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 Chemical Engineering
Program code: 064070

INTRODUCTION

The Chem. Eng. PhD Program strives to produce graduates that are distinguished and productive researchers, specialized in innovative areas in oil and gas, renewable energy, chemical processes, advanced materials, and environment, well prepared to effectively participate in academic, and research and development (R&D) institutions, also, capable of contributing to the economic and social development of the country.

According to the University Council decision dated 4/2/2007, Thesis students admitted with effect from September 2007 are exempted from the comprehensive examination.

PROGRAM REQUIREMENTS

60 TOTAL COURSE CREDITS

24 COMPULSORY ELECTIVE COURSES (3 credits each)

(According to the student academic background and supervisor approvement)

0640-610 Research Techniques & Methods in Chemical Engineering
0640-611 Advanced Chemical Engineering Thermodynamics
0640-612 Advanced Transport Phenomena
0640-613 Advanced Reaction Engineering
0640-614 Advanced Separation Processes
0640-616 Advanced Materials Engineering and Characterization
0640-617 Sustainable Energy, Renewables, and Energy Conversion
0640-621 Synthetic Biology for Biofuels
0640-623 Energy Management Systems
0640-624 Sustainability in Chemical Processes
0640-632 Wastewater Treatment in the Oil and Gas Industry
0640-635 Waste Minimization through Process Integration
0640-636 Design for Environment
0640-642 Polymers and Nanomaterial's
0640-643 Electrochemical Engineering
0640-644 Surface Chemistry and Catalysis
0640-645 Advanced Corrosion Engineering
0640-648 Advanced Multivariable Process Control
0640-651 Computer Control of Processes
0640-652 Model Predictive Control
0640-654 Applied Numerical Methods in Engineering

0640-656 Machine Learning and Data Science in Petroleum Industry
0640-670 Teaching Experience in Chemical Engineering

A student can register a maximum of (6) course credits from academic institutions outside Kuwait University upon the approval of the program committee.

36 COMPULSORY COURSES

0640-697 Dissertation (0)
0640-698 Dissertation (0)
0640-699 Dissertation (36)

COURSE DESCRIPTION

0640-610: RESEARCH TECHNIQUES & METHODS IN CHEMICAL ENGINEERING
CR: 3

The first theme of the course prepares students for planning and executing their research projects and preparing their dissertation. The second theme provides a rigorous introduction to designing experiments in order to solve research problems through quality and performance optimization. The third theme covers techniques including factorial and fractional factorial design, response surface techniques, regression analysis and using statistical software tools.

0640-613: ADVANCED REACTION ENGINEERING
CR: 3

Advanced models of reaction kinetics. Design of ideal reactors such as continuous stirred tank reactors (CSTR) and plug flow reactors (PFR). Modelling and design of fixed bed reactors. Design of fluid-fluid reaction kinetics and reactor design. Fluid-particles reaction kinetics and reactor design.

0640-614: ADVANCED SEPARATION PROCESSES
CR: 3

Complex distillation processes. Heterogenous and homogenous Azeotropic distillation. Pressure swing distillation. Extractive distillation. Membrane separations processes. Dialysis, liquid extraction, pervaporation, and reverse osmosis. Adsorption, ion exchange and chromatographic separations.

0640-616: ADVANCED MATERIALS ENGINEERING AND CHARACTERIZATION
CR: 3

Fundamental concepts related to advanced functional solid-state materials such as metallic alloys, ceramics, semiconductors, and thin-film materials. Fabrication, handling, and characterization techniques of functional materials.

0640-617: SUSTAINABLE ENERGY, RENEWABLES, AND ENERGY CONVERSION
CR: 3

The objective of this course is to equip students with the fundamentals, design and analysis tools of various sustainable, renewable, and/or green state of the art energy resources, along their limitations and opportunities. Topics covered include Solar, Wind, Ocean, Hydropower, and Geothermal Energy, biomass, Energy storage and conversion systems, and integrated energy systems.

0640-621: SYNTHETIC BIOLOGY FOR BIOFUELS
CR: 3

This course gives an overview of the synthetic biology approaches for biofuel production in microbial host. Pathway engineering design and optimization are discussed; protein engineering to improve flux, increasing flux by compartmentalization, and tuning transcription and translation of pathway genes. Different biofuels are to be discussed such as bioethanol, higher chain

alcohols, fatty acid and fatty acid esters, isoprene-based biofuels, and biohydrocarbons.

0640-623: ENERGY MANAGEMENT SYSTEMS
CR: 3

The course provides an overview of energy management practices to increase energy efficiency and decrease the release of energy-related pollutants into the environment. Special focus is on energy management in chemical processes. Covered topics include various techniques to lower energy use in utilities and unit operations, management of renewable energy and greenhouse gas emissions.

0640-624: SUSTAINABILITY IN CHEMICAL PROCESSES
CR: 3

This course covers the fundamentals of sustainability and the life cycle assessment (LCA) framework for products, services, and activities. Introduce tools and methods to assess the sustainability impacts of industrial activities. Topics covered include sustainability indicators, assessment methods, green materials and sustainable manufacturing. Assessment and analysis methods will cover the three pillars of sustainability: economic, environmental, and social. Methods and tools are applied in case studies from process industries.

0640-632: WASTEWATER TREATMENT IN THE OIL AND GAS INDUSTRY
CR: 3

Produced water characteristics, produced water management, management options. Technologies used for produced water treatment, application of novel/emerging technologies. Process design approaches and comparative evaluation of various technologies. Case Studies.

0640-635: WASTE MINIMIZATION THROUGH PROCESS INTEGRATION
CR: 3

The course presents systematic and state-of-the-art techniques for waste minimization of chemical processes. Emphasis is given to holistic and systematic approaches using process integration for the conservation of natural resources and the enhancement of process performance. A variety of visualization, algebraic, and mathematical optimization approaches are presented.

0640-636: DESIGN FOR ENVIRONMENT
CR: 3

This course presents engineering tools that are used to improve the environmental performance of chemical products and processes. This includes assessment tools, such as life cycle assessment and risk assessment, as well as design tools such as heat and mass exchange network synthesis.

0640-642: POLYMERS AND NANOMATERIALS
CR: 3

The course is designed to introduce students to two topics: polymers and Nanomaterials. Particular emphasis will be placed on polymer solutions, polymer rheology and polymer mechanical properties. Fundamentals of colloids and interface sciences will be presented. Emphasis will be placed on nanoparticles synthesis and applications.

0640-643: ELECTROCHEMICAL ENGINEERING
CR: 3

This course covers the fundamental of electrochemistry. Students study thermodynamic, rection kinetics, and transport phenomena of electrode processes. The course will also highlight electrode structure, electrode deposition and electroanalytical techniques. In addition, this course includes application to batteries, fuel cell and supercapacitors. After completing this course students should be able to use the modern electrochemistry, fuel cell and battery technologies into their research and career.

0640-644: SURFACE CHEMISTRY & CATALYSIS
CR: 3

Chemistry and physics of the interactions between atoms and surfaces. Common experimental techniques related to probing and characterization of solid surfaces. Concepts of heterogenous catalysis.

0640-645: ADVANCED CORROSION ENGINEERING
CR: 3

This course covers fundamental aspects of corrosion. Different forms of corrosion and their mechanisms will be studied in this course. In addition, metallurgical factors influencing corrosion and how material selection and design influence corrosion resistance will be presented in this course. Students also will study corrosion prevention, control and testing methods. At the end of this course, students will have a strong foundation in how electrochemical thermodynamic and electrode kinetics control corrosion process and how they can improve corrosion resistance through design and proper selection of materials.

0640-648: ADVANCED MULTIVARIABLE PROCESS CONTROL
CR: 3

The course provides an overview of multivariable control techniques and covers both theory and practical applications. The course involves MATLAB/Simulink hands-on learning modules for understanding and solving advanced control problems. Topics that will be covered include control loop interactions, pairing variables, decoupling, digital control, and multiple aspects of MPC implementation, including dynamical system models, state estimation, unconstrained and constrained optimal control, and dynamic matrix control (DMC). Practical applications include non-isothermal reactors, distillation columns and fluidized catalytic cracking units (FCCU).

0640-651: COMPUTER CONTROL OF PROCESSES
CR: 3

Applications of digital computers sampled data systems Z-transforms, control of multiple input-multiple output systems, optimal control, state estimation and filtering, and self-tuning regulators.

0640-652: MODEL PREDICTIVE CONTROL
CREDITS 3

Model Predictive Control (MPC) is one of the predominant advanced control techniques. MPC originated in the chemical process industry and is now applicable to a wide range of application areas. MPC is an optimization-based technique, which uses predictions from a model over a future control horizon to determine control inputs. This course will provide an overview of MPC and will cover both theory and practical applications. The course will involve MATLAB-based hands-on learning modules for understanding and solving advanced control problems. The course will cover multiple aspects of MPC implementation, including dynamical system models, state estimation, unconstrained and constrained optimal control, and model identification. Applications of practical / industrial relevance will also be discussed.

0640-654: APPLIED NUMERICAL METHODS IN ENGINEERING
CR: 3

Numerical solution of systems of linear and non-linear algebraic equations, eigenvalue problems. Numerical solution of systems of ordinary and partial differential equations. Initial value and boundary value problems. Finite difference and finites element methods. Numerical stability.

0640-656: MACHINE LEARNING AND DATA SCIENCE IN PETROLEUM INDUSTRY
CR: 3

The course introduces all aspects of data science and machine learning in a practical approach. Topics covered include data pre- and post-processing, supervised and unsupervised learning techniques, different neural network architectures, and validation of developed models. Real case studies will be used to demonstrate how machine learning can be specifically tailored to handle problems from upstream and downstream petroleum industry. Applications include predictive maintenance, soft sensing, forecasting, pattern recognition, selection, and real-time monitoring and control.

0640-670: TEACHING EXPERIENCE IN CHEMICAL ENGINEERING
CR: 3

Taking an assignment as a teaching assistant in an undergraduate or a graduate course.

0640-597: DISSERTATION
CR: 0

0640-598: DISSERTATION
CR: 0

0640-599: DISSERTATION
CR: 36