



# **Department of Chemical Engineering**

## **Postgraduate Calendar**

December 2022



**Bangladesh University of Engineering and  
Technology (BUET)**

## **Preamble**

The Department of Chemical Engineering of Bangladesh University of Engineering and Technology (BUET) is one of the oldest Chemical Engineering departments in South-East Asia. Since its inception, the department has aimed to offer courses focusing on the modern concepts of chemical engineering education with due regard for the requirements of local and international industries and on cutting-edge research relevant to chemical engineering and allied disciplines. The department conducts the review and upgradation of the curricula as a continuous process to cater to the incremental demands that may emerge. To meet global standards and provide quality education, the department now offers MSc. degrees in Biochemical Technology, Chemical Process Safety, and Energy Conversion Technology alongside the existing MSc. in Chemical Engineering. The course curriculum is designed to produce highly trained and competent graduates who will be adept at serving industrial sectors and academia, locally and globally.

The current Chemical Engineering Postgraduate Course Curriculum was approved in the following BUET Academic Council Meetings: Academic Council Meeting Resolution 13-07-2021 (Agenda 2101002), and Academic Council Meeting Resolution 25-05-2022 (Agenda 220707).

This booklet provides general information and information about the various graduate programs offered by the department of Chemical Engineering. Every student is suggested to read this booklet in its entirety to get acquainted with the programs offered by this department.

Published by -

Department of Chemical Engineering

Bangladesh University of Engineering and Technology (BUET)

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## **Department of Chemical Engineering**

# Introduction

The Department of Chemical Engineering of Bangladesh University of Engineering and Technology (previously known as the Ahsanullah Engineering College) is one of the Oldest Chemical Engineering departments in South Asia. In 1948, Professor M A Naser seized the opportunity to create a new dept in BUET, namely, the Department of Chemical Engineering in collaboration with Texas A & M University. He also succeeded in hiring senior and junior faculty, and attracting and mentoring the early students in the new department. The first batch of five chemical engineering students graduated in 1952.

Early faculty focused on the then-emerging field of chemical engineering in a number of important areas including corrosion, catalysis, and transport/fluid mechanics. More recently, the department has added biochemical, environmental, and energy engineering as well as process control and process safety to its core areas of excellence. Today, the Chemical Engineering department at BUET is known for its strong academic program and qualified faculty members. The courses offered in this department are designed based on the modern concepts of chemical engineering education with due emphasis on the industrial requirements in the country.

In addition to learning the core principles of chemical engineering, students become well-versed in specialized sub-domains of this dynamic field. Environmental Science and Industrial Pollution Control, Industrial Safety, Biochemical Engineering, Energy Engineering, Sustainable Process Engineering and Process Control, Petroleum Engineering - students have the freedom to explore a variety of related avenues, through courses and intensive research. Our undergraduate and graduate students regularly publish papers in international journals, which is a testament to the thriving research activities of the department's faculty members.



The faculty members are highly qualified and well regarded because of their research and other professional endeavors. Two of the faculty members were awarded Ekushey Padak (Dr. M. A. Naser, 1987 and Dr. Iqbal Mahmud, 2005), one of the highest civilian awards in Bangladesh, for their outstanding contributions to Education. But what sets the faculty members apart is their emphasis on mentorship. The department collectively believes in fostering friendly and supportive student-teacher connections, which continue well after students have graduated.

## **Laboratories and Research Facilities**

During the early days, a well-equipped Unit Operations Laboratory served the laboratory requirement of the department. Over the years, new laboratories were setup to keep the teaching in line with modern development. Currently, the department owns several additional laboratories including Corrosion Laboratory, Kinetics Laboratory, Fuel and Petroleum Processing Laboratory,

Mass Transfer Laboratory, Particle Technology Laboratory, Fluid Mechanics Laboratory, etc.

The department also possesses facilities for research in areas of Reaction Engineering and Oil and Gas Processing. Recently procured equipment and modern facilities for Process Control and Environmental Engineering Laboratories have enabled the department to develop expertise in computer-aided process control and air pollution monitoring. The department also has computer facilities equipped with specialized chemical engineering software for the use of undergraduate and post-graduate students. The department has other specialized laboratories solely for research purposes, which include the Applied Bioengineering Research Incubator and the Textile Analytical Laboratory. Each laboratory is equipped with state-of-the-art facilities to expand the department's research capabilities.

For more information, please visit: <https://che.buet.ac.bd/research-groups/>

# List of Faculty Members



## **Dr. Md. Shahinoor Islam**

Professor and Head

Ph.D., University of Alberta

*Adsorption, Advanced oxidation, Nanocomposite synthesis and applications, Effluent Treatment, Microbial Fuel Cells*

<https://che.buet.ac.bd/dr-md-shahinoor-islam/>



## **Dr. Iqbal Mahmud**

Professor Emeritus and Ex-Vice Chancellor, BUET

Ph.D., University of Manchester Institute of Science and Technology

*Corrosion Engineering*

<https://che.buet.ac.bd/dr-iqbal-mahmud/>



## **Dr. Syeda Sultana Razia**

Professor

Ph.D., University of Alberta

*Process safety, Chemical safety and security, Distillation and separation processes, Effluent treatment*

<https://che.buet.ac.bd/dr-syeda-sultana-razia/>



## **Dr. Md. Ali Ahammad Shoukat Choudhury**

Professor

Ph.D., University of Alberta

*Process Control, Chemical Engineering*

*Modeling and Identification*

<https://che.buet.ac.bd/dr-md-ali-ahammad-shoukat-choudhury/>



**Dr. Md. Mominur Rahman**

Professor

Ph.D., BUET

*Energy and Environment*

<https://che.buet.ac.bd/dr-md-mominur-rahman/>



**Dr. Shoeb Ahmed**

Professor

Ph.D., North Carolina State University

*Bioengineering & Biotechnology, Biological and Medical Image Analysis, Quantitative Biology, Air Pollution Modeling*

<https://che.buet.ac.bd/dr-shoeb-ahmed/>



**Dr. Kazi Bayzid Kabir**

Professor

Ph.D., Monash University

*Solid Fuels, Gasification, Coal/Biomass-to-Liquid, Heterogeneous Catalysis*

<https://che.buet.ac.bd/dr-kazi-bayzid-kabir/>



**Dr. Md. Tanvir Sowgath**

Professor

Ph.D., University of Bradford

*Process Modelling, Simulation and Optimization*

<https://che.buet.ac.bd/dr-md-tanvir-sowgath/>



**Dr. Nahid Sanzida**

Professor

Ph.D., Loughborough University

*Process Control, Electrochemical Engineering,  
Environmental Engineering* <https://che.buet.ac.bd/dr-nahid-sanzida/>



**Dr. Mohidus Samad Khan**

Professor

PhD (Monash Uni, AUS)

*Biotechnology: Health and Food, Biochemical and  
Bioprocess Engineering, Environmental  
Engineering, Engineering Education*  
<https://che.buet.ac.bd/dr-mohidus-samad-khan/>



**Dr. Md. Iqbal Hossain**

Associate Professor

Ph.D., Nanyang Technological University

*Energy Management in Industries, Separation  
Techniques, Fuel Chemistry and Technology, Gas  
Processing*

<https://che.buet.ac.bd/dr-md-iqbal-hossain/>



**Dr. Md. Easir Arafat Khan**

Associate Professor

Ph.D., Nanyang Technological University

*Chemical Process Safety, Fire Safety and Risk  
Management, Gas Liquid Separation, Advance porous  
Materials*

<https://che.buet.ac.bd/dr-md-easir-arafat-khan/>



**Dr. Nafisa Islam**

Associate Professor

Ph.D., North Carolina State University

*Biocompatible materials, Biosensing, Environmental Chemistry, Biomaterials*

<https://che.buet.ac.bd/dr-nafisa-islam/>



**Dr. Kawnish Kirtania**

Associate Professor

Ph.D., Monash University

*H<sub>2</sub> energy, Bioenergy/biofuels, CO<sub>2</sub> Utilization, Low carbon technology, Waste valorization, Techno-economic Analysis*

<https://che.buet.ac.bd/dr-kawnish-kirtania/>



**Dr. Iftekher Ahmed Khan**

Assistant Professor

Ph.D., University of South Carolina

*Environmental Engineering, Nanotechnology, Environmental Technology, Technology Management*

<https://che.buet.ac.bd/dr-ifteker-ahmed-khan/>



**Kaniz Fatema**

Assistant Professor

M.Sc., BUET

*Energy & Environment Engineering*

<https://che.buet.ac.bd/kaniz-fatema/>



**Ahaduzzaman Nahid**

Assistant Professor

M.Sc., BUET

*Process Systems Engineering*

<https://che.buet.ac.bd/ahaduzzaman-nahid/>



**Md. Burhan Kabir Suhan**

Lecturer

B.Sc., BUET

*Wastewater Management, Nanomaterials, Renewable Energy.*

<https://che.buet.ac.bd/bksuhan/>



**Tanzim Ur Rahman**

Lecturer

B.Sc., BUET

*Environmental Engineering and Energy*

<https://che.buet.ac.bd/tanzim-ur-rahman/>



**Zarin Tasnim Juthi**

Lecturer

B.Sc., BUET

*Biochemical Engineering*

<https://che.buet.ac.bd/zarin-juthi/>



**Hridoy Roy**

Lecturer

B.Sc., BUET

*Bio-materials and Environmental Engineering*

[https://che.buet.ac.bd/hridoy\\_roy/](https://che.buet.ac.bd/hridoy_roy/)

# DETAILS OF COURSE CURRICULUM

## Vision Statement

The vision of the department is to become one of the top-tier chemical engineering departments in Asia through academic excellence, research and innovation.

## Mission Statement

We provide world class education in chemical engineering along with contemporary topics so that the graduates are prepared to take up various positions in a wide range of industries, academia and research organizations. Our research is focused on the emerging needs of the country in the fields of process control and safety, energy and environmental engineering, and biochemical engineering. We aspire to develop teaching and research in sustainable and environmentally benign processing of fuels and chemicals through good engineering practices.

### Summary of all degrees:

| Available Degrees                     | Requirements to obtain the degree |
|---------------------------------------|-----------------------------------|
|                                       | Credits Required (Theory+Thesis)  |
| <u>MSc. In Chemical Engineering</u>   | <u>18+18</u>                      |
| <u>MEngg. In Chemical Engineering</u> | <u>30+6</u>                       |

|                                                 |                                                                                                        |
|-------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| <u>MSc. In Biochemical Technology</u>           | <u>18+18</u><br><b><u>Thesis/Project must be on Biochemical Technology related topic</u></b>           |
| <u>MSc. In Occupational And Process Safety</u>  | <u>18+18</u><br><b><u>Thesis/Project must be on Occupational And Process Safety related topic</u></b>  |
| <u>MSc. In Energy Technology And Management</u> | <u>18+18</u><br><b><u>Thesis/Project must be on Energy Technology and Management related topic</u></b> |

**NB: Students can register for any other relevant Post-graduate level course offered at BUET subject to the approval of supervisor/advisor with a condition that the minimum course requirement for any particular group is fulfilled.**

# **Postgraduate Courses**

**Department of Chemical Engineering, BUET**

# **General Chemical Engineering**

## **ChE 6101**

### **Advanced Transport Phenomena**

**3.00 credits, 3 hours / week**

Concepts of unified treatment of transport processes. Theories of viscosity, thermal conductivity and diffusivity. Generalized expressions for transport fluxes. Dimensionless analysis and time scales; and the similarity methodology. Equations of change for multicomponent systems. Analytical and approximate solutions of equations of change for advanced problems in momentum, heat and mass transfer processes.

## **ChE 6102**

### **Advanced Thermodynamics**

**3.00 credits, 3 hours / week**

Review of thermodynamic principles. Estimation of thermodynamic properties, ideal and non-ideal solution, phase equilibria, reacting mixtures.

## **ChE 6103**

### **Advanced Fluid Mechanics**

**3.00 credits, 3 hours / week**

Viscosity and the mechanism of momentum transport. Kinematics of fluid in motion. Stress in a fluid and the equations of motion of a fluid. Analytical solutions of Newtonian and non-Newtonian fluids in simple geometries. Ordering and approximations in fluid flow, creeping flow, boundary layer flow. Introduction to perturbation and numerical solutions of fluid mechanical problems.

## **ChE 6104**

### **Advanced Heat Transfer**

**3.00 credits, 3 hours / week**

Thermal conductivity and the mechanism of energy transport. The basic equations of momentum and energy transport. Analytical and numerical solutions of unsteady state and steady state heat conduction problems. Analytical solution of laminar forced convection heat transfer problems for Newtonian and non-Newtonian fluids. Thermal

boundary layer. Turbulent heat transport. Heat transfer with boiling and condensation. Design of heat exchangers.

## **ChE 6105**

### **Advanced Mass Transfer**

#### **3.00 credits, 3 hours / week**

Diffusivity and mechanisms of mass transport. The equations of change for multicomponent system. Steady and unsteady state. Diffusion in stagnant medium. Convective mass transfer in laminar and turbulent flows. Interphase transport and mass transfer at higher mass flux.

## **ChE 6106**

### **Kinetics and Catalysis**

#### **3.00 credits, 3 hours / week**

Definitions and concepts. The chemical basis of catalysis, classification of catalysts, adsorption and adsorption isotherms, multilayer adsorption theory and the BET equation, kinetics of heterogeneous reactions, model discrimination and parameter estimation, structure of heterogeneous catalysts, Catalyst design, preparation and characterization. Role of transport processes in heterogeneous catalysis, catalyst deactivation, gas-liquid reactions, non-catalytic gas-solid reaction, homogeneous catalysis. Examples of industrial heterogeneous catalytic reactions.

## **ChE 6107**

### **Advanced Chemical Reactor Design**

#### **3.00 credits, 3 hours / week**

Study of the factors involved in the design and operation of Chemical reactors for both homogeneous and heterogeneous systems, batch reactors continuous flow stirred tank reactors, tubular reactors, multibed adiabatic reactors and cold shot converters. Determination of optimal temperature gradients and yields, catalysis effectiveness factors, optimal control with decaying catalysis, reactor optimization problems in local industries.

## **ChE 6108**

### **Advanced Separation Processes**

### **3.00 credits, 3 hours / week**

Importance of modern separations, innovation research and optimization research, economic and commercial development. Crystallization and precipitation from solution, crystallization from the melt. Adsorption in packed beds (linear theories of adsorption and chromatography, non-linear theory of adsorption of packed bed adsorption system, adsorption-desorption operations). Ion exchange (ion exchange equilibrium, ion exchange theory, commercial applications). Membrane processes (reverse osmosis, ultrafiltration and microfiltration, gas permeation, pervaporation). Introduction to other advanced separation methods such as supercritical fluid extraction, electrophoresis, field induced separations, affinity separations, hybrid systems.

### **ChE 6109**

#### **Adsorption and Ion Exchange**

### **3.00 credits, 3 hours / week**

Fundamentals of adsorption, porous materials and their use in adsorption, experimental methods for surface characterization and acquisition of design data. Development of isotherm relationships (thermodynamic and kinetic models). Structure and properties of ion exchangers. Equilibria of ion exchange and thermodynamic models of equilibria. Ion exchange in concentrated solutions. Mass and heat transfer effects in fluid-solid batch and continuous systems. Column design and cyclic operations of different applications including pressure swing adsorption, ion exchange, chromatographic separations etc.

### **ChE 6110**

#### **Advanced Numerical Methods in Chemical Engineering**

### **3.00 credits, 3 hours / week**

Review of numerical techniques, Application of the methods of weighted residuals, orthogonal collocation and finite element methods to solution of problems in transport process and reaction engineering.

### **ChE 6111**

#### **Advanced Polymer Technology**

### **3.00 credits, 3 hours / week**

Characterization, rheology and other properties of polymers, Polymerization principles and kinetics. Commercial polymers and their applications. Polymer degradation and stabilization. Technology of polymer processing, design of polymer processing plants.

### **ChE 6112**

#### **Corrosion Protection Systems**

##### **3.00 credits, 3 hours / week**

Principles of protection, passivation and inhibition. Various protection systems, material selection, alteration of environment, design, coating inhibitors and passivators. Electrochemical systems, cathodic and anodic protection, design and applications. Economics of protection, multiple systems. Corrosion testing and practical applications.

### **ChE 6113**

#### **Optimization Techniques in Chemical Engineering**

##### **3.00 credits, 3 hours / week**

Study of optimization algorithms and their application to chemical engineering problems. Linear and nonlinear programming. Optimum search methods, geometric programming.

### **ChE 6114**

#### **Special Topics in Chemical Engineering**

##### **3.00 credits, 3 hours / week**

Selected topics in the area of chemical engineering. Recent progress, cutting-edge technologies and novel research pertaining to classical and modern chemical engineering.

## **Occupational And Process Safety**

### **ChE 6201**

#### **Occupational Safety Management**

##### **3.00 credits, 3 hours / week**

Introduction to OSHA, workers compensation, OSH Act, standard and liability, major occupational hazards, hazard communications and protection, ergonomics. Industrial hygiene, building codes, fire codes, storage of hazardous materials, personal protective equipment, safety plans, safety audits and incident investigations.

## **ChE 6202**

### **Industrial Hygiene and Safety**

#### **3.00 credits, 3 hours / week**

Introduction to industrial hygiene and safety, rules and regulations, hazard communication. Basics of toxicology, toxic effects, measuring toxicity, toxicokinetics, dermatosis and eye hazards, inhalation toxicology, flammable and explosive materials, electrical hazards, construction hazards, hearing loss, radiation, working in extreme temperature, cumulative trauma, bio-hazards. Concepts of hazard avoidance, prevention of accident, process safety, ergonomics, monitoring atmosphere, ventilation, and noise control, environmental management, personal protection, fire protection, emergency response, incident investigations.

## **ChE 6203**

### **Fire Protection and Safety**

#### **3.00 credits, 3 hours / week**

Fire protection, management overview, fire protection strategy, understanding fires, fire hazard analysis, portable fire extinguishers. Overview of fire prevention elements, fire risk assessment, fire protection systems, fire protection fundamentals and active systems, specific design guidance, vapor dispersion, installation of fire protection systems, inspecting, testing, and maintenance. Fire emergency response, active/passive fire protection systems presentations.

## **ChE 6204**

### **Process Safety Engineering**

#### **3.00 credits, 3 hours / week**

Toxic materials, hygiene, source models, toxic release and dispersion. Fires and explosions, fire and explosion protection and prevention. Reliefs, relief sizing. Hazard identification, hazard analysis, preliminary hazard analysis, fault & event trees, failure modes and effects analysis, operating and supporting hazard analysis, risk ranking/risk

assessment, LOPA, HAZOP analysis, human error, safety performance measurement, accident investigations, regulation and standards, process safety management.

## **ChE 6205**

### **Quantitative Risk Analysis**

#### **3.00 credits, 3 hours / week**

Hazards and risk, risk analysis, probability, reliability, quantitative risk assessment methods, performance assessment, uncertainty analysis, consequence analysis, risk contributors, risk values, risk acceptance criteria, risk management, risk communication and safety culture.

## **ChE 6206**

### **Process Safety Management**

#### **3.00 credits, 3 hours / week**

Elements of a process safety management system. Process safety in design, process safety in operations, reliability and maintainability. Case studies of major incidents, safety management systems in major hazards, process safety performance measurement through leading and lagging indicators. Organization, culture and leadership to enhance PSM in processing industries.

## **Process Control**

## **ChE 6301**

### **System Identification**

#### **3.00 credits, 3 hours / week**

Introduction to system identification, random variables and stochastic processes. Nonparametric identification (impulse and step response, correlation methods, spectral analysis). Regression analysis, input signals (commonly used signals: spectral properties, persistent excitation). Parameter estimation (minimizing prediction error, identifiability, consistency, bias, convergence, MLE, instrumental-variable method).

Computing the estimates (recursive estimation, kalman filter interpretation). Asymptotic analysis, model validation, closed loop identification, identification in practice (aliasing due to sampling, closed loop data, model order estimation), nonlinear identification.

## **ChE 6302**

### **Process Modeling and Dynamics**

#### **3.00 credits, 3 hours / week**

A study of the dynamic behavior of lumped and distributed system, dynamic model building and analysis. Interpretation of frequency and time response of linear systems. State-space methods, approximations to models and responses, stability analysis, and the behavior of nonlinear systems. Applications to heat exchangers, tubular reactors and fixed beds as sorption processes.

## **ChE 6303**

### **Advanced Process Control**

#### **3.00 credits, 3 hours / week**

A survey of selected advanced topics of control as applied to chemical processes, mathematical modeling, parameter estimation and process identification, multivariable control, optimal and adaptive control, Real-time, digital control.

## **ChE 6304**

### **Nonlinear and Robust Control**

#### **3.00 credits, 3 hours / week**

Linear and nonlinear systems. Feedback circuits. Differential equations and trajectories, multiple equilibria, limit cycles, chaos and other phenomena state space stability analysis, the theorems of Lyapunov, stability of nonlinear circuits and neural behaviors. Input / output stability analysis, describing functions, small gain theorems, passivity, MIMO control systems, stability and performance analysis of MIMO control systems, controller parameterization, uncertain systems and uncertainty representations. Stability and performance analysis of uncertain control systems. Linear matrix inequalities (LMIs) and convex optimization.

## **ChE 6305**

### **Process Fault Detection and Diagnosis**

#### **3.00 credits, 3 hours / week**

Review of statistical concepts (random variables, mean, variance, moments; Gaussian random variables, correlation, independence, hypothesis testing, analysis of variance, time series analysis). Data-driven modeling (dimensionality reduction, principal component analysis (PCA) and partial least square (PLS) and neural networks (ANN)). State space modeling. Model based fault diagnosis (observer-based diagnosis, parity space approach, method of structured residuals). State estimation and Kalman filtering, process monitoring and fault diagnosis using PCA, PLS and ANN. Fault diagnosis using Kalman filtering and generalized likelihood ratio method (detection of sensor / actuator faults, process leaks). Applications and case studies.

## **Energy Technology And Management**

## **ChE 6401**

### **Fuels and Combustion Science**

#### **3.00 credits, 3 hours / week**

Fuel types, properties and characterization. Combustion fundamentals, stoichiometry, mechanism and kinetics, premixed and diffusional flames, thermodynamics, and transport processes. Solid fuels pyrolysis, gasification and combustion, ash chemistry. Combustion and heat transfer modelling. Current state of combustion technologies. Oxy-fuel and chemical looping combustion. Burners for furnaces. Furnace design. Flue gas characterization. Gas cleaning.

## **ChE 6402**

### **Coal Energy Systems**

#### **3.00 credits, 3 hours / week**

Coal formation, reserves and production, coal sampling and analysis, coal treatment. Electricity generation, advanced power generation technologies. Coal liquefaction, carbon capture and storage. Use of coal in metallurgy, cement and other industries. Future directions toward more efficient and cleaner use of coal.

## **ChE 6403**

### **Energy Management and Modeling**

#### **3.00 credits, 3 hours / week**

Overview of global and local energy production. Energy utilization and conversion systems. Waste heat recovery. Energy modeling. Energy auditing, energy conservation schemes. Costing techniques, financial appraisal and profitability, investment decisions.

## **ChE 6404**

### **Low Carbon Energy Technologies**

#### **3.00 credits, 3 hours / week**

Energy supply and demand. Fundamentals of energy conversion. Environmental and ecological effects of energy production and consumption. Biomass and bioenergy. Low carbon combustion technologies. Fission and fusion energy. Solar energy. Wind energy. Geothermal energy. Energy storage. Energy conservation and efficiency. Economics of energy projects.

## **ChE 6405**

### **Solid Biofuels and Biorefineries**

#### **3.00 credits, 3 hours / week**

Energy consumption, reserves, depletion and environmental issues. Solid biofuels. Biomass drying. Biomass combustion characteristics, fluidized-bed combustion. Biomass gasification. Utilization of biomass ash. Fuels from biomass, biorefinery, thermochemical processing, biochemical processing. Biorefinery economy. Environmental impacts of biorefinery.

## **ChE 6406**

### **Industrial Ecology and LCA**

#### **3.00 credits, 3 hours / week**

Industrial ecology, goals and definition. Material flow analysis, physical input-output accounting, process analysis approach, life cycle assessment, impact evaluation. Stream splitting and utility targeting. Water and effluent systems, water use minimization, water reuse, process changes for decreased water consumption.

Distributed effluent treatment, types of emissions and environmental effects. Cleaner production. Economics and social impacts. Case studies on LCA.

### **ChE 6407**

#### **Natural Gas Processing**

##### **3.00 credits, 3 hours / week**

A review of the physical and chemical properties of natural gas, phase behavior, vapor-liquid equilibrium data and computation, water-hydrocarbon systems, engineering principles used in the production of natural gas and its associated liquids. A detailed review of design and operations criteria encountered in the production, well head treatment of natural gas, dew point control, LPG recovery, sulfur recovery. Gas processing plant operation. Dynamic simulation of gas processing plants, real-time optimization.

Synthetic natural gas (SNG) production, gasification, gas cleaning and methanation. SNG upgrading. Hydrothermal production of SNG.

## **Biochemical Technology**

### **ChE 6501**

#### **Biomaterials**

##### **3.00 credits, 3 hours / week**

Introduction to Biomaterials and history of biomaterials. Properties of biomaterials, classes of materials used in medicine, hard biomaterials and soft biomaterials. Polymeric and non-polymeric biomaterials, their properties, natural and synthetic polymers, commonly used polymeric biomaterials (PDMS, PHEMA etc.). Microfluidic devices. Classes, properties and applications of bioceramics. Cellulosic biomaterials. Interactions between biomolecules and surfaces, protein adsorption and biofouling. Surface modification methods applicable to biomaterials, surface characterization techniques. Practical aspects of biomaterials (implants, device, drug delivery etc.).

### **ChE 6502**

#### **Bionanotechnology**

##### **3.0 credits, 3 hours / week**

Fundamental concepts of nanotechnology. Characterization of biomaterials and bionanostructures (scanning probe microscopy, electron microscopy and compositional analysis of soft matter, fluorescence, NMR, surface characterization, surface plasmon resonance, ellipsometry, dual polarization interferometry, SAXS, XPS). Applications and manufacture of commercially important bionanostructures, including nanoparticles, ultra-thin films, microfluidics, self-assembling structures and biosensors.

### **ChE 6503**

#### **Biostatistics**

##### **3.00 credits, 3 hours / week**

Introduction to biostatistics and descriptive biostatistics. Grouped data and graphical methods, exploratory data analysis, basic probability theory, probability and probability distributions. Introduction to sampling distributions, estimation with confidence intervals, hypothesis testing, ANOVA - analysis of variance, t-test, chi square test, correlation and regression. Categorical data analysis, application of statistical techniques in biological data.

### **ChE 6504**

#### **Fermentation Technology**

##### **3.00 credits, 3 hours / week**

Morphology and physiology of industrial microorganisms. Mammalian cell culture aseptic technique. Separation, identification and quantitative estimation of microorganisms. Fermentation process kinetics. Rheological properties of biological fluids. Design, operation and control of industrial fermenters. Sterilization in the fermentation process. Basic concepts of Scaling up fermentation process. Application of fermentation technology in industries.

### **ChE 6505**

#### **Advanced Biochemical Engineering**

##### **3.00 credits, 3 hours / week**

Review of biochemistry, microbiology, cell biology and molecular biology, as applied to bioproduct formation. The application of chemical engineering principles of mass, momentum and energy transport as well as reaction kinetics to biochemical reaction

systems. Design of biochemical systems based on transport process and chemical reaction principles. Fed-batch, continuous, immobilized-cell and other advanced bioreactors, bioreactor monitoring and control, Study of different phases of some common biochemical systems. Protein engineering, Manipulation of gene expression.

## **ChE 6506**

### **Downstream Bio-processing**

#### **3.00 credits, 3 hours / week**

Process design for the recovery and purification of a target therapeutic protein. Unit operations used in downstream bioprocesses, both major (centrifugation, homogenization, chromatography, ultrafiltration) and minor (equipment cleaning/sanitization, filter integrity testing) unit operations. Liquid chromatography and protein purification (ion exchange, hydrophobic interaction, affinity chromatography). Key process and performance parameters for each of the unit operations in downstream processing, monitoring in-line parameters (e.g., temperature, flow, etc.), scale up from bench- to production-scale. Standard operation procedures (SOPs) and batch records. Calculating step and process yields for all major unit operations. Process validation.

## **ChE 6507**

### **Quantitative Cell Biology**

#### **3.00 credits, 3 hours / week**

Analysis of biological events using (qualitative vs. quantitative) data. Acquiring quantitative data (various biochemical assays, regular and fluorescent microscopy techniques), comparison among various methods. Applications of biosensors, signal transduction and modes of transduction, details of few clinically important pathways. Aspects of signaling network (compartmentalization, diffusion and diffusion limited reaction etc.). Medical and biological image analysis, mathematical tools for biological analysis. Modeling of biochemical networks (data-driven modeling, stochastic modeling, sensitivity analysis).

## **ChE 6508**

### **Special Topics in Biotechnology**

#### **3.00 credits, 3 hours / week**

Recombinant DNA technology (strategies of DNA cloning and manipulation, recombinant protein production and affinity purification, screening recombinant clones). Polymerase chain reaction (PCR) technology (introduction to PCR, primer design, optimizing PCR reactions, asymmetric PCR and cloning of PCR products, Reverse Transcriptase PCR, quantitative PCR assays and data analysis). DNA sequencing (Sanger and Maxam-Gilbert methods). Animal cell culture (cell culture basics, media preparation and formulations, primary cell culture, maintaining cells). Microscopy Techniques (microscopy basics, darkfield, Phase, DIC, widefield fluorescence microscopy, confocal laser scanning and TIRF Microscopy etc.). Bioinformatics.

### **ChE 6509**

#### **Molecular Simulation of Biological Systems**

##### **3.00 credits, 3 hours / week**

Basics of quantum chemistry and molecular mechanics. Density functional theory, force field theory. Applications of molecular mechanical models. Molecular dynamics, Monte Carlo simulations. Quantum Mechanical Methods (Hartree-Fock, ab initio, Huckel method, Extended Huckel method). Semi-Empirical methods (PM3, PM6, and others to model protein, antibody, DNA, RNA, enzymes, amino acids, nucleic acids, etc.). Modeling involving different pH conditions, heat transfer, mass transfer, fluid mechanics, mechanics, and materials science applications.

## **Food Technology**

### **ChE 6601**

#### **Chemistry and Microbiology of Food**

##### **3.00 credits, 3 hours / week**

Chemistry and biochemistry of food products. Compositions and nutritive values of foods. Microbiology of food. Physiology and genetics of bacterial, moulds, yeasts, fungi, virus and algae. Growth and destruction of microorganisms. Microbial spoilage of food. Food poisoning.

### **ChE 6602**

#### **Food Processing and Preservation**

### **3.00 credits, 3 hours / week**

Food preservation principles. Study of main food processing operations (heating and thermal processing, cooling, freezing and thawing, evaporation, dehydration, the use of membranes and packaging). Innovative thermal and non-thermal food processes, heat and mass transfer during food processing. Process impact on food safety, quality and preservation. Design of food processing equipment and plants. Plant effluent treatment and waste management.

### **ChE 6603**

#### **Food Technology**

### **3.00 credits, 3 hours / week**

An in depth study of different food processing industries with special reference to processing of cereal, vegetable, fruit, milk, fish, edible oils and production of fermented food products and sugar technology.

### **ChE 6604**

#### **Food Safety and Food Contamination**

### **3.00 credits, 3 hours / week**

Biological, Chemical and Physical contamination of foods. Food spoilage. Understanding microbial functions and microbial induced diseases. Cross contamination. Foodborne illness: causes and prevention techniques. Cleaning in the food industry. Managing disinfection and hygiene. High-risk foods and food allergies. Food adulteration and basic detection techniques. Food processing and preservation. Legislative aspect of food safety.

### **ChE 6605**

#### **Specialty Foods: Nutraceuticals and Functional Foods**

### **3.00 credits, 3 hours / week**

Basic knowledge and the latest research trend in nutraceuticals and functional foods. Analyses, chemistry, processing, bioavailability, and health benefits of bioactive food components. Fundamental concepts and knowledge related to functional food, examine and assess the latest development in nutraceutical research. Development of functional foods for market.

## **ChE 6606**

### **Quality Control in Food and Biochemical Industries**

#### **3.00 credits, 3 hours / week**

Food legislation. Principles of quality control. Chemical, physical and organoleptic methods for examination of foods and biochemical products. Laboratory control methods for processing plants. Detection of pathogens in food. Plant sanitation and quality assurance program in food and biochemical manufacture.

## **Industrial Pollution Management**

## **ChE 6701**

### **Industrial Pollution Management**

#### **3.00 credits, 3 hours / week**

Overview of industrial pollution. Management and applied advanced techniques to prevent and control industrial pollution. Legal aspects of pollution prevention and control. Setting up pollution prevention programs, pollution prevention assessments, economic evaluations and management principles in controlling industrial pollution.

## **ChE 6702**

### **Water Pollution and Control**

#### **3.00 credits, 3 hours / week**

Water quality standards and wastewater characterizations. Sources and nature of water pollution. Physical, chemical and biological methods of waste treatment. Disposal of highly toxic wastes. Oil spills and clean-up methods. Process control and monitoring standards. Legislation. Pollution control of textiles, pulp and paper, fertilizer, refinery, steel and metal finishing, food and pharmaceutical industries.

## **ChE 6703**

### **Air Pollution and Control**

#### **3.00 credits, 3 hours / week**

Air pollution meteorology (nature and properties of the atmosphere). Types, sources, effects of air pollutants. Air pollution from mobile sources. Methods of pollutant measurement. Methods of control. Stack gas clean-up from industrial plants, stack design, automobile exhausts, monitoring. Air quality standards. Legislation. Indoor

Air pollution (causes and sources of indoor air quality problems, types of indoor air pollutants, calculation of emission rate, indoor air quality assessment and control, Indoor air quality regulations).

## **ChE 6704**

### **Industrial Solid Waste Management**

#### **3.00 credits, 3 hours / week**

Introduction to solid waste management, technology, economics, policy and regulation. Generation, classification, characterization, onsite handling and storage, collection and transfer of solid waste. Recycling and disposal techniques of industrial solid waste: mechanical treatment, thermal treatment, land filling, biological treatment. Concept of integrated solid waste management, existing practices and their hazards. Bio-hazardous waste management. Concepts of industrial symbiosis and waste minimization. Resource recovery, recycling and waste prevention. Application of solid wastes in energy production.

## **ChE 6705**

### **Air Quality Modeling**

#### **3.00 credits, 3 hours / week**

Introduction to air pollution, atmosphere, air pollutants and chemistry of air pollution. History and applications of air quality modeling. Physico-chemical process analysis of the atmosphere. Tools of air quality modeling (Eulerian and Lagrangian Models, discussion of air quality models, types and applications). Development of an atmospheric chemical transport model for urban and regional-scale applications. Performance evaluation and statistical assessment of air quality models. Stochastic modeling and analysis of air quality problems. Evaluations and analysis of air quality modeling results.

## **ChE 6706**

### **Environmental Biotechnology**

#### **3.00 credits, 3 hours / week**

Scope of Environmental Biotechnology. Introduction to microbiology, taxonomy of microorganisms, microbial nutrition, microbial metabolism, growth and control, methods for the analysis of the microbial population, identification of the

microorganisms, relationship of the microorganisms to the environment. Microbial technologies related to environment, physical, chemical and biological analysis. Toxicity tests. Sewage treatment methods, industrial wastes, agricultural waste, and their treatment. Microbiology for nutrients removal process (C, N, P, and S), microbiology for anaerobic sludge processes, microbial ecology in biofilms, biofilm structure and function. Bioremediation.

## **Thesis / Project**

**ChE 6000**

**Thesis / Project**