

**Master of Science in Chemical Engineering**  
**Program code: 064010**

***INTRODUCTION***

The Department of Chemical Engineering (College of Engineering and Petroleum) offers a Master of Science program in **Chemical Engineering**. Research requirements include either thesis or non-thesis options. The program prepares qualified Engineers for an advanced professional career in three main areas: Water & Environmental Engineering, Petroleum Refining and Petrochemicals and Process Engineering & Economics. Research interests in the department lie in these four main areas: Environmental Process Engineering; Water technology, including Desalination and Waste Water Treatment; Petroleum and Petrochemical and Process System Engineering & Economics.

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

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***PROGRAM REQUIREMENTS***

**33 (33) TOTAL COURSE CREDITS** (non-thesis option in parenthesis)

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

**Student chooses 9 credits from the following courses:**

0640-511 Advanced Mathematics in Chemical Engineering

0640-521 Advanced Chemical Engineering Thermodynamics

0640-522 Advanced Reactor Design

0640-541 Advanced Momentum Transfer

**OR** 0600-510 Advanced Fluid Mechanics

0640-543 Advanced Heat Transfer

0640-544 Advanced Mass Transfer

0640-545 Advanced Transport Phenomena

0640-555 Chemical Process Dynamics and Control

**OR** 0670-560 Chemical Process Dynamics and Control

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

Student can select 9 credits from any of the following three sub-disciplines.

**I. WATER & ENVIRONMENTAL ENGINEERING**

0640-513 Food Processing

0640-551 Air Pollution Control

0640-552 Waste Minimization

0640-557 Industrial Water Treatment

- 0640-561 Advanced Desalination
- 0640-562 Multi-phase Flow
- 0640-565 Advanced Corrosion Engineering
- 0640-567 Membrane Technology
- 0640-569 Special Topics in Water Technology
- 0640-595 Special Topics in Pollution Engineering

## **II. PETROLEUM REFINING AND PETROCHEMICALS:**

- 0640-512 Fluidization Engineering
- 0640-563 Advanced Natural Gas Processing
- 0640-565 Advanced Corrosion Engineering
- 0640-566 Catalytic Process in Petroleum Refining
- 0640-570 Polymer Engineering
- 0640-571 Energy Conservation
- 0640-572 Advanced Petroleum Refining
- 0640-574 Estimation of Fluid Properties
- 0640-575 Fluid Phase Equilibrium
- 0640-577 Special Topics in Petrochemical Engineering
- 0640-579 Advanced Petrochemical Engineering

## **III. PROCESS ECONOMICS AND SYSTEMS ENGINEERING**

- 0640-540 Artificial Intelligence in Chemical Engineering
- 0640-553 Computer Aided Process Design
- 0640-555 Chemical Process Dynamics and Control
- 0640-571 Energy Conservation
- 0640-581 Advanced Economic Analysis
- 0640-582 Process Optimization
- 0640-583 Innovation and Technology Management
- 0640-584 Analytical Tools for Investment Management
- 0640-590 Special Topics in Process System Engineering
- 0640-591 Special Topics in Techno-Economics

## 6 (12) FREE ELECTIVE COURSES

A maximum of 3 credits hours (thesis students) and 6 credits hours (project students) of graduate courses can be taken from:

- Area of Engineering (Core and elective)
- Area of Science
- Area of Joint Graduate Programs (Engineering/Science Specialization)

with the approval of the graduate program director before registering for the course.

## 9 (3) COMPULSORY COURSES

|          |         |                       |
|----------|---------|-----------------------|
| 0640-592 | Seminar | (0)                   |
| 0640-593 | Project | (3) (non-thesis only) |
| 0640-597 | Thesis  | (0)                   |
| 0640-598 | Thesis  | (0)                   |
| 2000-599 | Thesis  | (9)                   |

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## COURSE DESCRIPTION

### 0640-511: ADVANCED MATHEMATICS IN CHEMICAL ENGINEERING CR: 3

First order differential equation. Partial differential equations. Laplace transforms. Fourier transform. Separation of variables. Similarity solution. Perturbation analysis. Polynomial approximation. Non-linear regression. Multiple regression. Introduction to neural networks.

### 0640-512: FLUIDIZATION ENGINEERING CR: 3

This objective of this course is to give students a good grounding in fluidization technology, which is widely employed in the petrochemical and other industry sectors. Topics to be covered include: basics of fluidization; types of fluidized bed (e.g. dense-phase, fast-fluidized beds, three-phase beds, etc.); industrial applications; gas distributors - their importance and design; gas cleaning equipment, e.g. cyclones, bag filters, etc., bubble mechanics; heat and mass transfer; modelling and design.

### 0640-513: FOOD PROCESSING CR: 3

Background to the food industry, food-processing operations; brief descriptions of relevant food chemistry and microbiology; heat-treatment operations; sterilization and pasteurization (retorting); UHT processing; refrigeration; and a

description of food processing sectors relevant to Kuwait (e.g. milling and baking).

### 0640-521: ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS CR: 3

Review of first second and third laws of thermodynamics. Applications of the first and second laws. Fundamental equations and thermodynamic relations. Gibbs-Duhem equation. Partial molar quantities. Equations of state and fugacity calculations. Thermodynamic departure quantities. Intermolecular forces and property estimations. Phase equilibrium calculations. Chemical reaction equilibrium and effects of temperature and pressure on reaction conversions. Statistical thermodynamics and partition functions. Use of statistical thermodynamics in estimating thermodynamic properties.

### 0640-522: ADVANCED REACTOR DESIGN CR: 3

Effect of temperature, pressure and mixing patterns on conversion and product distribution in complex homogeneous reactions. Theoretical models for non-ideal flow and fluid mixing.

**0640-540: ARTIFICIAL INTELLIGENCE IN CHEMICAL ENGINEERING  
CR: 3**

History of artificial intelligence. Expert system knowledge, computing and manipulation of knowledge. Process applications of expert systems such as the co-operate intelligence network, production management and supervision including setpoint optimization, process sequencing and production recipes. Process control applications in intelligent operator interface, predictive control and fuzzy control. Applications in safety systems and alarm management.

**0640-541: ADVANCED MOMENTUM TRANSFER  
CR: 3**

Different patterns of flow: in an annulus, two immiscible fluids, creeping. Equation of continuity, of motion and of change. Velocity distribution in turbulent flow. Time smoothed equations, eddy viscosity and friction factors for different flows. Fluidized bed hydrodynamics. Turbulence theory and applications to mixing.

**0640-543: ADVANCED HEAT TRANSFER  
CR: 3**

Correlations of heat transfer coefficient. Unsteady and two dimensional conduction: analytical solution compared to numerical techniques and where each method fits. Thermal boundary-layers flow and temperature distribution in turbulent flows. Application of different numerical techniques in fluid flow-heat transfer problems. Introduction to some topics in radiation. Two phase heat transfer case study for design.

**0640-544: ADVANCED MASS TRANSFER  
CR: 3**

Models for diffusion and dispersion. Mass transfer with chemical reactions. Simultaneous heat and mass transfer. Modelling of absorption, extraction and adsorption systems. Energy requirements for operations. Synthesis of separation sequences.

**0640-545: ADVANCED TRANSPORT PHENOMENA  
CR: 3**

Principles of molecular diffusion and measurement and characteristics of diffusion coefficient. Flow field induced by mass transfer. Heat and mass transfer in absence of a flow field. Flow field induced by body forces or external forces, finite

difference solution of transport problems. Moving boundary problems.

**0640-551: AIR POLLUTION CONTROL  
CR: 3**

Dispersion models of pollutants in the atmosphere. Particulate matter and design of control equipment. Gaseous pollutants and design of control equipment. Atmospheric photochemical reactions. Instrumentation, measurement and emission testing equipment. Air pollution packages. Application.

**0640-552: WASTE MINIMIZATION  
CR: 3**

Concept of clean technologies with minimal emissions. Concept of waste minimization and its applications in process design. Waste reduction technologies such as in-plant modifications, recycle, recovery and re-use and waste exchange. Case studies will include examples from petroleum refining, petrochemical and chemical industries.

**0640-553: COMPUTER AIDED PROCESS DESIGN  
CR: 3**

Introduction to Computer Aided Design (CAD). Chemical Engineering Simulation Systems (CHESS). Flow sheet synthesis. Distillation column simulators (Distill). Absorption, extraction and distillation simulators (ABDIS). Workshop problems.

**0640-555: CHEMICAL PROCESS DYNAMICS AND CONTROL  
CR: 3**

Mathematical principles of process dynamics and control. Derivation and solution of differential equations describing the behaviour of typical chemical engineering process units. Mathematical analysis and design of control systems. Digital and sampled data control systems.

**0640-557: INDUSTRIAL WATER TREATMENT  
CR: 3**

Application of chemical engineering principles to selected operations encountered in industrial waste water treatment. The course highlights the removal of suspended solids biological treatment, and chemical treatment methods.

**0640-561: ADVANCED DESALINATION  
CR: 3**

Development of desalination technology. Basic principles of desalination. Theory and practice of

the following desalination plants: Multistage flash distillation, multiple effect boiling, Reverse osmosis, electro dialysis, solar distillation, freezing. Dual-purpose desalination plants. Main problems in desalination (e.g. scale formations and corrosion). Cost considerations, comparative studies of some desalination plants.

**0640-562: MULTI-PHASE FLOW  
CR: 3**

Gas-liquid systems, solid-liquid systems, homogeneous slurries, heterogeneous slurries, long distance transportation in pipelines, gas-solid pneumatic transportation. Complex flow systems. Modelling and computational aid in multiphase flow.

**0640-563: ADVANCED NATURAL GAS  
PROCESSING  
CR: 3**

Layout of local petroleum industry, phase equilibria concepts, water-hydrocarbon systems, hydrate formation, amine treatment, carbonate treatment, liquifaction, liquids recovery.

**0640-565: ADVANCED CORROSION  
ENGINEERING  
CR: 3**

Advanced treatment of corrosion engineering with emphasis on industrial local problems. Atmospheric and seawater corrosion. Cathodic and anodic protection. Corrosion: Protection and inhibition.

**0640-566: CATALYTIC PROCESSES  
IN PETROLEUM REFINING  
CR: 3**

This course focuses on the design and modeling of various types of catalytic reactors used in Petroleum Refining Industry. Emphasis will be focused on the following refining operations: Catalytic cracking, catalytic hydrocracking, catalytic hydrotreating, catalytic reforming, catalytic isomerization, catalytic alkylation, and catalytic polymerization.

**0640-567: MEMBRANE TECHNOLOGY  
CR: 3**

Types of membrane separation processes. Gas permeation in a membrane. Dialysis. Reverse osmosis. Ultrafiltration membrane process. Gel permeation chromatography. Membrane

manufacture. Membrane physical and chemical properties.

**0640-569: SPECIAL TOPICS IN WATER  
TECHNOLOGY  
CR: 3**

An upper division of graduate technical elective treating topics in Engineering mostly not covered in other courses, chosen at the discretion of the Graduate Program Committee.

**0640-570: POLYMER ENGINEERING  
CR: 3**

Introduction to statistical mechanical theories. Brownian motion. Dynamics of flexible polymers in ideal solutions. Multichain systems. Viscoelasticity theories. Dynamic of a Polymer in a fixed network. Ridged rodlike polymers in ideal solutions. Ridged rodlike polymers in semidilute solutions. Ridged rodlike polymers in concentrated solutions.

**0640-571: ENERGY CONSERVATION  
CR: 3**

Thermodynamics and energy conservation, energy and separation processes, optimization of heat exchanger systems, thermally coupled distillation systems, heat pumps, hybrid desalination systems, economic analysis of technical solution to energy conservation problems, term paper.

**0640-572: ADVANCED PETROLEUM  
REFINING  
CR: 3**

Refinery configurations. Characterizations of crude oils and products. Coking. Catalytic cracking. Catalytic hydrocracking. Hydroprocessing and Hydrotreating. Reforming. Product blending. Computer simulation of refinery processes.

**0640-574: ESTIMATION OF FLUID  
PROPERTIES  
CR: 3**

Estimation procedures for properties of gases and liquids. Critical properties PVT, heat capacities. Thermodynamic properties, vapor pressure, surface tension, viscosities, thermal conductivities and diffusion coefficients. Application to industrial problems.

**0640-575: FLUID PHASE EQUILIBRIUM  
CR: 3**

Essence of the problem. Thermodynamics of phase equilibrium. Fugacity calculation of

thermodynamic properties of fluids using equation of state. Intermolecular forces and theory of corresponding states. Property changes on mixing phase rule. Gibbs Duhem equation. Fundamental equations of, calculation of vapor liquid, liquid-liquid-solubility stability. Application and impact of data precision on design.

**0640-577: SPECIAL TOPICS IN  
PETROCHEMICAL ENGINEERING  
CR: 3**

An upper division of graduate technical elective treating topics in mostly not covered in other courses, chosen at the discretion of the Graduate Program Committee.

**0640-579: ADVANCED PETROCHEMICAL  
ENGINEERING  
CR: 3**

Selected topics in Petrochemical Engineering. Production of alcohols, ethers, aromatics, ethylene, propylene and glycols. Computer simulation of one of the above topics.

**0640-581: ADVANCED ECONOMIC  
ANALYSIS  
CR: 3**

The project cycle. Financial statements and ration analysis. Discounted cash flow analysis. Decision rules for single and multiple alternatives. Inflation and currency issues. Rate of return and leverage. Cost/benefit analysis. Cost estimation. Sensitivity analysis and risk management. Monte Carlo simulation and decision tree analysis. Market assessment and forecasting. Supply and demand analysis. Project and case studies.

**0640-582: PROCESS OPTIMIZATION  
CR: 3**

This course surveys basic computational tools and theory for solving linear and nonlinear optimization problems. The value of these tools will be illustrated on applications including chemical plant design, process operations and scheduling, and parameter estimation. A main goal of the course is to introduce students to the philosophy underlying optimization and the tools necessary to implement this philosophy. A large variety of examples show the wide applicability of optimization methodology.

**0640-583: INNOVATION AND TECHNOLOGY  
MANAGEMENT  
CR: 3**

R&D environment. R&D communication and virtual teams. Integration of R&D into corporate strategy. Developing corporate competence area. Managing competence. Technology acquisition and transfer. Approaches to developing new business areas and management of change. Internal development, licensing, joint ventures, alliances, venture capital and acquisitions.

**0640-584: ANALYTICAL TOOLS FOR  
INVESTMENT MANAGEMENT  
CR: 3**

The concept of technical analysis. Dow theory and behavioral finance. Cycle theory and applications. The long wave and technological issues. Business and market cycles. Elliot wave theory. Fibonacci numbers and applications. Pattern recognition and time series identification. Input/output models and multivariable modelling. Neural networks and applications. Detrending techniques. Oscillators and market timing. Statistical analysis applied to investment management.

**0640-590: SPECIAL TOPICS IN PROCESS  
SYSTEM ENGINEERING  
CR: 3**

An upper division of graduate technical elective treating topics in Engineering mostly not covered in other courses, chosen at the discretion of the Graduate Program Committee.

**0640-591: SPECIAL TOPICS IN  
TECHNO-ECONOMICS  
CR: 3**

An upper division of graduate technical elective treating topics in Engineering mostly not covered in other courses, chosen at the discretion of the Graduate Program Committee.

**0640-592: SEMINAR  
CR: 0 CO-Requisites: 0640-593 Or 0640-597**

With the guidance of the graduate program committee, the seminar topics include:

- Research writing methods.
- Presentation skills
- Surveying literature.
- Bibliography style.
- New tools (LaTeX, Data analysis etc...)

**0640-593: PROJECT**

**CR: 3 CO-Requisites: 0640-592**

The student undertakes an independent project on a research topic of theoretical and/or experimental focus under the supervision of a faculty member listed in the supervisory list of the College of Graduate Studies. The objective is to provide the student with an opportunity to integrate and apply the knowledge gained throughout the course of study in a practical problem. The student must document the project in a scientific report following standard research writing guidelines and give a public presentation to the project examination committee.

**0640-595: SPECIAL TOPICS IN POLLUTION  
ENGINEERING**

**CR: 3**

An upper division of graduate technical elective treating topics in Engineering mostly not covered in other courses, chosen at the discretion of the Graduate Program Committee.

**0640-597: THESIS**

**CR: 0 CO-Requisites: 0640-592**

**0640-598: THESIS**

**CR: 0**

**2000-599: THESIS**

**CR: 9**