety issues.
- And by developing multidisciplinary team skills, as demonstrated by the ability to integrate information and data from multiple sources and to enhance critical team skills sets.

These program objectives and student outcomes can be found on the Petroleum Engineering Department's website 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, 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 senior design course is truly multidisciplinary with students and professors from the Petroleum Engineering, Geophysics, and Geology and Geological Engineering departments.

As of August 2012 the program has new 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

		lec	lab sem.hrs	
<b>Fall</b>				
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS	3.0	3.0	4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
EDNS151	INTRODUCTION TO DESIGN			3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				16.0

		lec	lab sem.hrs	
<b>Spring</b>				
PHGN100	PHYSICS I - MECHANICS	3.5	3.0	4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125	3.0	3.0	4.0
HASS100	NATURE AND HUMAN VALUES			4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				17.0

### Sophomore

		lec	lab sem.hrs	
<b>Fall</b>				
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
EDNS251	THE PRACTICE OF DESIGN, 261, 262, 263, 264, CEEN 267, or GPGN 268			3.0
CEEN241	STATICS			3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				18.0

		lec	lab sem.hrs	
<b>Spring</b>				
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CEEN311	MECHANICS OF MATERIALS			3.0
PEGN251	FLUID MECHANICS	3.0		3.0
PEGN308	RESERVOIR ROCK PROPERTIES	2.0	3.0	3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
HASS200	GLOBAL STUDIES			3.0
				18.0

		lec	lab sem.hrs	
<b>Summer</b>				
PEGN315	SUMMER FIELD SESSION I	1.0		1.0
				1.0

		lec	lab sem.hrs	
<b>Junior</b>				
<b>Fall</b>				
GEOL315	SEDIMENTOLOGY AND STRATIGRAPHY	2.0	3.0	3.0
PEGN305	COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING	2.0		2.0
PEGN311	DRILLING ENGINEERING	3.0	3.0	4.0
PEGN312	PROPERTIES OF PETROLEUM ENGINEERING FLUIDS	2.0	3.0	3.0
HASS/EBGN	HASS Mid-Level Restricted Elective	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				15.5

		lec	lab sem.hrs	
<b>Spring</b>				
GEOL308	INTRODUCTORY APPLIED STRUCTURAL GEOLOGY	2.0	3.0	3.0
PEGN361	COMPLETION ENGINEERING	3.0		3.0
PEGN411	MECHANICS OF PETROLEUM PRODUCTION	3.0		3.0
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION	3.0		3.0
PEGN438	PETROLEUM DATA ANALYTICS	2.0	3.0	3.0
FREE	Free Elective	3.0		3.0
				18.0

		lec	lab sem.hrs	
<b>Summer</b>				
PEGN316	SUMMER FIELD SESSION II	2.0		2.0
				2.0

		lec	lab sem.hrs	
<b>Senior</b>				
<b>Fall</b>				
PEGN481	PETROLEUM SEMINAR	2.0		2.0
PEGN423	PETROLEUM RESERVOIR ENGINEERING I	3.0		3.0
PEGN414	WELL TESTING AND ANALYSIS	3.0		3.0
PEGN422	ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS	3.0		3.0
HASS/EBGN	HASS Mid-Level Restricted Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
				17.0

		lec	lab sem.hrs	
<b>Spring</b>				
PEGN424	PETROLEUM RESERVOIR ENGINEERING II	3.0		3.0
PEGN426	FORMATION DAMAGE AND STIMULATION	3.0		3.0
PEGN439	MULTIDISCIPLINARY PETROLEUM DESIGN	2.0	3.0	3.0
HASS/EBGN	HASS 400-Level Restricted Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
				15.0

Total Semester Hrs: 137.5

## 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 Masters 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. These combined programs are individualized and a plan of study should be discussed with the student's academic advisor any time after the Sophomore year.

The Petroleum Engineering Department offers the following minor programs:

1. Petroleum Engineering
2. Midstream Engineering
3. Petroleum Data Analytics

## Petroleum Engineering Minor

The PE department tailors the student's minor to correlate with their interests in the petroleum industry. For example, students majoring in mechanical, civil, and electrical engineering, the focus typically would be in operations. For students majoring in chemical engineering, geologists and geophysicists, the focus is typically in reservoir engineering. The choice is left to the student which area of interest they wish to follow.

For a minor in Petroleum Engineering, the student must complete a minimum of 18 credit hours from the following:

### Required Course:

PEGN308	RESERVOIR ROCK PROPERTIES	3.0
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### For a minor with an operations focus, 15 hours of the following:

PEGN102	INTRODUCTION TO PETROLEUM INDUSTRY	3.0
PEGN312	PROPERTIES OF PETROLEUM ENGINEERING FLUIDS	3.0
PEGN311	DRILLING ENGINEERING	4.0
PEGN361	COMPLETION ENGINEERING	3.0
PEGN411	MECHANICS OF PETROLEUM PRODUCTION	3.0
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION	3.0
PEGN426	FORMATION DAMAGE AND STIMULATION	3.0

### For a minor with a reservoir focus, 15 hours of the following:

PEGN102	INTRODUCTION TO PETROLEUM INDUSTRY	3.0
PEGN312	PROPERTIES OF PETROLEUM ENGINEERING FLUIDS	3.0
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION	3.0
PEGN423	PETROLEUM RESERVOIR ENGINEERING I	3.0

PEGN424	PETROLEUM RESERVOIR ENGINEERING II	3.0
PEGN414	WELL TESTING AND ANALYSIS	3.0
PEGN439	MULTIDISCIPLINARY PETROLEUM DESIGN	3.0

## Midstream Engineering Minor

**Program Advisor: Dr. Rosmer Brito**

This minor is available to all students that meet the minor requirements including Petroleum Engineering majors.

The petroleum industry Midstream area involves the transportation, storage, and marketing of crude oil, gas or refined products. Most of these products are transported through pipelines. Pipeline engineers design, construct, replace, repair, monitor and operate pipelines, pumps and gas compression stations.

The midstream sector provides an integral link between the upstream and downstream petroleum sectors. This in turn makes it possible for the end consumers to purchase the goods and utilize the services that they are dependent upon.

### Minor Requirements

To obtain a Midstream Engineering minor, students must take 18 credits related to Midstream Engineering. Six restricted courses (18 credits) are required. Petroleum Engineering students can use any of their elective classes to take the classes that this minor requires. See CSM minor requirements here (<http://bulletin.mines.edu/undergraduate/undergraduateinformation/minorasi>). Students should begin their classes for this minor in the spring semester of their junior year in order to graduate in four years.

### Pre-requisite classes

The following classes are required before the students can take midstream minor classes:

- CHGN209 Thermodynamics or Equivalent
- PEGN305 Computation Method, Equivalent class or Professor Approval
- MATH225 Differential Equations or Equivalent

### Required Courses (18 credit hours)

PEGN251	FLUID MECHANICS	3.0
PEGN312	PROPERTIES OF PETROLEUM ENGINEERING FLUIDS	3.0
PEGN460	FLOW IN PIPE NETWORKS	3.0
PEGN461	SURFACE FACILITIES DESIGN AND OPERATION	3.0
PEGN462	FLOW ASSURANCE	3.0
PEGN463	PETROLEUM MIDSTREAM DESIGN	3.0
Total Semester Hrs		18.0

## Minor in Petroleum Data Analytics

**Program Advisor: Dr. Alfred Eustes**

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. Six courses (18 credits) are required. Petroleum Engineering students can use any of their free elective classes and take their PEGN438 required course as part of the normal PEGN credit hour requirements. See CSM minor requirements here (<http://bulletin.mines.edu/undergraduate/undergraduateinformation/minorasi>). Students should begin their classes for this minor by the fall semester of their junior year in order to graduate in four years.

#### Pre-requisite 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 credit hours)

MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
CSCI261	PROGRAMMING CONCEPTS	3.0
EBGN325	OPERATIONS RESEARCH	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0
PEGN438	PETROLEUM DATA ANALYTICS	3.0
PEGN440	PETROLEUM DATA ANALYSIS	3.0

## Professors

Erdal Ozkan, Professor and Department Head, "Mick" Merelli/Cimarex Energy Distinguished Chair

Ramona M. Graves, Dean, College of Earth Resource Sciences and Engineering

Hossein Kazemi, Chesebro' Distinguished Chair

Azra N. Tutuncu, Harry D. Campbell Chair

Manika Prasad

Yu-Shu Wu, CMG Chair

## Associate Professors

Alfred W. Eustes III

Jennifer Miskimins

Jorge H. B. Sampaio Jr.

Xiaolong Yin

## Assistant Professors

Luis Zerpa

## Teaching Professor

Linda A. Battalora

## Teaching Associate Professors

Mansur Ermila

Carrie J. McClelland

Mark G. Miller

## Teaching Assistant Professor

Elio S. Dean

## Research Associate Professor

Philip H. Winterfeld

## Adjunct Professor

William W. Fleckenstein

## Professor Emeritus

Bill Scoggins , President Emeritus

Craig W. Van Kirk

## Associate Professor Emeritus

Richard Christiansen

## Courses

### PEGN102. INTRODUCTION TO PETROLEUM INDUSTRY. 3.0 Semester Hrs.

(II) A survey of the elements comprising the petroleum industry- exploration, development, processing, transportation, distribution, engineering ethics and professionalism. This elective course is recommended for all PE majors, minors, and other interested students. 3 hours lecture; 3 semester hours.

### 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.

**PEGN251. FLUID MECHANICS. 3.0 Semester Hrs.**

(I, II) Fundamental course in engineering fluid flow introducing flow in pipelines, surface facilities and oil and gas wells. Theory and application of incompressible and compressible flow, fluid statics, dimensional analysis, laminar and turbulent flow, Newtonian and non-Newtonian fluids, and two-phase flow. Lecture format with demonstrations and practical problem solving, coordinated with PEGN308. May not also receive credit for MEGN351 or CEEN310. Co-requisites: CEEN241. 3 hours lecture; 3 semester hours.

**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.**

(I) 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. Prerequisite: MATH213. 2 hours lecture; 2 semester hours.

**PEGN308. RESERVOIR ROCK PROPERTIES. 3.0 Semester Hrs.**

(I, II) (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. 2 hours lecture; 3 hours lab; 3 semester hours.

**PEGN311. DRILLING ENGINEERING. 4.0 Semester Hrs.**

(I) Study of drilling operations, fluid design, hydraulics, drilling contracts, rig selection, rotary system, well control, bit selection, drill string design, directional drilling, and casing seat selection. Prerequisites: PEGN251 (grade of C or higher), PEGN315, CEEN241. Co-requisites: PEGN305. 3 hours lecture; 3 hours lab; 4 semester hours.

**PEGN312. PROPERTIES OF PETROLEUM ENGINEERING FLUIDS. 3.0 Semester Hrs.**

(I) (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.

**PEGN315. SUMMER FIELD SESSION I. 1.0 Semester Hr.**

(S) 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. Prerequisite: PEGN308 (grade C or better). 3 hours lab; 1 semester hour.

**PEGN316. SUMMER FIELD SESSION II. 2.0 Semester Hrs.**

(S) 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. Prerequisites: PEGN315, PEGN419, GEOL308, and GEOL315. 6 hours lab; 2 semester hours.

**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. SUSTAINABLE ENERGY SYSTEMS. 3.0 Semester Hrs.**

(I or II) A sustainable energy system is a system that lets us meet present energy needs while preserving the ability of future generations to meet their needs. Sustainable Energy Systems introduces undergraduate students to sustainable energy systems that will be available in the 21st century. The course focuses on sustainable energy sources, especially renewable energy sources and nuclear energy (e.g., fusion). Students are introduced to the existing energy infrastructure, become familiar with finite energy sources, and learn from a study of energy supply and demand that sustainable energy systems are needed. The ability to improve energy use efficiency and the impact of energy sources on the environment are discussed. Examples of sustainable energy systems and their applicability to different energy sectors are presented. The course is recommended for students who plan to enter the energy industry or students who would like an introduction to sustainable energy systems. Prerequisites: EDNS151. 3 hours lecture; 3 semester hours.

**PEGN361. COMPLETION ENGINEERING. 3.0 Semester Hrs.**

(II) (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. Prerequisites: PEGN311, and CEEN311 or MEGN312. 3 hours lecture; 3 semester hours.

**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.**

(II) 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. Prerequisites: PEGN251, PEGN308 (grade of C or better), PEGN311, and PEGN312. 3 hours lecture; 3 semester hours.

**PEGN414. WELL TESTING AND ANALYSIS. 3.0 Semester Hrs.**

(I) 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.

**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.

**PEGN422. ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS. 3.0 Semester Hrs.**

(I) 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.**

(II) 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. Prerequisites: PEGN419 and (MATH225 or MATH235 or MATH222 only for non PE majors). 3 hours lecture; 3 semester hours.

**PEGN424. PETROLEUM RESERVOIR ENGINEERING II. 3.0 Semester Hrs.**

(II) 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 simulation, history matching and forecasting. Prerequisite: PEGN423 and PEGN438. 3 hours lecture; 3 semester hours.

**PEGN426. FORMATION DAMAGE AND STIMULATION. 3.0 Semester Hrs.**

(II) Completion parameters; design for well conditions. Skin damage associated with completions and well productivity. Fluid types and properties; characterizations of compatibilities. Stimulation techniques; acidizing and fracturing. Selection of proppants and fluids; types, placement and compatibilities. Estimation of rates, volumes and fracture dimensions. Reservoir considerations in fracture propagation and design. Prerequisite: PEGN361 and PEGN411. 3 hours lecture; 3 semester hours.

**PEGN428. ADVANCED DRILLING ENGINEERING. 3.0 Semester Hrs.**

(II) 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.**

(II) (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.

**PEGN438. PETROLEUM DATA ANALYTICS. 3.0 Semester Hrs.**

(II) 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. Prerequisites: MATH112. 2 hours lecture; 3 hours lab; 3 semester hours.

**PEGN439. MULTIDISCIPLINARY PETROLEUM DESIGN. 3.0 Semester Hrs.**

Equivalent with GEGN439, GPGN439,

(II) (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: GE Majors: GEOL309, GEOL314, GEGN438, and EDNS264; GP Majors: GPGN304, GPGN305, and GPGN268; PE Majors: GEOL308, PEGN316. Co-requisites: PEGN426. 2 hours lecture, 3 hours lab; 3 semester hours.

**PEGN440. PETROLEUM DATA ANALYSIS. 3.0 Semester Hrs.**

(II) 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. Prerequisites: EBGN325, CSC1303, and PEGN438. 3 hours lecture; 3 semester hours.

**PEGN450. ENERGY ENGINEERING. 3.0 Semester Hrs.**

(I or II) 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.**

(II) 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.

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

(I) 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.

**PEGN462. FLOW ASSURANCE. 3.0 Semester Hrs.**

(I) 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.

**PEGN463. PETROLEUM MIDSTREAM DESIGN. 3.0 Semester Hrs.**

(II) 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. Prerequisites: PEGN251, PEGN305, CHGN209, and MATH225. 3 hours lecture; 3 semester hours.

**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.

**PEGN490. RESERVOIR GEOMECHANICS. 3.0 Semester Hrs.**

(I) 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.