The SPE Model Petroleum Engineering Curriculum – What it is and what it isn't

The model petroleum engineering curriculum is intended as an aid to universities worldwide that want to start new petroleum engineering programs. It is not intended to be a "standard" curriculum, in that no petroleum engineering curriculum would have all of the course listed here. Any petroleum engineering curriculum should educate students in fundamental mathematics and science, humanities and liberal arts, engineering science, and the foundational course in petroleum engineering. Most curricula will include some more specialized petroleum engineering courses, like those listed in the model curriculum as petroleum engineering electives. No Bachelor's of Science level degree program could include all of the courses shown in the elective list. The SPE model curriculum includes all of the educational areas needed to create a specific petroleum engineering curriculum.

Every petroleum engineering curriculum in the world is unique, none are exactly the same. Many countries or regions have course requirements that do not appear anywhere else in the world. In the United States, there are significant variations in curricula, with some programs having emphases on particular areas of petroleum engineering that are different from other programs. This model curriculum can be used to construct a unique degree program for new programs, with the particular courses included based on the particular needs of that university, or that country.

Model Petroleum Engineering Curriculum

Fundamental Math and Science

- Calculus 1
- Calculus 2
- Differential equations
- Numerical methods
- Physics 1 (Mechanics and heat)
- Physics 1 lab
- Physics 2 (Electricity and magnetism)
- Physics 2 lab
- Chemistry 1
- Chemistry 2

Engineering Science

- Statics and Dynamics
- Thermodynamics
- Transport phenomena
- Solid mechanics (strength of materials)
- Computer programming

Geology

- Physical geology
- Petroleum geology

Humanities / liberal arts

- Writing and composition
- English as a second language
- Technical writing and presentation skills
- Social science
- Fine arts
- Ethics

Petroleum engineering fundamentals and practice

- Introductory petroleum engineering course
- Properties of petroleum fluids
- Drilling engineering
- Well completions
- Flow in porous media
- Reservoir engineering
- Petrophysics (Properties of sedimentary rocks)
- Production technology (well deliverability models, tubing flow, stimulation, artificial lift)
- Well logging
- Well testing
- Reservoir geomechanics
- Geostatistics
- Resource economics and evaluation
- Engineering capstone design
- Reservoir simulation

Petroleum Engineering Electives

- Integrated Reservoir Modeling
- High Performance Drilling Design and Operational Practices
- Advanced Production Engineering
- Formation Damage and Stimulation
- Well Completions and Production in Unconventional Reservoirs
- Petroleum Data Analytics
- Petroleum Leasing Regulations and Practices
- Natural Gas Engineering
- Deepwater Operations
- Applied Reservoir Characterization
- Artificial Lift
- Surface Facilities
- Hydraulic fracturing
- Enhanced oil recovery
- Reserve estimation
- Well and Reservoir Monitoring

Other Electives

- Finance
- Language
- Engineering project management
- Data analytics
- Operations research

Model Petroleum Engineering Curriculum – Schedule

Year 1

- Calculus 1
- Calculus 2
- Differential equations
- Numerical methods
- Physics 1 (Mechanics and heat)
- Physics 1 lab
- Physics 2 (Electricity and magnetism)
- Physics 2 lab
- Chemistry 1
- Chemistry 2
- Writing and composition or English as a second language
- Physical geology
- Computer programming

Year 2

- Differential equations
- Statics and Dynamics
- Thermodynamics
- Transport phenomena
- Solid mechanics (strength of materials)
- Petroleum geology
- Technical writing and presentation skills
- Properties of petroleum fluids
- Petrophysics (Properties of sedimentary rocks)
- Humanities or social science elective

Year 3

- Drilling engineering
- Well completions
- Flow in porous media
- Reservoir engineering
- Production technology (well deliverability models, tubing flow, stimulation, artificial lift)
- Well logging

- Well testing
- Reservoir geomechanics
- Geostatistics
- Numerical methods

Year 4

- Resource economics and evaluation
- Engineering capstone design
- Reservoir simulation
- Petroleum Engineering electives
- Ethics
- Humanities and social science electives

Model Petroleum Engineering Curriculum – Course Descriptions

Humanities and Social Sciences

Composition and Rhetoric
Credits 3. 3 Lecture Hours.
Composition and Rhetoric. Focus on referential and persuasive researched essays through the development of analytical reading ability, critical thinking and library research skills; for freshman and sophomore students only.

Technical and Business Writing
Credits 3. 3 Lecture Hours.
Technical and Business Writing. Focus on writing for professional settings; correspondence and researched reports fundamental to the technical and business workplace—memoranda, business letters, research proposals and presentations, use of graphical and document design; emphasis on audience awareness, clarity of communication and collaborative team-work.

Communication for Technical Professions
Credits 3. 3 Lecture Hours.
Design and presentation of oral reports for technical professions; incorporation of visual and graphic materials into presentation required; written reports required.

Ethics and Engineering
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Development of techniques of moral analysis and their application to ethical problems encountered by engineers, such as professional employee rights and whistle blowing; environmental issues; ethical aspects of safety, risk and liability and conflicts of interest; emphasis on developing the capacity for independent ethical analysis of real and hypothetical cases.

Mathematics

Calculus I
Credits 4. 3 Lecture Hours. 2 Lab Hours.
Rectangular coordinates, vectors, analytic geometry, functions, limits, derivatives of functions, applications, integration.

Calculus II
Credits 4. 3 Lecture Hours. 2 Lab Hours.
Differentiation and integration techniques and their applications (area, volumes, work), improper integrals, approximate integration, analytic geometry, vectors, infinite series, power series, Taylor series.

Calculus III
Credits 3. 3 Lecture Hours.
Vector algebra, calculus of functions of several variables, partial derivatives, directional derivatives, gradient, multiple integration, line and surface integrals, Green's and Stokes' theorems.

Differential Equations
Credits 3. 3 Lecture Hours.
Ordinary differential equations, solutions in series, solutions using Laplace transforms, systems of differential equations.

Physics

Physics, Electricity and Optics
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Electricity, magnetism, and introduction to optics.

Physics, Mechanics
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Classical Newtonian Mechanics.

Chemistry

General Chemistry
Credits 3. 3 Lecture Hours.
Introduction to important concepts and principles of chemistry; emphasis on areas considered most relevant in an engineering context; practical applications of chemical principles in engineering and technology.

General Chemistry Laboratory
Credit 1. 3 Lab Hours.
Introduction to important concepts and principles of chemistry in the laboratory; emphasis on areas considered most relevant in an engineering context; practical applications of chemical principles in engineering and technology.

Geology

Physical Geology
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Earth materials, structures, external and internal characteristics; physical processes at work upon or within the planet. A working knowledge of high school chemistry and mathematics is required.

Petroleum Geology
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Origin, migration and accumulation of petroleum; typical U.S. oil and gas fluids; laboratory work in subsurface geology.

Engineering Science

Mechanics of Materials
Credits 3. 3 Lecture Hours.
Applications of conservation principles and stress/deformation relationships for continuous media to structural members; axially loaded members; thin-walled pressure vessels; torsional and flexural members; shear; moment; deflection of members; combined loadings; stability of columns; nonsymmetrical bending, shear center; indeterminate members; elastic foundations.

Statics and Particle Dynamics
Credits 3. 3 Lecture Hours.
Application of the fundamental principles of Newtonian mechanics to the statics and dynamics of particles; equilibrium of trusses, frames, beams and other rigid bodies.

Principles of Thermodynamics
Credits 3. 3 Lecture Hours.
Theory and application of energy methods in engineering; conservation of mass and energy; energy transfer by heat, work and mass; thermodynamic properties; analysis of open and closed systems; the second law of thermodynamics and entropy; gas, vapor and refrigeration cycles.

Computer Programming
Credits 4. 3 Lecture Hours. 2 Lab Hours.
Basic concepts in using computation to enhance problem solving abilities; understanding how people communicate with computers, and how computing affects society; computational thinking; representation of data; analysis of program behavior; methods for identifying and

fixing errors in programs; understanding abilities and limitation of programs; development and execution of programs.

Petroleum Engineering

Introduction to Petroleum Engineering
Credit 1. 1 Lecture Hour.
Overview and history of the petroleum industry and petroleum engineering; nature of oil and gas reservoirs, exploration and drilling, formation evaluation, well completions and production, surface facilities, reservoir mechanics, improved oil recovery; impact of ethical, societal, environmental considerations; career development resources, including professional society.

Formulation and Solution of Petroleum Engineering Problems
Credit 3. 3 Lecture Hours.
Introduction to mathematical equations typically encountered in petroleum engineering; methods to solve equations graphically, analytically, and with numerical methods; applications of computers to problem solving.

Petroleum Engineering Numerical Methods
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Use of numerical methods in a variety of petroleum engineering problems; numerical differentiation and integration; root finding; numerical solution of differential equations; curve fitting and interpolation; computer applications; introduction to the principles of numerical simulation methods.

Reservoir Fluids
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Thermodynamic behavior of naturally occurring hydrocarbon mixtures; evaluation and correlation of physical properties of petroleum reservoir fluids including laboratory and empirical methods. PVT report interpretation and application of equations of state.

Reservoir Petrophysics
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Systematic theoretical and laboratory study of physical properties of petroleum reservoir rocks; lithology, porosity, elastic properties, strength, acoustic properties, electrical properties, relative and effective permeability, fluid saturations, capillary characteristics and rock-fluid interactions such as adsorption and absorption.

Reservoir Geomechanics.
Credits 3. 3 Lecture Hours.
An introduction to fundamental rock mechanics with emphasis on 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.

Transport Processes in Petroleum Production
Credits 3. 3 Lecture Hours.
Basics and applications of fluid mechanics (statics; mass, energy, momentum balances; laminar and turbulent flow, Reynolds number, Moody diagram; non-Newtonian fluid flow; multi-phase flow; flow in porous media, non-Darcy flow); heat transfer (heat conduction, convection, heat exchangers); emphasis on analogies and similarities within mass, energy and momentum transport.

Formation Evaluation
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Well-log interpretation for formation evaluation of hydrocarbon-bearing reservoirs; basic rock physics principles; theory of tool operation; analysis of open hole logs and core measurements to estimate hydrocarbon reserves and petrophysical properties of the formation such as porosity, net pay thickness, water/hydrocarbon saturation, permeability and saturation-dependent capillary pressure; formation evaluation of clay-free and shaly-sand formations as well as basic introduction to formation evaluation of organic-shale formations.

Geostatistics
Credits 3. 3 Lecture Hours.
Introduction to geostatistics; basic concepts in probability and univariate statistics; bivariate statistics and spatial relationship; covariance and correlation; second order stationarity; variogram estimation and modeling; spatial estimation and reservoir modeling; simple and ordinary kriging; uncertainty analysis; estimation versus conditional simulation; sequential Gaussian simulation.

Fundamentals of Reservoir Engineering
Credits 3. 3 Lecture Hours.
Determination of reserves; material balance methods; aquifer models; fractional flow and frontal advance; displacement, pattern and vertical sweep efficiencies in waterfloods; enhanced oil recovery processes; design of optimal recovery processes; introduction and performance analysis of unconventional reservoirs.

Well Testing
Credits 3. 3 Lecture Hours.
Analysis of well performance under varied reservoir conditions including evaluation of unsteady, pseudo-steady and steady state flow; well testing methods used to determine well and reservoir parameters; applications to conventional and unconventional wells producing gas and/or liquids; fundamentals of preparing and operating well test equipment to monitor, measure and gather samples for evaluating well performance.

Petroleum Production Systems
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Petroleum operation and oil field equipment including onshore and offshore production systems; wellbore inflow and outflow and backpressure analysis; downhole completion and sand control equipment; artificial lift equipment and design; stimulation, workover/completion nomenclature; flow assurance; produced fluids, fluid separation and metering, safety systems, pressure boosting

and monitoring.

Petroleum Project Evaluation
Credits 3. 3 Lecture Hours.
Economic analysis and investment decision methods in petroleum and mineral extraction industries; depletion, petroleum taxation regulations, and projects of the type found in the industry; mineral project evaluation case studies. Financing of oil and gas developments.

Drilling Engineering
Credits 3. 3 Lecture Hours.
Design and evaluation of well drilling systems; identification and solution of drilling problems; wellbore hydraulics, well control, casing design; well cementing directional drilling, offshore drilling.

Well Completions
Credits 3. 3 Lecture Hours.
Topics include casing design, cement planning, completion techniques and equipment, tubing design, wellhead selection, and sand control, perforation procedures, and completions for multi-stage stimulation treatments.

Production Engineering
Credits 3. 3 Lecture Hours.
Fundamental production engineering design, evaluation and optimization for oil and gas producing well; well deliverability; formation damage and skin analysis; well completion selection; technologies that improve oil and gas well performance including artificial lift and well stimulation.

Reservoir Simulation
Credits 2. 1 Lecture Hour. 3 Lab Hours.
Solution of production and reservoir engineering problems using state-of-the-art commercial reservoir simulation software, using data commonly available in industry; emphasis on reservoir description, reservoir model design and calibration, production forecasting and optimization, economic analysis and decision making under uncertainty.

Integrated Asset Development (Capstone Design)
Credits 3. 1 Lecture Hour. 6 Lab Hours.
Capstone design encompassing previously acquired skills; project teams formed to solve practical petroleum engineering problems using current tools; technical content of the projects may include any combination of drilling and completion, formation evaluation, inflow/outflow design and analysis, and application of reservoir engineering principles. Actual field data is used in developing a comprehensive design solution to a petroleum engineering problem.

Petroleum Engineering Electives

Integrated Reservoir Modeling
Credits 3. 3 Lecture Hours.
Geophysical, geological, petrophysical and engineering data with geostatistical methods to create reservoir descriptions for dynamic reservoir modeling (simulation); geostatistical concepts such as variogram modeling, kriging and sequential Gaussian simulation; combines several techniques to quantify uncertainty in a realistic dynamic reservoir simulation.

High Performance Drilling Design and Operational Practices
Credits 3. 3 Lecture Hours.
Preparation in achieving differentiating drilling performance in the most complex wells; includes training in the underlying physics of each type of performance limiter and real time and engineering practices to address the limitation; performance management workflows and change models required to effectively change the way organizations conduct work essential in achieving higher performance.

Advanced Production Engineering
Credits 3. 3 Lecture Hours.
Application of petroleum engineering tools, methods and techniques to solve real problems that petroleum engineers encounter in producing individual wells; focus primarily on problems associated with single-phase gas wells and uses Microsoft Excel to solve many of these problems.

Formation Damage and Stimulation.
Credits 3. 3 Lecture Hours.
(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.

Well Completions and Production in Unconventional Resources.
Credits 3. 3 Lecture Hours.
Completion and production practices in shales, coalbed methane, tight sands, and heavy oil reservoirs. Multi-stage hydraulic fracturing design and operations. Water management issues for unconventional resources.

Petroleum Data Analytics
Credits 3. 3 Lecture Hours.
Introduction to elementary probability theory and its applications in engineering and sciences; discrete and continuous probability distributions; parameter estimation; hypothesis earth sciences and engineering.

Petroleum Leasing Regulations and Practices.
Credits 3. 3 Lecture Hours
Domestic and worldwide regulations associated with petroleum leasing, including offshore areas, and environmental provisions concerning petroleum exploration and production.

Natural Gas Engineering.
Credits 3. 3 Lecture Hours.
Production, transportation, and storage of gas; metering and gauging; performance of wells; estimation of gas reserves; prevention of waste and utilization of natural gas.

Deepwater Operations.
Credits 3. 3 Lecture Hours.
Restricted to students admitted to major sequence in geosystems engineering and hydrogeology or petroleum engineering. Overview of various technical, logistical, and managerial elements that are functionally integrated in deepwater operations.

Applied Reservoir Characterization.
Credits 3. 3 Lecture Hours.
Reservoir modeling using software tools for statistical analysis of reservoir data; variogram analysis and modeling; spatial interpolation (kriging); tools for data integration in kriging; stochastic simulation of rock-types (lithology), pay thickness/porosity, and permeability; inputting geological models into flow simulation; uncertainty assessment.

Artificial Lift.
Credits 3. 3 Lecture Hours.
Life of a well, well testing, gas and plunger lift, progressive cavity pumps, electric submersible pumps, and beam lift.

Surface Facilities.
Credits 3. 3 Lecture Hours.
Petroleum fluid characteristics, process control, separators, metering, produced water, tanks, gas processing, gas compression, and liquid pumps.

Hydraulic Fracturing.
Credit 3. 3 Lecture Hours.
Physical principles and engineering methods involved in hydraulic fracturing; an advanced treatise integrating the necessary fundamentals from elasticity theory, fracture mechanics and fluid mechanics to understand designs, optimization and evaluate hydraulic fracturing treatments including special topics such as high permeability fracturing and deviated well fracturing. Multi-stage hydraulic fracturing design and productivity. Fracture monitoring and evaluation.

Enhanced Oil Recovery Processes.
Credits 3. 3 Lecture Hours.
Fundamentals and theory of enhanced oil recovery; polymer flooding, surfactant flooding, miscible gas flooding and steam flooding; application of fractional flow theory; strategies and displacement performance calculations.

Reserves and Evaluation
Credits 3. 3 Lecture Hours
Reserves definitions and reporting requirements; deterministic reserves estimation methods, including analogy, volumetric, decline trend, material balance, and simulation; probabilistic reserves estimation methods, with emphasis on Monte Carlo simulation; applications in both conventional and unconventional (low permeability) reservoirs.

Well and Reservoir Monitoring.
Credits 3. 3 Lecture Hours.
Reviews methods used to monitor wells and reservoirs including surface and downhole rates and pressures, distributed temperature and acoustic sensors, microseismic monitoring, and smart field technology. Data acquisition and data interpretation.

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Year 2

- Differential equations
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- Transport phenomena
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- Petroleum geology
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- Humanities or social science elective

Year 3

- Drilling engineering
- Well completions
- Flow in porous media
- Reservoir engineering
- Production technology (well deliverability models, tubing flow, stimulation, artificial lift)
- Well logging
- Well testing
- Reservoir geomechanics
- Geostatistics
- Numerical methods

Year 4

- Resource economics and evaluation
- Engineering capstone design
- Reservoir simulation
- Petroleum Engineering electives