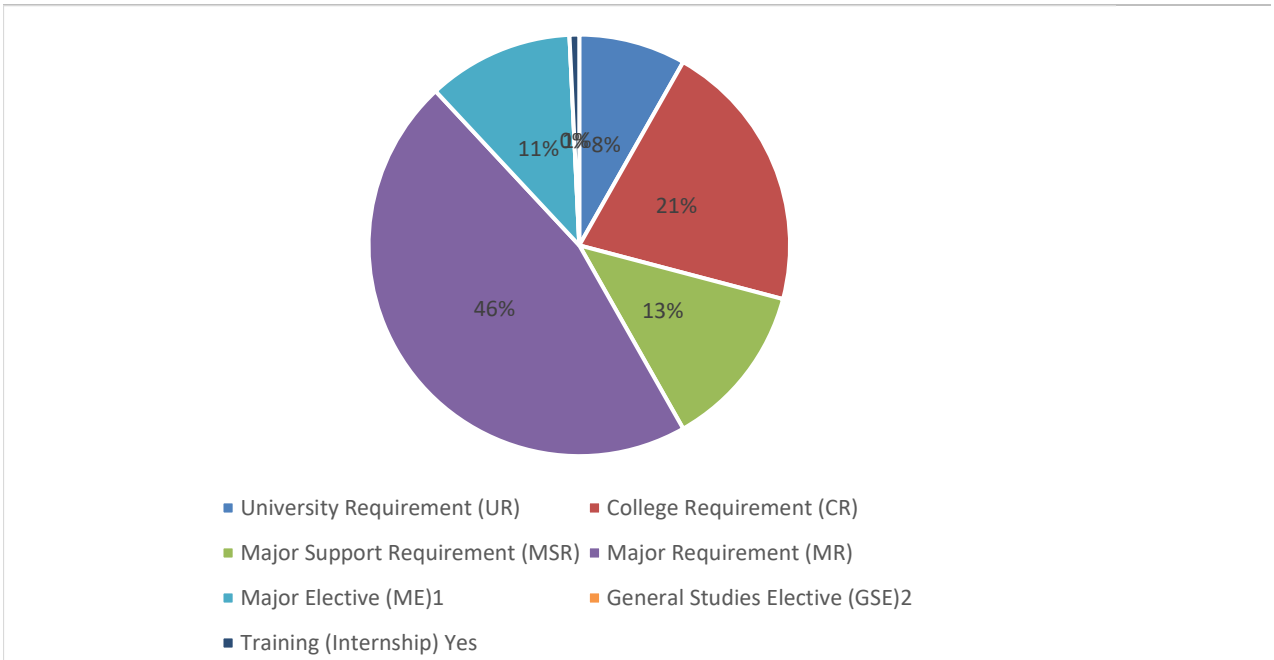
# Bachelor of Science in Chemical Engineering 2022

## Program Components




| | |
|---|---|
| **University Requirement (UR)** | **11** |
| **College Requirement (CR)** | **28** |
| **Major Requirement (MR)** | **62** |
| **Major Elective (ME)[1]** | **15** |
| **Major Support Requirement (MSR)** | **17** |
| **Minor Requirements (Minor)** | **------** |
| **Training** (Internship) **Yes** | **1** |
| **Total Credit (CRD)** | **134** |

## Detailed Study Plan

### Year 1 - Semester 1

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEMY 101 | General Chemistry I | 3 | 2 | 4 | CR | ------ | NO |
| ENGL 101 | Communication Skills I | 3 | 0 | 3 | CR | ------ | NO |
| ISLM 101 | Islamic Culture | 3 | 0 | 3 | UR | ------ | NO |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MATHS 101 | Calculus I | 3 | 0 | 3 | CR | ------ | NO |
| PHYCS 111 | Fundamentals of Physics | 3 | 2 | 4 | MSR | ------ | NO |
| | Total | 15 | 4 | 17 | | | |

## Year 1 - Semester 2

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| ARAB 110 | Arabic Language Skills | 3 | 0 | 3 | UR | ------ | NO |
| CHEMY 102 | General Chemistry II | 3 | 2 | 4 | MSR | CHEMY 101 | NO |
| CHEN 101 | Chemical Engineering Principles I | 2 | 2 | 3 | MR | CHEMY 101<br>MATHS 101 | YES |
| HIST 122 | Modern History of Bahrain and Citizenship | 3 | 0 | 3 | UR | ------ | NO |
| MATHS 102 | Calculus II | 3 | 0 | 3 | CR | MATHS 101 | NO |
| | Total | 14 | 4 | 16 | | | |

## Year 2 - Semester 3

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| BIOLS 261 | Introductory Biology for Engineering | 2 | 3 | 3 | MSR | ------ | NO |
| CHEMY 220 | Organic Chemistry for Chemical Engineering | 2 | 2 | 3 | MSR | CHEMY 102 | NO |
| CHEN 202 | Chemical Engineering Principles II | 2 | 2 | 3 | MR | CHEN 101<br>CHEMY 102 | YES |
| HRLC 107 | Human Rights | 2 | 0 | 2 | UR | ------ | NO |
| MATHS 203 | Calculus III | 3 | 0 | 3 | CR | MATHS 102 | NO |
| MATHS 205 | Differential Equations | 3 | 0 | 3 | CR | MATHS 102 | NO |
| | Total | 14 | 7 | 17 | | | |

## Year 2 - Semester 4

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 203 | Computer Programming & Applications for Chemical Engineering | 0 | 6 | 3 | MR | CHEN 202 | YES |
| CHEN 211 | Chemical Engineering Thermodynamics I | 2 | 2 | 3 | MR | CHEN 202 | YES |
| CHEN 213 | Fluid Mechanics | 2 | 2 | 3 | MR | CHEN 202<br>MATHS 205 | YES |
| EENG 263 | Circuits and Electronics | 3 | 2 | 3 | MSR | MATHS 101<br>PHYCS 111 | NO |
| ENGL 242 | Report Writing and Presentation | 3 | 0 | 3 | CR | ENGL 101 | NO |
| | Total | 10 | 12 | 15 | | | |

## Year 3 - Semester 5

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 304 | Linear Algebra and Numerical Methods | 2 | 2 | 3 | MR | CHEN 203<br>MATHS 205 | YES |
| CHEN 312 | Chemical Engineering Thermodynamics II | 2 | 2 | 3 | MR | CHEN 211 | YES |
| CHEN 314 | Heat Transfer | 2 | 2 | 3 | MR | CHEN 213 | YES |
| CHEN 315 | Mass Transfer | 2 | 2 | 3 | MR | CHEN 213 | YES |
| CHEN 316 | Applied Physical Chemistry | 2 | 2 | 3 | MR | CHEN 202 | YES |
| MENG 303 | Engineering Economics | 3 | 0 | 3 | CR | Completion of 70 credits | NO |
| | Total | 13 | 10 | 18 | | | |

## Year 3 - Semester 6

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 305 | Properties and Strength of Materials | 2 | 2 | 3 | MR | CHEN 316<br>PHYCS 111 | YES |
| CHEN 317 | Chemical Reactor Analysis and Design | 2 | 2 | 3 | MR | BIOLS 261<br>CHEN 314<br>CHEN 316 | YES |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CHEN 321 | Chemical Engineering Laboratory I | 0 | 6 | 3 | MR | CHEN 312<br>CHEN 314<br>ENGL 242 | YES |
| CHEN 323 | Equilibrium Stage Separation Processes | 2 | 2 | 3 | MR | CHEN 312<br>CHEN 315 | YES |
| STAT 276 | Statistical Data Analysis for Engineering | 3 | 0 | 3 | CR | MATHS 102 | NO |
| | Total | 9 | 12 | 15 | | | |

**Training Requirement**

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 390 | Industrial Training | 0 | 3* | 1 | MRT | Completion of 90 credits | YES |

***** 300 hours of supervised training.

## Option 1: Process Systems

Process Systems option includes a package of five major electives shown in italic: CHEN 431, CHEN 432, CHEN 433, CHEN 434, and CHEN 4xx.

### Year 4 - Semester 7

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 424 | Process Control | 4 | 1 | 4 | MR | CHEN 317<br>CHEN 323 | YES |
| CHEN 425 | Process Equipment Design | 2 | 2 | 3 | MR | CHEN 314<br>CHEN 323 | YES |
| CHEN 426 | Process Design and Economics | 2 | 2 | 3 | MR | CHEN 317<br>CHEN 323 | YES |
| *CHEN 431* | *Process Optimization* | 2 | 2 | 3 | ME | CHEN 304 | YES |
| *CHEN 432* | *Computer-Aided Modeling and Simulation* | 2 | 2 | 3 | ME | CHEN 304<br>CHEN 317<br>CHEN 323 | YES |
| CHEN 495 | Senior Project I | 0 | 3 | 1 | MR | Completion of 90 credits | YES |
| | Total | 12 | 12 | 17 | | | |

### Year 4 - Semester 8

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 422 | Chemical Engineering Laboratory II | 0 | 6 | 3 | MR | CHEN 317<br>CHEN 321<br>CHEN 323<br>CHEN 424 | YES |
| CHEN 427 | Capstone Plant Design | 0 | 6 | 3 | MR | CHEN 425<br>CHEN 426 | YES |
| *CHEN 433* | *Heat Integration* | 2 | 2 | 3 | ME | CHEN 211<br>CHEN 314 | YES |
| *CHEN 434* | *Plantwide Process Control* | 2 | 2 | 3 | ME | CHEN 424<br>CHEN 431 | YES |
| CHEN 496 | Senior Project II | 0 | 9 | 3 | MR | CHEN 495 | YES |
| *CHEN 4xx* | *Elective* | 2 | 2 | 3 | ME | | YES |
| | Total | 6 | 27 | 18 | | | |

Total Credits Hours required in the B.Sc. Program = 134 Credits

## *OPTION 2: OIL AND GAS*

Oil and Gas option includes a package of five major electives shown in italic: CHEN 441, CHEN 442, CHEN 443, CHEN 444, and CHEN 4xx.

**Year 4 - Semester 7**

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 424 | Process Control | 4 | 1 | 4 | MR | CHEN 217<br>CHEN 323 | YES |
| CHEN 425 | Process Equipment Design | 2 | 2 | 3 | MR | CHEN 314<br>CHEN 323 | YES |
| CHEN 426 | Process Design and Economics | 2 | 2 | 3 | MR | CHEN 317<br>CHEN 323 | YES |
| *CHEN 441* | *Petroleum Engineering* | 3 | 2 | 3 | ME | CHEN 213<br>CHEMY 220<br>CHEN 315 | YES |
| *CHEN 442* | *Petroleum Refinery Engineering* | 2 | 2 | 3 | ME | CHEN 323<br>CHEN 317<br>CHEMY 220 | YES |
| CHEN 495 | Senior Project I | 0 | 3 | 1 | MR | Completion of 90 credits | YES |
| | Total | 13 | 12 | 17 | | | |

**Year 4 - Semester 8**

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 422 | Chemical Engineering Laboratory II | 0 | 6 | 3 | MR | CHEN 317<br>CHEN 321<br>CHEN 323<br>CHEN 424 | YES |
| CHEN 427 | Capstone Plant Design | 0 | 6 | 3 | MR | CHEN 425<br>CHEN 426 | YES |
| *CHEN 443* | *Natural Gas Processing* | 2 | 2 | 3 | ME | CHEN 323<br>CHEMY 220 | YES |
| *CHEN 444* | *Petrochemical Processing* | 2 | 2 | 3 | ME | CHEN 323<br>CHEN 317<br>CHEMY 220 | YES |
| CHEN 496 | Senior Project II | 0 | 9 | 3 | MR | CHEN 495 | YES |
| *CHEN 4xx* | *Elective* | 2 | 2 | 3 | ME | | YES |
| | Total | 6 | 27 | 18 | | | |

Total Credits Hours required in the B.Sc. Program = 134 Credits

# Major Elective Courses

Students must choose one elective course from the following list:

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 471 | Aluminum Processing | 2 | 2 | 3 | ME | CHEN 316 | YES |
| CHEN 472 | Analytical Measurements | 2 | 2 | 3 | ME | CHEN 316 | YES |
| CHEN 473 | Bioprocess Engineering | 2 | 2 | 3 | ME | CHEN 317 | YES |
| CHEN 474 | Corrosion Engineering | 2 | 2 | 3 | ME | CHEN 305 | YES |
| CHEN 475 | Environmental Engineering | 2 | 2 | 3 | ME | CHEN 315 | YES |
| CHEN 476 | Process Safety | 2 | 2 | 3 | ME | CHEN 312 | YES |
| CHEN 477 | Quality Assurance and Reliability Engineering | 2 | 2 | 3 | ME | Completion of 90 credits | YES |
| CHEN 478 | Water Desalination | 2 | 2 | 3 | ME | CHEN 315 | YES |
| CHEN 479 | Special Topics | 2 | 2 | 3 | ME | Completion of 90 credits | YES |
| MENG 420 | Project Management | 3 | 1 | 3 | ME | MENG 303 | YES |

For students registered in Option 1 (Process Systems), the following courses are considered part of the list of elective courses:

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 441 | Petroleum Engineering | 2 | 2 | 3 | ME | CHEN 213, CHEMY 220 & CHEN 315 | YES |
| CHEN 442 | Petroleum Refinery Engineering | 2 | 2 | 3 | ME | CHEN 312, CHEN 317 & CHEMY 220 | YES |
| CHEN 443 | Natural Gas Processing | 2 | 2 | 3 | ME | CHEN 323 & CHEMY 220 | YES |
| CHEN 444 | Petrochemical Processing | 2 | 2 | 3 | ME | CHEN 312, CHEN 317 & CHEMY 220 | YES |

For students registered in Option 2 (Oil and Gas), the following courses are considered part of the list of elective courses:

| Course Code | Course Title | Course Hours | | | Course Type | Pre requisite | Major GPA |
|---|---|---|---|---|---|---|---|
| | | LEC | PRAC | CRD | | | |
| CHEN 431 | Process Optimization | 2 | 2 | 3 | ME | CHEN 304 | YES |
| CHEN 432 | Computer-Aided Modeling and Simulation | 1 | 4 | 3 | ME | CHEN 304<br>CHEN 317<br>CHEN 323 | YES |
| CHEN 481 | Principles of Enhanced Oil Recovery | 2 | 2 | 3 | ME | CHEN 213<br>CHEN 441 | YES |
| CHEN 482 | Well Testing and Performance | 2 | 2 | 3 | ME | CHEN 213<br>CHEN 441 | YES |

# Courses Descriptions

## Description of Major Courses

**Course Code:** CHEN 101 **Course Title:** Chemical Engineering Principles I
Units and dimensions. Introduction to chemical process calculations. Processes and process variables. Process flowcharts. Material balances on single and multiple-unit processes, without and with chemical reactions, including bypass and recycle. Introduction to single-phase systems: solid/liquid densities, ideal gases, introduction to non-ideal gases EOS, the compressibility factor. Tools: spreadsheet software (e.g., Microsoft® Excel).

**Course Code:** CHEN 202 **Course Title:** Chemical Engineering Principles II
Introduction to multiphase systems: single-component phase equilibrium, Gibbs phase rule, one condensable component, multicomponent gas-liquid systems. Forms of energy and energy conservation law. Energy balance on closed and open systems. Tables and charts of thermodynamic data. Combined material and energy balances on nonreactive and reactive processes. Computer-aided balance calculations. A case study on a chemical process. Tools: spreadsheet software (e.g., Microsoft® Excel).

**Course Code:** CHEN 203 **Course Title:** Computer Programming & Applications for Chemical Engineering
Introduction to modern programming languages. MATLAB®: creating vector and matrices, if statements, while and for loops, script and function files, matrix operations, MATLAB® built-in functions, plot commands. Solving systems of linear and nonlinear equations. Introduction to chemical process flowsheet package, applications to material and energy balances. Tools: chemical process flowsheet package (e.g., AspenTech products), programming and computing environment (e.g., MATLAB®).

**Course Code:** CHEN 211 **Course Title:** Chemical Engineering Thermodynamics I
First law of thermodynamics. Applications of the first law for closed, open, steady and unsteady systems. Volumetric properties of pure fluids. Heat effects. The second law of thermodynamics, heat engines, heat pumps and refrigerators, reversible and irreversible processes, Carnot cycle and performance indicators. Entropy and entropy relations. Applications of the second law to steady-flow devices. Vapor power cycles and vapor-compression refrigeration cycles. Tools: spreadsheet software (e.g., Microsoft® Excel), programming and computing environment (e.g., MATLAB®).

**Course Code:** CHEN 213 **Course Title:** Fluid Mechanics
Classification of fluids. Fluid statics. Flow of fluids in closed conduits. Friction factor. The mechanical energy balance. Bernoulli's equation and fluid flow measurements. Characteristics of pumps. Compressible flow. Momentum balance. Navier-Stokes equations. Dimensional analysis. Laminar boundary layer. Universal velocity distribution. Flow past regular bodies, flow through packed beds, fluidization. Tools: spreadsheet software (e.g., Microsoft® Excel), programming and computing environment (e.g., MATLAB®).

**Course Code:** CHEN 304 **Course Title:** Linear Algebra and Numerical Methods
Linear algebraic equations and selected matrix operations (e.g., Reduced row echelon form, Eigenvalues etc.). Numerical Methods and errors. Numerical solution of systems of linear equations: Elimination and iterative methods. Numerical solution of nonlinear equations: bracketed and open methods. Open methods for simultaneous nonlinear equations. Interpolation and curve-fitting. Finite difference methods. Numerical differentiation and integration. Solution of ODE's - Initial Value Problems. Applications related to chemical engineering. Tools: spreadsheet software (e.g., Microsoft® Excel), programming and computing environment (e.g., MATLAB®)

**Course Code:** CHEN 305 **Course Title:** Properties and Strength of Materials
Major strands of materials. Processing, structure, properties, and performance of materials. Crystalline and amorphous materials, lattice parameter, crystalline systems, crystalline structures. Unit cells, coordinate indices, imperfect lattice and crystalline defects. Mechanical property, elastic, plastic and fracture phases. Elements of failure analysis and design/safety factors. Thermomechanical processing and materials strengthening. Design using fracture mechanics and emanating materials selection. Fundamentals of corrosion. Related laboratory experiments. Tools: spreadsheet software (e.g., Microsoft® Excel).

**Course Code:** CHEN 312 **Course Title:** Chemical Engineering Thermodynamics II
Thermodynamic properties of fluids: Maxwell equations, residual properties, enthalpy of vaporization calculations. Vapor/liquid equilibrium calculations. Solution thermodynamics: theory and applications, partial molar properties and fugacity. Topics in phase equilibrium: excess properties, activity coefficient calculation. Chemical reaction equilibria: Gibbs energy change, effect of temperature, composition and pressure on equilibrium constant. Tools: spreadsheet software (e.g., Microsoft® Excel), chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 314 **Course Title:** Heat Transfer
Modes of heat transfer. Mechanism of conduction in gases, liquids and solids. Steady-state heat conduction in one and two dimensions, transient heat conduction. Convection, equations of momentum and heat transport. Dimensionless correlations for free and forced convection. Heat transfer with phase change: boiling, condensation, and evaporation. Thermal radiation. Heat exchangers. Tools: spreadsheet software (e.g., Microsoft® Excel), chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 315 **Course Title:** Mass Transfer
Fundamentals of mass transfer. The control volume approach to the mass transfer processes. Diffusion coefficients. Mass transfer across phase boundary. Mass transfer coefficients. Convective mass transfer correlations. Rate based mass transfer operations in chemical engineering: drying, absorption, membrane separation. Adsorption: mechanisms and types of adsorption, adsorption isotherms, breakthrough curves, sizing of adsorption packed bed. Tools: spreadsheet software (e.g., Microsoft® Excel).

**Course Code:** CHEN 316 **Course Title:** Applied Physical Chemistry
The rate of reaction and its relation to chemical reaction equilibria. The general mole balance equation for reactors, conversion, and reactor sizing. Stoichiometry and rate laws. Collection and analysis of rate data. Reaction mechanisms: active intermediates and non-elementary rate laws, fundamentals of enzyme kinetics and inhibition. The adsorption theory. Electrochemistry: electrochemical cells, cell potential under standard and non-standard conditions, application of electrochemistry. Tools: spreadsheet software (e.g., Microsoft® Excel), programming and computing environment (e.g., MATLAB®).

**Course Code:** CHEN 317 **Course Title:** Chemical Reactor Analysis and Design
Mole balances on ideal reactors. Isothermal reactor design of constant and variable density systems. Pressure drop in reactors. Non-isothermal reactor design. Design of reactors for multiple reactions. Kinetics of heterogenous catalytic reactions. Mass transfer effects. Design of heterogeneous reactors. Bioreactors. Tools: spreadsheet software (e.g., Microsoft® Excel), chemical process flowsheet package (e.g., AspenTech products), programming and computing environment (e.g., MATLAB®).

**Course Code:** CHEN 321 **Course Title:** Chemical Engineering Laboratory I
Developing awareness of laboratory safety. Laboratory work in thermodynamics and unit operations involving heat and momentum transfer. Error analysis and interpretation of experimental data. Improving teamwork, technical report writing and oral presentation skills. At least one experiment should demonstrate on-line measurement and data acquisition. Tools: spreadsheet software (e.g., Microsoft® Excel).

**Course Code:** CHEN 323 **Course Title:** Equilibrium Stage Separation Processes
Single equilibrium stages and flash calculations. Continuous distillation: McCabe-Thiele and Ponchon-Savarit methods. Liquid-liquid extraction with ternary systems: Hunter and Nash method. Approximate methods for multicomponent multistage separations. Batch distillation with reflux. Absorption and stripping. Tools: chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 390 **Course Title:** Industrial Training
All students in the program must participate in an approved training program in a relevant industry. At the completion of 300 hours of supervised training, each student must submit a formal report and conduct an oral presentation.

**Course Code:** CHEN 422 **Course Title:** Chemical Engineering Laboratory II
Laboratory safety awareness. Experiments in reaction engineering, process control and unit operations involving mass transfer. Error analysis and interpretation of experimental data. Teamwork and communication skills. Application of

statistical Design of Experiment (DoE) for conducting at least one experiment. Tools: spreadsheet software (e.g., Microsoft® Excel), design of experiment software (e.g., Minitab), chemical process flowsheet package (e.g., AspenTech products). Applications of virtual reality experiments.

**Course Code:** CHEN 424 **Course Title:** Process Control

Introduction to feedback control. Control loop elements. Control system instrumentation. Piping and Instrumentation Diagram (P&ID). Transfer functions. Process dynamics. Development of empirical dynamic models from step response data. Stability of closed-loop systems. Controller tuning and troubleshooting control loops. Controller design using frequency response criteria. Advanced control strategies. Cascade, Feed-forward Control, etc. Synthesis of control systems for complete plants. Tools: programming environment (e.g., MATLAB®).

**Course Code:** CHEN 425 **Course Title:** Process Equipment Design

Fluid flow and fluid handling, head loss calculations, economic pipe size, design of pumping systems. Compressors. Mixing and agitation of liquids. Estimation of individual, overall and fouling heat transfer coefficients. Design of shelland-tube heat exchangers. Mass transfer operations, shortcut design methods, tray hydraulics and efficiencies. Process vessels design. Tools: chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 426 **Course Title:** Process Design and Economics

Methodology of approaching open-ended design problems. Engineering method of design, hierarchy of decisions, structures of process flow sheets and evolution of process design. Evaluation of process alternatives. Safety and environmental impacts of chemical processes. HAZOP study. Economic methods of estimating capital and production costs, profitability analysis. Tools: spreadsheet software (e.g., Microsoft® Excel), chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 427 **Course Title:** Capstone Plant Design

The course is a comprehensive design problem to be undertaken by students working in groups and individually. It presents an overall analysis of the major factors involved in process design, with emphasis on ethical, economic, environmental, safety and health considerations. The design project illustrates computer-aided plant design based on fundamental understanding of chemical process engineering. Written design reports and oral presentations are required periodically. Tools: chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 495 **Course Title:** Senior Project I

In this 1$^{st}$ phase of the project, a preliminary study is carried out in teams under the supervision of a faculty member on an approved proposal of a research project relevant to the field. The research project may be of experimental or theoretical nature, where the application of engineering knowledge towards the project development is demonstrated. This phase involves a thorough literature review, the development of a detailed implementation plan, as well as the conduction of any preliminary studies and preparation needed for the execution of the 2nd phase of the project in the subsequent course (Senior Project II). An end-of-term written report is required.

**Course Code:** CHEN 496 **Course Title:** Senior Project II

In this 2nd phase of the project, the development and implementation of the research project are continued by the same team under the supervision of the same faculty member. This phase involves accurate implementation and completion of the project tasks, deep analysis of the results, and logical and evident-based reasoning of the outcomes and drawn conclusions. End-of-term written formal report, poster, and oral presentation are required.

# Description of Major Electives of Option 1: Process Systems

**Course Code:** CHEN 431 **Course Title:** Process Optimization
Uses of mathematical models. Model building and solution. Formulation of the optimization problem. Basic concepts of optimization: stationary points of a function, unimodal and multimodal functions, convexity etc. Optimization of unconstrained single and multi-variable functions: direct and indirect search methods. Linear programming: simplex algorithm. Integer linear programming: branch and bound. Nonlinear constrained optimization problems: selected techniques. Case studies. Tools: spreadsheet software (e.g., Microsoft® Excel), programming and computing environment (e.g., MATLAB®).

**Course Code:** CHEN 432 **Course Title:** Computer-Aided Modeling and Simulation
Degree of freedom analysis. Material and Energy balances in Process flow sheets. Strategy of manual calculations. The single-unit case. The multiunit case. Strategy for machine computations. Sequential modular, elements of a modular simulation. Cyclic Systems and Convergence block. Simultaneous solution strategies. Equation-Tearing procedures. Inside-Out method. Tools: chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 433 **Course Title:** Heat Integration
Energy targets for heat exchanger networks and utilities. Composite curves, the heat recovery pinch, the threshold problems. The problem table algorithm, process constraints. Utility selection, furnaces, combined heat, and power (co-generation). Heat exchanger: number of units and targets. Heat exchanger network design, the pinch design method. Use of the grand composite curve. Tools: spreadsheet software (e.g., Microsoft® Excel), chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 434 **Course Title:** Plantwide Process Control
Nature of Multivariable Systems. Process interactions and Control loop interactions. Pairing of controlled and manipulated variables. Controllability and Observability. Plantwide control fundamentals. Integrated processes, units in series, effects of recycle, reaction/separation interaction. Common Plantwide control design procedures. Control of individual units: reactors, heat exchangers, distillation columns, other common unit operations e.g., furnaces, compressors etc. Industrial examples using computer-aided design software. Tools: chemical process flowsheet package (e.g., AspenTech products).

# Description of Major Electives of Option 2: Oil and Gas

**Course Code:** CHEN 441 **Course Title:** Petroleum Engineering
Origin, composition and properties of petroleum fluids. Reservoir rocks and their properties. Predication of oil reservoir behavior, material balance, reservoir simulation. Basic drilling techniques. Details of drilling equipment and accessories. Oil well completion, testing and production of oil and gas. Reservoir life and improving of oil and gas recovery. Tools: finite element method (FEM)-based package (e.g., COMSOL Multiphysics®).

**Course Code:** CHEN 442 **Course Title:** Petroleum Refinery Engineering
Refinery organization. Refinery feed stock and products. Crude oil characterization. Crude oil distillation. Chemical conversion processes: cracking, reforming, alkylation and polymerization. Blending processes. Design and simulation of typical equipment/unit operations. Refinery economics and planning. Tools: spreadsheet software (e.g., Microsoft® Excel), chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 443 **Course Title:** Natural Gas Processing
Introduction to natural gas processing principles, technology and engineering design. Overview of natural gas resources. Properties and behavior of natural gas. Gas liquid separators. Compression and transportation of natural gas. Simulation, design and cost estimation of the main gas treatment processes such as dehydration, sweetening, liquefaction, sulfur recovery. Tools: spreadsheet software (e.g., Microsoft® Excel), chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 444 **Course Title:** Petrochemical Processing
Overview of the petrochemical industry. Raw materials for the petrochemical industry. Petrochemicals from methane: synthesis gas, ammonia and methanol. Production of olefins. Petrochemicals from ethylene. Petrochemicals from propylene and higher olefins. Petrochemicals from benzene, toluene, and xylene. Synthetic Petroleum-Based Polymers. Complete simulation and economic analysis of one selected process is introduced. Tools: chemical process flowsheet package (e.g., AspenTech products).

# Description of the other Major Elective Courses

**Course Code:** CHEN 471 **Course Title:** Aluminum Processing
Aluminum properties, production evolution and role in present industries and world economy. Upstream Bauxite (Ore) refining and smelting of hi-purity aluminum. Simulation of coke calcining process and anode production. Unit operations in aluminum plant. Principles of electro-chemistry. International standards of Aluminum Alloys (AA) classification. Development of cast structure and solidification essentials. Downstream processing routes. Metallurgical principles of AA Thermo-Mechanical Processing. Technological status of AA applications. Recycling and environmental impacts. Tools: chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 472 **Course Title:** Analytical Measurements
Fundamental principles of operation. Application of in-situ and real-time analyzers for industrial processes and environmental monitoring, including spectroscopic, chromatographic, chemiluminescence and electrochemical techniques. Introduction to chemometric analysis, total chemical analysis, and flow injection analysis. Miniaturization of analytical systems, including their principles, designs and applications.

**Course Code:** CHEN 473 **Course Title:** Bioprocess Engineering
Key concepts on biotechnology/bioprocess engineering; Fundamentals of biochemistry and microbiology. The kinetics of enzyme-catalysed reaction. Growth kinetics of cells and substrate utilization. Stoichiometry of microbial growth and product formation. Engineering principles for bioprocess including the design and analysis of bioreactors, scale-up of bioreactors. Sterilization and recovery of fermentation products. Biotechnology applications in process engineering. Tools: chemical process flowsheet package (e.g., AspenTech products).

**Course Code:** CHEN 474 **Course Title:** Corrosion Engineering
Corrosion thermodynamics and kinetics. Polarization and mixed potential theory. Corrosion mechanisms. Forms of corrosion: uniform corrosion, pitting, stress corrosion cracking, crevice corrosion, microbial corrosion, bio fouling. Corrosion testing and inspection methods. Important process variables in corrosion severity. Prevention of corrosion: physical, chemical, and electrical methods. Design of corrosion prevention systems and related economy. Failure analysis. Case studies.

**Course Code:** CHEN 475 **Course Title:** Environmental Engineering
Engineering and sustainable development. Environmental measurements. Environmental standards and legislation. Air pollution: human health, emissions, and control technologies. Greenhouse gases and climate change. Solid-waste management. Wastewater treatment: primary, secondary, tertiary and sludge disposal and treatment.

**Course Code:** CHEN 476 **Course Title:** Process Safety
Safety awareness. Learning from disasters. Hazard, accident and risk. Types of hazards and hazard identification; HAZOP. Toxic release and dispersion models. Fires and explosions, and designs to prevent them. Reliefs and relief sizing. Inherently safer pre-design. Risk assessment and management.

**Course Code:** CHEN 477 **Course Title:** Quality Assurance and Reliability Engineering
Quality assurance, understanding, commitment, leadership, and organization. The role of quality system, planning, flow-charting. How to maintain plant quality and operation reliability. Causes and consequences of failure. Reliability of series, parallel, standby, and complex systems. Analytical methods including fault trees. Implementation methods, communication and training for quality. Guidelines for writing a quality manual.

**Course Code:** CHEN 478 **Course Title:** Water Desalination
Water chemistry, types and qualities. Classification of desalination processes. Theoretical and practical aspects of seawater and ground water desalination technologies, including thermal-based (MSF, MED, VC) and membrane-based (RO and other desalination processes). Design and performance of desalination processes. Fouling, scaling and cleaning. Water pre-treatment and post-treatment. Economics of desalinated water. Environmental issues in desalination.

**Course Code:** CHEN 479 **Course Title:** Special Topics

Any important, relevant topic that is not covered in the given elective list. Topics may be varied subject to students' interest and availability of staff

**Course Code:** CHEN 481 **Course Title:** Principles of Enhanced Oil Recovery

Introduction to enhanced oil recovery (EOR) different techniques including chemical flooding (surfactants flooding, polymers flooding), miscible-gas displacement (LPG, $CO_2$/$N_2$/Flue gas), thermal processes (steam flooding, hot water/steam flooding, in situ combustion etc.) and environment friendly approach (microbial EOR). The advantages and drawbacks of each technique are discussed and linked to typical selection criteria for target reservoirs. A simple performance prediction procedure for each process is also covered.

**Course Code:** CHEN 482 **Course Title:** Well Testing and Performance

Introduction to the different methodologies used in well testing including single and multi-rate testing, single and multi-well testing, homogeneous and heterogeneous reservoirs. Fluid flow equations under steady-state and transient behavior, derivation of the diffusivity equation, solution of the diffusivity equation, analysis of pressure drawdown and buildup tests, wellbore storage and skin effects, behavior of vertically fractured wells, behavior of dual porosity reservoir systems, analysis of production performance, rate forecasting using semi-analytical, empirical, and IPR methods, deliverability testing.

**Course Code:** MENG 420 **Course Title:** Engineering Management

Introduction to engineering management. Types and characteristics of production systems. Forecasting methods and techniques. Product design. Capacity planning. Aggregate planning. Inventory planning and materials management. Short term scheduling. Quality management and quality control. Job design and work methods. Project planning and scheduling.

# Description of Major Support Requirement Courses

**Course Code:** BIOLS 261 **Course Title:** Introductory Biology for Engineering
Fundamental concepts in understanding biochemistry and cell biology. Chemistry of amino acids, carbohydrates, lipids, nucleic acids including DNA, RNA, and protein synthesis. Properties and functions of biopolymers. Cell structure and diversity, and relationship of biochemistry with cell metabolism. Molecular genetics. Application in biomimetic, proteomics/metabolomics, system biology and high throughput analysis.

**Course Code:** CHEMY 102 **Course Title:** General Chemistry II
Gaseous equilibrium (equilibrium constant, Kc and Kp); acids and bases (water dissociation, pH, weak acids and bases, salts); acid-base and precipitation equilibria (buffers, indicators, titrations, pH curves); thermochemistry (calorimetry, enthalpy, thermochemical equations, heats of formation, first law of thermodynamics); rate of reaction, rate and concentration, concentration and time, activation energy, rate and temperature, catalysis, mechanisms; electrochemistry; voltaic cells; cell voltages. Organic chemistry (alkanes, alkenes, alkynes, isomerism, nomenclature, arenas, functional groups, reaction). Related practical work.

**Course Code:** CHEMY 220 **Course Title:** Organic Chemistry for Chemical Engineering
Isomerism; alkanes and cycloalkanes; geometric isomerism; alkenes and alkynes; petroleum; gasoline; and octane number, aromatic compounds; polycyclic aromatic hydrocarbons, Phenols and thiols, ethers and epoxides; aldehydes and ketones; tautomerism; carboxylic acids and their derivatives. Related practical work.

**Course Code:** EENG 263 **Course Title:** Circuits and Electronics
Fundamentals of circuit theory: Ohm and Kirchoff Laws; series/parallel AC/DC circuits; basic DC/AC circuit analysis tools and theorems; transient and steady-state analysis of RLC circuits. Fundamentals of power systems: single and three-phase balanced and unbalanced systems. Fundamentals of electronics: basic semiconductor devices; diode and transistor types with applications; ideal operational amplifier with applications. Related laboratory experiments.

**Course Code:** PHYCS 111 **Course Title:** Fundamentals of Physics
Vectors and scalars; straight line and projectile motion; Newton's laws of motion; work, energy and power, momentum and impulse; rotational motion; periodic motion; the electric field; Gauss's law; electric potential; capacitance and dielectrics; magnetic fields and magnetic forces.

# College Requirement Courses Descriptions

**Course Code:** CHEMY 101 **Course Title:** General Chemistry I

Significant figures, chemical formulas and equations; mass relations, limiting reactions and theoretical yield; Physical behavior of gases; electronic structure, periodic table, covalent bonding; Lewis structures, Molecular structures, hybridization; molecular orbitals, solutions; colligative properties. Related practical work.

**Course Code:** ENGL 101 **Course Title:** Communication Skills I

This course focuses on reading skills and strategies and language development. The reading section concentrates on high-interest contemporary topics and encourages students to increase speed and efficiency. The writing component, integrated to the reading materials, reviews grammatical structures, develops language accuracy and introduces paragraph writing. Students are required to upgrade their grammar, reading, and listening skills on the internet.

**Course Code:** ENGL 242 **Course Title:** Report Writing and Presentation

To develop theoretical and practical skills of technical report writing and oral presentation. Students are to be given a number of specific technical report tasks to complete and present orally.

**Course Code:** MATHS 101 **Course Title:** Calculus I

Algebra. Functions and graphs. Trigonometry. Conic sections. Limits and continuity. Derivatives and integrals. Applications of derivatives which include mean value theorem, extrema of functions and optimization. Definite integrals and the Fundamental Theorem of Calculus.

**Course Code:** MATHS 102 **Course Title:** Calculus II

Applications of definite integrals, including areas, volumes and surface areas of solids of revolution, arc length and centroids. Transcendental functions, indeterminate form and L'Hopital's Rule. Techniques of integration and improper integrals. Infinite series, power series. Maclaurin and Taylor Theorem.

**Course Code:** MATHS 203 **Course Title:** Calculus III

Parametric equations and polar coordinates. Vectors and surfaces. Limits, derivatives, and integrals of vector-valued functions. Partial differentiation. Multiple and line integrals and their applications. Green's and Stokes' Theorems.

**Course Code:** MATHS 205 **Course Title:** Differential Equations

Differential equations of first order and their solution. Separable and exact equations. Equations convertible to separable type. Higher order linear equations with constant coefficients (homogeneous and non-homogeneous). Power series method for second order linear equations. Variation of parameters. Laplace transform technique. Applications of differential equations.

**Course Code:** MENG 303 **Course Title:** Engineering Economics

Fundamentals of engineering economy. Time value of money. Present worth analysis. Annual worth analysis. Rate of return analysis. Replacement and retention analysis. Capital rationing. Breakeven analysis. Payback period analysis. Cost estimation and indirect cost allocation. Depreciation methods.

**Course Code:** STAT 276 **Course Title:** Statistical Data Analysis for Engineering

Introduction to statistical methods for data analysis and interpretation. Statistical concepts, probability distributions, descriptive statistics and data visualization, confidence intervals, significance tests, Analysis of Variance (ANOVA), linear and nonlinear regression analysis. Principles of design of experiments, full factorial and fractional designs, statistical quality control. Tools: spreadsheet software (e.g., Microsoft® Excel) and programming environment (e.g., MATLAB®).

# University Requirements Courses Descriptions

**Course Code:** ARAB 110 **Course Title:** Arabic Language Skills

This course focuses on basic Arabic skills including form, function, and meaning. It also helps the student to appreciate and understand structures and approach them from a critical point of view, through various genres in literature.

**Course Code:** HIST 122 **Course Title:** Modern History of Bahrain and Citizenship

Spatial identity of Bahrain: Brief history of Bahrain until the 18th century; the historical roots of the formation of the national identity of Bahrain since the 18th century; the modern state and evolution of constitutional life in Bahrain; the Arabic and Islamic dimensions of the identity of Bahrain; the core values of Bahrain's society and citizenship rights (legal, political, civil and economic); duties; responsibilities and community participation; economic change and development in Bahrain; Bahrain's Gulf, Arab and international relations.

**Course Code:** HRLC 107 **Course Title:** Human Rights

This course deals with the principles of human rights in terms of the definition of human rights, scope, sources with a focus on the International Bill of Human Rights; The Charter of the United Nations; Universal Declaration of Human Rights; The International Covenant on Economics, Social and Culture rights; Convention against Torture and other Cruel, Inhuman or Degrading Treatment or Punishment; Mechanics and the Constitutional Protection of Rights and Public Freedoms in Kingdom of Bahrain.

**Course Code:** ISLM 101 **Course Title:** Islamic Culture

An introduction to the general outline and principles of Islamic culture, its general characteristics, its relationships with other cultures, general principles of Islam in beliefs, worship, legislation and ethics.