# College of Engineering

- **Master of Science in Systems & Process Control Engineering**
- **Master of Science in Electrical Engineering**
- **Master of Science in Computer Engineering**
- **Master of Science in Civil Engineering**
- **Master of Science in Mechanical Engineering**
- **Master of Science in Chemical Engineering**
- **Doctor of Philosophy in Chemical Engineering**
- **Master of Science in Petroleum Engineering**
- **Doctor of Science in Petroleum Engineering**
- **Master of Science in Industrial & Management System Engineering**

# ENGINEERING (CORE COURSES)

## *INTRODUCTION*

Engineering graduate programs require the study of some of the following general (core) graduate engineering courses.

| | | |
|---|---|---|
| 0600-503 | Statistical Concepts in Engineering | (3) |
| 0600-504 | Numerical Analysis and Computation | (3) |
| 0600-505 | Finite Element Methods | (3) |
| 0600-506 | Continuum Mechanics | (3) |
| 0600-507 | Mathematical Optimization | (3) |
| 0600-508 | Random Variables and Stochastic Processes | (3) |
| 0600-510 | Advanced Fluid Mechanics | (3) |
| 0600-511 | Computational Fluid Dynamics | (3) |
| 0600-512 | Advanced Engineering Mathematics I | (3) |
| 0600-513 | Advanced Engineering Mathematics II | (3) |

## *COURSE DESCRIPTION*

**0600-503: STATISTICAL CONCEPTS IN ENGINEERING**
**CR: 3**

Elements of probability theory, random variables, analytical models of random phenomena, reliability, factor of safety, safety margin, extreme value statistics, Monte-Carlo simulation, empirical determination of distribution models, confidence intervals, regression and correlation analysis, general applications to engineering design problems, stochastic processes.

**0600-504: NUMERICAL ANALYSIS AND COMPUTATION**
**CR: 3**

Norms, limits and condition numbers. Inverses of perturbed matrices. Integrative techniques for solving systems of equations. The LU, QR and singular value decompositions. Algorithms for the linear least squares and linear minimax problems. Computation of the eigenvalues of a matrix. the interpolation and polynomial approximation. Approximate methods for initial value problems and for boundary value problems.

**0600-505: FINITE ELEMENT METHODS**
**CR: 3**

Origin and basis of finite-element methods in continuum mechanics, stiffness method, assumed displacement field, potential energy and Rayleigh-Ritz method, types of elements, modeling, accuracy and convergence, solution techniques and computer application to structural and fluid mechanics.

**0600-506: CONTINUUM MECHANICS**
**CR: 3**

Cartesian tensors. Basic principles of continuum mechanics: deformation, displacement, strain, stress, conservation of mass, continuum thermodynamics and constitutive equations. Illustrative applications in elasticity, fluid dynamics, viscoelasticity ad plasticity.

**0600-507: MATHEMATICAL OPTIMIZATION**
**CR: 3**

Basic Concepts: The gradient vector and the Hessian Matrix, multidimensional Taylor's theorem, linear and quadratic approximation of a function. Unconstrained optimization, necessary

and sufficient conditions for optimality. Algorithms for single variable minimization, the Fibonacci search and the Golden section search, algorithms that use repeated polynomial interpolation. Algorithms for multi-dimensional minimization; The steepest descent, the Newton method and its variations, conjugate gradient algorithms such as the Flecter-Reeves, Polak and Ribieve, Quasi-Newton Methods such as the DEP-BFGS, Huang's family of algorithms. Constrained optimization: Necessary and sufficient conditions for constrained minima. Algorithms for constrained optimization: interior and exterior penalty function methods, augmented Lagrangian methods, Resen's gradient projection.

**0600-508: RANDOM VARIABLES AND STOCHASTIC PROCESSES**
**CR: 3**

Introduction to probability theory and engineering applications of probability. random variables and expected values. distribution of functions of random variables and applications of R.V. to system problems. Stochastic processes, correlation and power spectra, systems and random signals. Engineering decisions and estimation theories.

**0600-510: ADVANCE FLUID MECHANICS**
**CR: 3**

Motion of ideal, Newtonian, and non-Newtonian single-phase fluids. Continuity and Navier-Stokes equations for one and two dimensional flows. Turbulence and boundary layer theories. Flow through conduits, and porous medium. Homogenous and non-homogenous multiphase flow systems.

**600-511: COMPUTATIONAL FLUID DYNAMICS**
**CR: 3**

This course introduces students to the numerical and computational fluid dynamics. It will provide graduate students (Science and Engineering students) with techniques and approaches to solve numerical fluid mechanics problems encountered in real fluid flows. Methods for boundary layers, incompressible viscous flows, and inviscid compressible flows are studied. Finite differences and finite volume techniques are emphasized. The course utilizes using commercial CFD packages and MATLAB to solve fluid flow problems.

**0600-512: ADVANCED ENGINEERING MATHEMATICS I**
**CR:3**

Analytic function, residues, contour integration. Power series solutions of ordinary differential equations: Bessel's, Legendre's, Chebysheve's and Laguerre's functions. Matrix algebra eigenvalues, eigen-functions, and solutions of systems of differential equations. Software applications.

**0600-513: ADVANCED ENGINEERING MATHEMATICS II**
**CR:3**

Sturm-Liouville problem. Partial differential equations: Characteristic curves, separation of variables and integral transforms (Laplace and Fourier), method of characteristics. Wave, heat and diffusion-equations. Software applications.

# Doctor of Philosophy in Petroleum Engineering
## Program code: 065070

***INTRODUCTION***

The PE Ph.D. program is designed to graduate Ph.D. holders that are proficient and independent researchers who can synthesize, critique, apply, and extend major theories and methods related to various innovative areas of the oil and gas industry. Possess good written and oral communication skills to effectively participate in the growth of academic, and research and development (R&D) institutions. Demonstrate high standards of ethical, environmental, and societal awareness.

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***PROGRAM REQUIREMENTS***

**60 TOTAL COURSE CREDITS**

**9 SPECIAL COURSES (3 credits each)**

0650-612 Applied Petroleum Geomechanics
0650-613 Water Shutoff and Conformance Improvement
0650-622 Unconventional Reservoirs
0650-627 Flow Assurance in Oil and Gas Production
0650-630 Complex Well Planning and Construction
0650-632 Oil-water Dispersion and Emulsion
0650-633 Reservoir Characterization
0650-634 Chemical EOR Processes

**15 GENERAL COURSES (3 credits each)**

0650-611 Engineering Research Methods
0650-614 Simulation of EOR Processes
0650-615 Heat and Mass Transfer
0650-621 Multilateral Well Completion
0650-624 Production Logging
0650-625 CO2 Capture and Sequestration for Enhanced Oil Recovery
0650-626 Transient Multiphase Production.
0650-628 Underbalanced and Managed Pressure Drilling
0650-629 Offshore Drilling Engineering
0650-631 Application of Nanotechnology in Petroleum Industry

A maximum of 6 credit hours may be taken from the PE 500 level subdiscipline courses upon the approval of program director before registration. A maximum of 6 credits may be taken from relevant Non-Petroleum engineering or sciences graduate programs upon the approval of the program director.

## 36 COMPULSORY COURSES

| | | |
|---|---|---|
| 0650-692 | Seminar | (0) |
| 0650-697 | Dissertation | (0) |
| 0650-698 | Dissertation | (0) |
| 0650-699 | Dissertation | (36) |

## *COURSE DESCRIPTION*

**0650-611: ENGINEERING RESEARCH METHODS**
**CR: 3**

Research methods, type of modeling, design, theoretical, computational and interpretive issues in applied and fundamental research studies. Research components, sequence and methodology. Typical research designs, rationale for use, computational and/or computing procedures, interpretation, verification and validation of results. Scientific writing and publication.

**0650-612: APPLIED PETROLEUM GEOMECHANICS**
**CR: 3**

The course provides fundamental rock mechanics concepts and aims to emphasize their role in exploration, drilling, completion and production engineering operations. Basic stress and strain concepts, pore pressure, fracture gradient and in situ stress magnitude and orientation determination and how these properties are obtained from the field measurements. Mechanisms of deformation in rock, integrated wellbore stability analysis, depletion induced compaction and associated changes in rock properties and formation strength. Hydraulic fracturing and fracture stability are among the topics to be covered in this rock course.

**0650-613: WATER SHUT-OFF AND CONFORMANCE IMPROVEMENT**
**CR: 3**

This course aims at teaching students how to diagnose water-shutoff problems and to design water shutoff treatment and conformance improvement jobs. Factors that lead to an increase in water production, such as the presence of thief zones or high permeability zones, fractures and water coning. Water shut off and conformance-control treatments that can be used to generate relatively large volumes of incremental oil production with low costs. Selectively, targeted small volume treatments, which extends the economic lives of marginal and mature wells.

**0650-614: SIMULATION OF EOR PROCESSES**
**CR: 3**

Recent advances in concepts of reservoir simulation within the context of reservoir management will be covered. The course will focus on the capabilities and operational features of well-known simulators for simulating thermal recovery methods and chemical flooding.

**0650-615: HEAT AND MASS TRANSFER**
**CR: 3**

Steady and unsteady mass and heat diffusion in solids and stagnant liquids. Laminar, forced and natural convection. Equations of change for non-isothermal systems and multi-component systems. Analytical and approximate solutions to equations of change with applications to problems in research and design. Heat and Mass Transport in Turbulent Flows. Diffusion under various driving forces and with chemical reaction. Energy and mass transport in boundary layers with relevant analogies. Simultaneous heat and mass transfer. Multi-component mass transport for dilute solutions.

**0650-621: MULTILATERAL WELLS COMPLETION**
**CR: 3**

The utility of multilateral wells. Drilling and well control of multilateral wells. Designing a multilateral well completions. Multilateral wells production and well performance. Discussion of case studies and economics of multilateral wells.

**0650-622: UNCONVENTIONAL RESERVOIRS**
**CR: 3**

This course is designed to expose students to the latest techniques of reserve evaluations, well test analysis, decline curve analysis, and field economics applied to unconventional reservoirs

like tight gas, shale gas, shale oil, coalbed methane, gas hydrate reservoirs, and heavy oil reservoirs.

**0650-624: PRODUCTION LOGGING**
**CR: 3**

Mapping of fluid movement down-hole in both injection and producing wells, assessing the integrity of cement and casing, and formation evaluation using cased-hole logs.

**0650-625: CO2 CAPTURE AND SEQUESTRATION FOR ENHANCED OIL RECOVERY**
**CR: 3**

This course is designed to cover the mechanisms of CO2-EOR projects, CO2 Capturing options, miscible and immiscible CO2 displacement processes, phase behavior of CO2-Crude oil systems, measurements and predictions of minimum miscibility pressure, and design considerations in CO2-EOR projects.

**0650-626: TRANSIENT MULTIPHASE PRODUCTION**
**CR: 3**

A combination of transient multiphase flow theoretical modeling and design applications. Detailed derivation of the two transient two-phase flow models: Two-fluid model and Drift flux model. As study of the numerical aspects in transient two-phase flow: method of characteristics, explicit vs. implicit, numerical diffusion, wellposedness, and stability. Application to multiphase transient flow assurance phenomena: severe slugging and terrain slugging. A study and application of transient multiphase flow simulators.

**0650-627: FLOW ASSURANCE IN OIL AND GAS PRODUCTION**
**CR: 3**

Multi-disciplinary subject addressing hydrocarbon flow assurance from reservoir to sales. Topics include prediction, mitigation, and preventions of: organic and inorganic deposition; pipe erosion/corrosion; severe/terrain slugging, liquid loading, heavy oil, and others. Production system design and operational issues. Application of commercial simulators.

**0650-628: UNDERBALANCED AND MANAGED PRESSURE DRILLING**
**CR: 3**

Advanced analysis of underbalanced and managed pressure drilling techniques, applications, candidate selection, equipment and fluid types. Underbalanced drilling hydraulic models, risk identification and uncertainty in underbalanced and managed pressure drilling.

**0650-629: OFFSHORE DRILLING ENGINEERING**
**CR: 3**

Advanced study of the unique aspects of offshore drilling operations. Introduction to Floating Drilling Vessels. Types of Motion and Waves. Drilling with a Riser, Fracture Gradients in Deep Water. Directional Well Planning and Design.

**0650-630: COMPLEX WELL PLANNING AND CONSTRUCTION**
**CR: 3**

Planning and calculating trajectories for complex wells such as directional, horizontal, extended reach, and multi-lateral wells. Screening analysis for selecting the optimum complex well design. Extensive survey calculation methods. Deflection tools, different bottom-hole assemblies used in complex well drilling operations, and geo-steering. Torque and drag problems, and buckling in complex wells. Wellbore stability for complex wells.

**0650-631: APPLICATION OF NANOTECHNOLOGY IN PETROLEUM INDUSTRY**
**CR: 3**

A comprehensive review of the different applications of nanotechnology in the oil and gas industry. A summary of all nanoparticles used along with a detailed analysis of their performance in improving the targeted parameters is comprehensively presented. Comprehensive summary of the different successful applications of nanotechnology in reservoir, production and drilling engineering and its associated challenges.

**0650-632: OIL-WATER DISPERSION AND EMULSION**
**CR: 3**

Advances of oil-water emulsion. Emulsion types and interfacial phenomena. Oil-water flow patterns. Emulsion stability and the use of surfactants.

Emulsion processing and transportation. Comprehensive modeling and applications.

**0650-633: RESERVOIR CHARACTERIZATION**
**CR: 3**

Build static models by integrating geological, seismic, core and well log data to predict alteration of reservoir characteristics. Study the impact of altered reservoir characteristics on reservoir performance.

**0650-634: CHEMICAL EOR PROCESSES**
**CR: 3**

This course provides an integrated workflow for various chemical EOR processes (CEOR). Mechanisms involved in the main CEOR processes (polymer, surfactant, and alkaline), are discussed in detail. The course addresses the properties of chemicals, base behavior, fluid geochemical reactions encountered in CEOR processes, flow in porous media, challenges in CEOR, performance of CEOR, and the design of CEOR processes.

**0650-692: SEMINAR**
**CR: 0**

The student must conduct two presentations. The first one presents the research proposal and work plan of the Dissertation. The second presentation is made prior to the final Dissertation defense.

**0650-697: DISSERTATION**
**CR: 0**

**0650-698: DISSERTATION**
**CR: 0**

**0650-699: DISSERTATION**
**CR: 36**