CHEMICAL ENGINEERING

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The Chemical Engineering academic plan provides students with a versatile engineering experience based on fundamental sciences, mathematics, and engineering science, combined with engineering design. Students may elect to pursue the Chemical Process Engineering Sub-plan (CHE1) or the Bioengineering - Biochemical, Biomedical, Bioenvironmental Sub-plan (CHE2). In addition to the technical content of the plan, students are introduced to business skills (engineering communication and ethics, innovation and entrepreneurship, process economics and project management) and acquire laboratory experience in state-of-the-art facilities. Group-based design projects are offered throughout the design spine. In their fourth year students select client-based industrial consulting projects, or research projects under the supervision of academic staff or professional engineers. All students have access to a computing facility, equipped with software programs and simulators.

Ancillary Fees

Chemical Engineering and Engineering Chemistry students may be required to pay ancillary fees for course related learning materials, safety equipment and field trips.

Programs

- (CHE1) Chemical Engineering - Chemical Process Engineering Sub-Plan, B.A.Sc. (Class of 2025) (https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/chemical-engineering/che1-chemical-process-engineering-sub-plan-basc-class-2024/)
- (CHE1) Chemical Engineering - Chemical Process Engineering Sub-Plan, B.A.Sc. (Class of 2026) (https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/chemical-engineering/che1-chemical-process-engineering-sub-plan-basc-class-2026/)
- (CHE1) Chemical Engineering - Chemical Process Engineering Sub-Plan, B.A.Sc. (Class of 2027) (https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/chemical-engineering/che1-chemical-process-engineering-sub-plan-basc-class-2027/)
- (CHE2) Bioengineering - Biochemical, Biomedical, Bioenvironmental Sub-Plan, B.A.Sc. (2025) (https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/chemical-engineering/che2-bioengineering-biochemical-biomedical-bioenvironmental-sub-plan-basc-2024/)
- (CHE2) Bioengineering - Biochemical, Biomedical, Bioenvironmental Sub-Plan, B.A.Sc. (2026) (https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/chemical-engineering/che2-bioengineering-biochemical-biomedical-bioenvironmental-sub-plan-basc-2026/)
- (CHE2) Bioengineering - Biochemical, Biomedical, Bioenvironmental Sub-Plan, B.A.Sc. (2027) (https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/chemical-engineering/che2-bioengineering-biochemical-biomedical-bioenvironmental-sub-plan-basc-2027/)
- Chemical Process and Bioengineering Sub-plan: Technical Electives (https://queensu-ca-public.courseleaf.com/engineering-applied-sciences/academic-plans/chemical-engineering/chemical-process-bioengineering-sub-plan-technical-electives/)

Courses

CHEE 209 Analysis of Process Data Units: 3.50
Statistical methods for analyzing and interpreting process data are discussed, . Topics include: role of data in assessing process operation, identifying major problems, graphical and numerical summaries, principles of valid inference, probability distributions for discrete and continuous data, and an introduction to linear regression analysis.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: APSC 171 , APSC 172 , APSC 174 Corequisites: Exclusions: STAT 268, STAT 269, MTHE 367
Offering Term: F
CEAB Units:
Mathematics 27
Natural Sciences 0
Complementary Studies 0
Engineering Science 15
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Summarize visualize and interpret data using quantitative and graphical methods.
2. Apply simple discrete probability models to analyze data related to quality such as particle size and to evaluate risk factors such as safety and environmental compliance.
3. Apply continuous probability models to assist in decision-making with applications to quality improvement resource estimation safety and environmental compliance.
4. Formulate confidence intervals and hypothesis tests for mean and variance using standard conditions, with applications including decision-making for quality improvement.
5. Develop, estimate and analyze linear regression models to describe and predict process and laboratory behaviour.
6. Use computer software to solve statistical problems.

CHEE 210 Thermodynamics of Energy Conversion Systems Units: 3.50
This course is an introduction to thermodynamics for chemical engineering systems analysis. The principles arising from First and Second laws of thermodynamics will be applied to the solution of mass, energy, and entropy balances for homogeneous closed and open systems. Properties of ideal gases and real fluids will be derived from Equations of State and applied in the analysis of simple flow processes. The students will compute efficiencies and coefficients of performance for energy production, conversion, and storage systems. The impacts of energy process design choices on efficiency, performance, and sustainability will be measured through exergy analysis.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 221 (or MINE 201) Corequisites: None Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 42
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Develop and solve material, energy, and entropy balances for process components, open or closed.
2. Apply the First Law of Thermodynamics to compute heat, work, and changes in internal energy and enthalpy for the analysis of open or closed homogeneous systems undergoing reversible or irreversible processes. Apply the Second Law of Thermodynamics and the concept of entropy production to the analysis of open or closed homogeneous systems undergoing reversible or irreversible processes.
3. Use the fundamental relation or the equation of state of a given substance to determine changes in its properties and to compute changes in macroscopic quantities of interest. Understand the relationships between internal energy, enthalpy, entropy, Gibbs and Helmholtz free energies potentials. Relate these potentials to fluid properties, measurable variables, and macroscopic quantities of interest.
4. Describe and analyze the performance and efficiency of gas engines. Describe and analyze ideal and non-ideal gas cycles, including Brayton cycles, regenerator cycles, and gas refrigeration cycles. Apply the combined material, energy, entropy, and exergy balance equations to solve and analyze process flow problems.
5. Describe and analyze the performance and efficiency of ideal and non-ideal multi-phase cycles, including Rankine

CHEE 218 Laboratory Projects I Units: 2.50
The projects provide a practical introduction to processes that occur in chemical engineering operations. Bench-scale and pilot plant equipment are used. Students plan and carry out the experiments, analyze the data and prepare written reports
(Lec: 0.15, Lab: 2, Tut: 0.35)
Requirements: Prerequisites: APSC 100 (or APSC 102), CHEE 209, or permission of the department. Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 10
Engineering Science 20
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Demonstrate proficiency in operation and control of process and analytical equipment.
2. Demonstrate engineering judgment and an awareness of the nature and magnitude of physical and chemical effects and factors, as well as errors and uncertainties.
3. Collect and interpret data to draw meaningful conclusions and evaluate the strengths, weaknesses and limitations of current chemical engineering theory.
4. Write concise, coherent, and grammatically correct lab reports that reflect critical analysis and synthesis. Deliver clear and organized formal oral presentations.
5. Demonstrate effective independent learning, initiative, originality and creativity in completion of pre-lab preparation and other tasks.
6. Work effectively as group member and demonstrate good leadership skills when team leader, adopting a professional approach during all project phases.
7. Document and follow appropriate safety protocols.

CHEE 221 Chemical Processes and Systems Units: 3.50
Introduction to the fundamentals and principles of chemical engineering, with applications to chemical and biochemical processes, via an analysis of processing units including distillation, crystallization and combustion. Specific topics include conservation equations for mass and energy, process flow diagrams, material and energy balances, chemical reaction fundamentals, and applications of the First Law of Thermodynamics.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: APSC 131, APSC 132, APSC 172, or permission of the department Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 42
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Draw and fully label a process flow diagram (PFD) for application of material and energy balances.
2. Formulate and solve the material balance equations to analyze steady-state single-unit and multiple-unit processes without reaction.
3. Formulate and solve the material balance equations to analyze steady-state processes with reaction.
4. Formulate and solve combined steady-state material and energy balances for chemical processes.

CHEE 222 Process Dynamics and Numerical Methods Units: 3.50
Time-varying operation of chemical and biochemical processes is introduced. Dynamic mathematical models are formulated using material and energy balances. Effects of operational and design parameters on steady-state and dynamic operations are investigated. Numerical techniques are introduced to solve systems of algebraic and differential equations. Numerical and symbolic computation tools are used to analyze dynamic and steady-state process behaviour.

(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: APSC 142 or APSC 143 or MNTC 313, CHEE 221, MTHE 225 or permission of the department Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 22
Natural Sciences 0
Complementary Studies 0
Engineering Science 20
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Develop dynamic and steady-state models of chemical processes using mass balance, energy balance and constitutive relationships.
2. Calculate states, inputs or parameters at steady states via solving relevant algebraic equations.
3. Analyze process dynamics via solving relevant ordinary differential equations.
4. Develop linearized models with deviation variables and solve using Laplace transforms.
5. Solve complex algebraic and ordinary differential equations using MATLAB built-in functions, and implement classical numerical methods on MATLAB.

CHEE 223 Fluid Mechanics Units: 3.50
Principles of momentum and energy transport are applied to the analysis of fluid systems commonly encountered in chemical engineering practice. This approach is via the macroscopic and differential balances of mass, momentum and energy. Topics include fluid statics; incompressible flow in closed conduits; flow and pressure measurement; transportation of fluids; laminar, turbulent and creeping flows; boundary layer effects; sizing of commercial components (piping, tubing, valves, pressure and flow meters and other fittings, as well as pumps) for fluid transport systems in industrial settings.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 221, MTHE 225 (MATH 225) Corequisites: None Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 42
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Calculate the pressure distribution in static fluids and the forces on submerged surfaces.
2. Formulate mass, momentum and energy balances using the control volume and differential analysis of fluid flow.
3. Identify boundary conditions and solve differential equations describing one-dimensional fluid flow.
4. Determine frictional losses, size pipes and calculate pump power requirements in laminar and turbulent flow for viscous flow in closed conduits.
5. Calculate the drag forces on submerged objects in laminar and turbulent flow.
6. Use dimensional analysis to derive relationships among process or system variables.
7. Demonstrate an understanding of the technical aspects of pressure, flow and viscosity measurement and sizing of pumps and pipes.

CHEE 224 Transport Phenomena Fundamentals Units: 3.00
The theory and mathematical framework of transport phenomena are introduced. Mass, energy and momentum balances are developed using the integral and differential methods of analysis. The tools used to formulate and solve the problems include representation of physical entities in vector form, multivariable functions and vector operations in 2D and 3D. Specific topics of Chemical Engineering interest include moments of a force, work done by a force, moments of inertia, control surfaces and control volumes and fluid kinematics.
NOT OFFERED 2024-2025
(Lec: 2, Lab: 0, Tut: 1)
Requirements: Prerequisites: APSC 171, APSC 172
Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 18
Natural Sciences 0
Complementary Studies 0
Engineering Science 18
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Calculate centre of mass, moment of inertia and volumes using multiple integrals, to determine hydrostatic forces on surfaces.
2. Analyze transport phenomena fundamentals (forces in space, moment of a force, work done by a force) and fluid kinematics (displacement, velocity and acceleration, motion along a curve)Define streamlines, streaklines and pathlines.
3. Apply the integral relations for a control volume and the Reynolds transport theorem to analyze fluid motion.
4. Analyze fluid motion using the differential analysis: Velocity and acceleration fields, linear and angular motion and deformation, differential form of the continuity equation (Cartesian and polar forms), stream function, potential function.
5. Formulate equations for heat and momentum transport using partial derivatives, multivariable functions, differentials, the chain rule for multivariable functions, directional derivatives.
6. Development of mathematical skills: (i) the mathematical formulation of engineering transport problems and corresponding analytical solution strategies(ii) Handling of differential operators in vector calculus and coordinate systems important for engineering applications.

CHEE 229 Cell Based Engineering Principles Units: 4.00
Introduction to the Biological, Biochemical and Life Science principles of cell/ enzyme-based engineering systems and processes. The emphasis will be placed on microbial cell culture, but comparisons will be drawn to related systems including viral, plant and animal cell culture as it relates to medicine, industrial practice or the environment.
(Lec: 3, Lab: 0.75, Tut: 0.25)
Requirements: Prerequisites: APSC 131 and APSC 132; or permission of the Department. Corequisites: Exclusions: MICR 221
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 35
Complementary Studies 0
Engineering Science 13
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Identify and explain the major cellular processes in prokaryotes and eukaryotes.
2. Describe the interrelationships between organisms and their environments.
3. Identify and describe the relationship between structure and function on a molecular cellular and organismal level.
4. Identify a range of fields where biological systems are being applied to solve engineering problems and discuss the most recent advances in each field as well as the strengths and limitations of each approach.
5. Explain a variety of advanced molecular and cellular biology techniques used for the characterization and manipulation of micro-organisms, with applications in medicine, industry, and the environment."
6. Demonstrate laboratory skills and expertise with microbiological techniques.

CHEE 270 ChemEtronics Units: 3.00
This course combines elements of chemical and electrical engineering to measure, calculate and control electrical signals. The course introduces basic electrical circuit analysis theory with an emphasis on concepts utilized in analytical chemistry instrumentation and energy conversion and storage. An introduction to signal analysis, data acquisition, sampling and quantization, as well as the fundamental statistical techniques necessary to process and analyze measured data with uncertainty is given. Course content is delivered via a blended offering with on-line instruction and active learning sessions.
K3(Lec: Yes, Lab: Yes, Tut: No)
Requirements: Prerequisites: APSC 112, APSC 142 or APSC 143 or MNTC 313 Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 24
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Analyze electrical circuits utilized in analytical chemistry instrumentation.
2. Compare electrical power designs related to energy conversion and storage.
3. Analyze analog and digital signals.
4. Select transducers for temperature, light, pressure, flow and conductivity measurements.
5. Calculate uncertainty from measured data sets.
6. Apply statistical methods to single and derived data sets.
7. Design an experimental procedure and analytical instrument to obtain data required to solve a given problem.

CHEE 302 Technical Entrepreneurship Units: 3.50
This course will help learners from all disciplines develop an entrepreneurial mindset capable of turning problems into opportunities. Learners will identify sources, rates, and directions of technological change, and begin to understand the role and challenges of technological innovation across sectors, countries, and organizations. Learners will investigate the relationships between innovation and industrial dynamics, and seek to understand the fundamental forces that drive the science and technology industries' evolution and industry life cycles. In the process, learners will explore frameworks and tools used to analyze new technology adoption, predict technology diffusion patterns, and assess the strategic value of technological innovation. NOTE: Offered only at the Bader College, Herstmonceux, in the fall term.
K3.5(Lec: Yes, Lab: No, Tut: No)
Requirements: Prerequisites: Corequisites: Exclusions: CHEE 310, CHEE 410
Offering Term: FW
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 42
Engineering Science 0
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Describe how technical innovation arises from advances in knowledge and the motivation of necessity or opportunity.
2. Identify problems and generate ideas using design and systems thinking tools.
3. Identify how to take an innovation to commercialization using a structured design process, including appropriate strategies for protecting the strategic advantage of intellectual property.
4. Identifying time, risk, and capital scales for a technological innovation.
5. Communicate the value of technical innovation to stakeholders and develop social acceptance to operate for ventures.
6. Design business models using the business model canvas framework.

CHEE 310 Engineering Innovation and Entrepreneurship Units: 3.50
This is a course about innovation - distinctive ideas, of value, put to practice - and entrepreneurship - the process of putting to practice and sustaining the implementation of innovations - for societal benefit and wealth creation. Curiosity of the world around us is emphasized for identifying opportunities to have an impact and make a difference, to which a discipline is imposed - one that identifies who might be interested in or benefit from our product or service, and how we can bring an idea to fruition and provide the necessary resources (e.g., financial, intellectual) to provide it to society. Legal aspects (e.g., incorporation, partnerships), raising capital, and protecting the strategic advantage of intellectual property (e.g., patents, trade secrets) are discussed, together with the importance of having a social license to operate. The concept of a business model, summarized using the business model canvas methodology, is presented, together with the concept of a business plan describing how a venture will be operated over a time horizon. For-profit and not-for-profit ventures, and the elements of the business models for each, are studied and compared. Financial metrics for assessing the viability of ventures and guiding investment decisions are presented (e.g., IRR, NPV, EBITDA). Systems Thinking (recognizing the whole/parts and that which is common/distinct) is introduced. Design Thinking - a human-centered design emphasizing observation and experimentation gaining traction in engineering, business and social sciences - is presented. Working in groups, students identify a venture opportunity having a technological component, and propose a business model and plan as the major evaluation in the course.
COURSE DELETED 2018-2019
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: NOT open to ASC students
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 42
Engineering Science 0
Engineering Design 0
Offering Faculty: Smith Engineering

CHEE 311 Fluid Phase and Reaction Equilibrium Units: 3.50
This course is concerned with the application of thermodynamics to practical problems of the chemical industry. Emphasis is placed on the study of phase equilibrium, including vapour-liquid equilibrium and liquid-liquid equilibrium. Contemporary methods of calculating the thermodynamic properties of non-ideal vapours and liquids will be presented and applied. The principles of chemical reaction equilibrium will also be studied. The design component of the course will require students to perform theoretical vapour-liquid equilibrium calculations and recommend proper operating conditions for a single-stage unit (flash drum) that separates a non-ideal binary mixture.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 210 Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 30
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Identify and understand the principles of chemical equilibrium thermodynamics to solve multiphase equilibria and chemical reaction equilibria.
2. Analyze the conditions associated with ideal and non-ideal vapour-liquid systems at equilibrium through the construction and interpretation of phase diagrams for ideal and non-ideal binary mixtures.
3. Use empirical correlations and experimental data to evaluate thermodynamic quantities that relate to the vapour-liquid or liquid-liquid equilibria of ideal and non-ideal chemical mixtures.
4. Determine equilibrium constants for chemical reactions and equilibrium point compositions for multiple reaction systems.
5. Solve single and multistage separation processes involving non-ideal chemical mixtures using numerical methods and simulations and recommend appropriate operating conditions.

CHEE 315 Laboratory Projects II Units: 4.00
The main objectives are to develop skill in using process and analytical equipment, to examine the strengths, weaknesses, and limitations of current theory, to improve the student's ability to obtain and interpret data, to demonstrate the value of planning experiments, to develop engineering judgement, and to provide experience in oral and written reporting.
(Lec: 0.25, Lab: 3, Tut: 0.75)
Requirements: Prerequisites: CHEE 222 and CHEE 223
Corequisites: Exclusions:
Offering Term: FW
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 16
Engineering Science 32
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Demonstrate proficiency in operation and control of process and analytical equipment.
2. Demonstrate engineering judgment and an awareness of the nature and magnitude of physical and chemical effects and factors, as well as errors and uncertainties.
3. Collect and interpret data to draw meaningful conclusions and evaluate the strengths, weaknesses and limitations of current chemical engineering theory.
4. Write concise, coherent, and grammatically correct lab reports that reflect critical analysis and synthesisDeliver clear and organized formal oral presentations.
5. Demonstrate effective independent learning, initiative, originality and creativity in completion of pre-lab preparation and other tasks.
6. Work effectively as group member and demonstrate good leadership skills when team leader, adopting a professional approach during all project phases.
7. Document and follow appropriate safety protocols.

CHEE 319 Process Dynamics and Control Units: 3.50
The dynamic behaviour and automatic control of processes are studied. Mathematical tools for analyzing the transient behaviour of open and closed-loop systems are presented. The steps of controller development are treated: process characterization (using mathematical models), controller design, and implementation. Methods for assessing system stability and performance are investigated, and are used in the design of controllers. Frequency response methods are introduced, as is the development and implementation of controller enhancements including feedforward and cascade control.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 222 or MINE 201, MTHE 225 (MATH 225), CHEE 321 or permission of the department. Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 30
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Develop ordinary differential equation models to describe process dynamic behaviour, using fundamental material and energy balances, and constitutive relationships.
2. Identify nonlinearity in model equations, and linearize appropriately.
3. Derive transfer function models from process models and process data.
4. Identify important dynamic features of single-input single-output (SISO) and multi-input multi-output (MIMO) linear dynamical systems.
5. Apply modern control theory to design controllers for uncertain SISO linear dynamical systems.
6. Explain the trade-offs in performance that arise in the design of a controller.
7. Analyze the frequency response behaviour of a process (using Nyquist and Bode approaches), and use this information to design controllers.
8. Determine when to use controller enhancements such as the internal model principle and feedforward control, and design such enhancements.

CHEE 321 Chemical Reaction Engineering Units: 3.50
This course provides a detailed and in-depth analysis to the principles of chemical kinetics, and reactor analysis and design. The topics in chemical kinetics include: rate constants, reaction order, rate equations for elementary and complex reactions, kinetic data analysis, and product distribution. In reactor analysis and design, discussion is focused on ideal reactor systems and arrangements, including batch reactors, plug flow reactors, continuous stirred tank reactors, and recycle reactors. The last part of the course considers homogeneous and heterogeneous catalytic reactions. The design component consists of how to make an appropriate choice of reactor type and operating conditions to optimize a desired product; sizing such reactors and determining conversion levels under various conditions of temperature and pressure; determination of reaction kinetics from experimental data.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 210, (CHEE 222 or MINE 201), or permission of the department. Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 30
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Formulate expressions for extent of reactions for multiple reversible and irreversible reactions. Use stoichiometry and thermodynamics to analyze the effect of temperature, pressure, and concentrations on equilibrium conditions. Apply the quasi steady-state assumption, thermodynamic equilibrium assumption, and rate limiting assumptions to develop overall reaction rate expressions and production rate expressions.
2. Develop mass and energy balances for ideal isothermal reactors to decide on reactor operation parameters. Evaluate the impact of parameters on conversion, selectivity, and/or yield.
3. Develop mass and energy balances for ideal non-isothermal reactors to decide on reactor operation parameters. Evaluate the impact of parameters on conversion, selectivity, and/or yield.
4. Understand and evaluate the impacts of transport phenomena limitations on the modeling, operation, and performance of chemical reactors.
5. Decide on appropriate reactor type and operating conditions to achieve desired conversion, selectivity, and/or yield.

CHEE 323 Industrial Catalysis Units: 3.50
Students will learn, discuss and apply knowledge of the chemical structure and reactivity of industrial catalytic compounds, with particular emphasis placed upon the integration of fundamental catalytic chemistry with the principles of chemical reaction engineering, transport phenomena and thermodynamics. Industrial processes of interest include homogeneous ionic, radical, and coordinative catalytic systems, as well as heterogeneous fluid-solid systems. The design component of the course will require students to develop catalytic processes to meet productivity targets from provided kinetic and thermodynamic data.
NOT OFFERED 2024-2025
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: ENCH 245, CHEE 321, CHEE 330 or permission of the Chemical Engineering department Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 11
Complementary Studies 0
Engineering Science 20
Engineering Design 11
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Apply rate determining step, steady state hypothesis, and material balance equations appropriately to derive rate expressions from reaction coordinate diagrams and/or mechanisms for ionic, radical, and catalytic reaction networks.
2. Integrate principles of chemical thermodynamics, reaction kinetics, interfacial mass transfer and diffusional mass transfer to develop mathematical models of multi#phase reactors.
3. Design catalytic reactors to meet productivity targets from provided kinetic and thermodynamic data.

CHEE 324 Organic Process Development Units: 3.50
Students will expand their knowledge of functional group interconversions and C-C bond forming reactions learned in ENCH 245, and apply retrosynthetic analysis to propose multi-step syntheses of organic target molecules. Selection of reagents, solvents and reaction conditions will be examined in the context of process safety, reaction yield, product isolation, and profitability. This will be followed by studies of target molecule recovery by extraction, recrystallization, distillation and chromatography. The design component of the course is a series of two-hour design challenges in which student teams generate solutions to process development problems. This includes proposing reaction sequences for producing a target molecule, conducting safety analyses of hazardous reactions, choosing from multiple synthetic routes, and recommending separation trains for product isolation.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: ENCH 245 and CHEE 311
Corequisites: Exclusions: ENCH 345
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 12
Complementary Studies 0
Engineering Science 15
Engineering Design 15
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Devise methodologies for quenching reaction mixtures and isolating target molecules, including appropriate use of liquid-liquid extraction, distillation, chromatography, recrystallization and trituration.
2. Design multistep reaction sequences leading to the synthesis of organic molecules containing up to three functional groups.
3. Evaluate organic syntheses taken from the scholarly and patent literature on aspects of process safety, environmental impact, economics and operability.
4. Compare pathways for the synthesis of an organic molecule based on process safety, environmental impact, economics and operability.
5. Depict multi-step organic processes using appropriate block flow diagrams.

CHEE 330 Heat and Mass Transfer Units: 3.50
This course follows a unified approach to introduce the physical origins and rate equations of heat and mass transfer. The principal topics covered include identification of the driving forces for heat and mass diffusion, development of transport models from first principles, steady state and transient solutions, and convective transfer. The boundary layer analogies are introduced. Closed form analytical solutions and correlations derived from dimensional analysis are used to estimate the heat and mass transfer convection coefficients.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 210, CHEE 223, or permission of the department. Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 42
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Identify mechanisms of heat and mass transfer in order to formulate rate equations.
2. Develop transport models based on the differential equations of heat and mass transfer and their simplified forms in order to identify suitable boundary conditions.
3. Solve the differential equations for steady-state, one-dimensional problems and non-steady state problems.
4. Estimate heat and mass transfer coefficients based on dimensional analysis, boundary layer analysis and similarity between momentum, heat and mass transfer.
5. Solve problems involving convective heat and mass transfer in one phase and two-phase systems.

CHEE 331 Design of Unit Operations Units: 4.50
This course is part of the Engineering Design and Practice Sequence. Heat and mass transfer knowledge is applied in the analysis and design of unit operations, including separation processes and heat exchanging equipment. The equilibrium stage concept is used to perform calculations and size separation processes including distillation, gas absorption/stripping and liquid-liquid extraction. Heat transfer processes are taught with an emphasis on the design various types of heat exchanging equipment, including shell and tube heat exchangers, condensers and reboilers. The chemical process design component of the course involves a series of activities, dealing with the design of separation processes, heat exchanger sizing and design, process hazards analysis, implementation of instrumentation and construction of piping and instrument diagrams. In addition to choosing and sizing unit operations and implementing appropriate process instrumentation, the students will learn to use simulation tools and will incorporate economics, safety and environmental responsibility in all stages of the design. The course is integrated with CHEE 361 Engineering Communications, Ethics and Professionalism.
K4.5(Lec: Yes, Lab: No, Tut: Yes)
Requirements: Prerequisites: APSC 200 or APSC 202, APSC 293, CHEE 311, CHEE 321, CHEE 330, or permission of the department. Corequisites: CHEE 361 Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 14
Engineering Design 40
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Development of engineering science knowledge on separation processes (distillation, absorption/stripping, extraction) and heat transfer processes (heat exchangers).
2. Application of engineering science knowledge to size separation process equipment and heat exchangers.
3. Development of competency in constructing process flow and P&I diagrams.
4. Implementation of process instrumentation and simple control loops, as well as safety instrumentation.
5. Development of competency in using engineering tools, such as Excel spreadsheets and Mathcad to perform engineering calculationsImplementation of process simulation software, such as Aspen HYSYS to simulate separation processes.
6. Demonstrate the ability to provide accurate, comprehensive, objective technical opinions and recommendations, including the choice of appropriate

CHEE 340 Biomedical Engineering Units: 3.50
This course will provide students with a fundamental understanding of cell biology, human physiology and the application of engineering principles (momentum and mass transfer, mechanics, materials) for the solution of medical problems. Topics include: Cell Biology, Anatomy and Physiology, Transport Phenomena in the Body, Biomechanics, Materials in Medicine, and Regenerative Medicine and Tissue Engineering.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: Corequisites: Exclusions: CHEE 442 and MECH 394
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 12
Complementary Studies 0
Engineering Science 30
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Describe the organization of cells, proteins and macromolecules into tissues and organs as well as the function of major organ systems within the body, including the cardiovascular, musculoskeletal, renal and immune systems.
2. Analyze and solve problems involving transport phenomena in the body in the context of the design and application of biomedical devices for the treatment of injury and disease.
3. Apply the principles of mechanics to competently analyze gross movement of the human body.
4. Apply the principles of materials properties and engineering for the design and application of biomedical devices.
5. Apply the principles of cell biology and engineering for the design and application of tissue engineering, bioreactors and regenerative medicine.

CHEE 342 Environmental Biotechnology Units: 3.50
This course gives a broad perspective of the use of microbial systems to treat environmental pollutants and of microorganisms as potential environmental contaminants. Biogeochemical cycles and their applications to processes such as the desulphurization of coal and crude oil, biocorrosion, mineral (eg. uranium, copper and iron) leaching, the degradation of organic compounds, and nitrate removal from drinking water will be studied. Microbial waste disposal systems such as composting and soil bioremediation and the role of biotechnology in waste minimization will be examined. Microorganisms found in air, soil and water, their detection, enumeration and control will be discussed.
(Lec: 3, Lab: 0, Tut: 0.5)
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 42
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Describe the role of microorganisms in processes such as biofilm formation, biocorrosion, mineral leaching, composting, clean drinking water.
2. Explain how environmental conditions can be manipulated to enhance or retard the above processes.
3. Summarize the significance of the biorefinery concept and explain how plant biomass can be converted to fermentable substrates and subsequently microbially transformed into biochemicals, biopolymers and biofuels.
4. Critically analyze relevant journal articles and investigate industrial application of the above concepts.

CHEE 361 Engineering Communications, Ethics and Professionalism Units: 1.00
This course provides advanced instruction and practice in engineering communications, engineering ethics and professionalism. Effective engineering writing and speaking skills are developed with an emphasis on engineering reports and oral presentations. Students will learn how to gather information, apply appropriate citation styles, write effective documents, and present data effectively. Activities include case studies involving the application of codes, engineering ethics, equity and professionalism. This course is integrated with CHEE 331.
K1(Lec: Yes, Lab: Yes, Tut: Yes)
Requirements: Prerequisites: APSC 200 or APSC 202, APSC 293 or permission of the Department. Corequisites: CHEE 331 or permission of the Department. Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 12
Engineering Science 0
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Critically evaluate written material, including scholarly sources.
2. Present concise, coherent, and grammatically correct materials (written and oral) that reflect critical analysis and synthesis, and appropriately address the needs of the audience.
3. Create accurate and complete technical graphics to explain, interpret, and assess information.
4. Deliver formal and informal oral presentations with appropriate language, style, timing, and flow.
5. Apply principles of engineering ethics and equity to issues encountered during engineering practice.
6. Analyze social and environmental aspects of engineering activities.

CHEE 363 Electrochemical Engineering Units: 3.50
This engineering science course covers aspects of technological applications of electrochemistry. It can be considered as overlap between electrical engineering, electrochemistry and chemical engineering. The course addresses the following 7 major topics of electrochemical engineering: 1) Introduction into Electrochemical Engineering and Systems: Characteristics, Charge Conservation, Faraday's Law; 2) Elements of Electrochemical Systems I. Electrolytes: Transport processes, electrolyte conductivity, pH and buffer solutions; 3) Elements of Electrochemical Systems II. Electrodes: Electrochemical Thermodynamics, Nernst Equation, Reference Electrodes, Cell Potential, Electrochemical Kinetics; 4) Electrical Double Layers: Theory & Models, Electrokinetic Phenomena; 5) Electrochemical Characterization Methods: Cyclic Voltammetry, Electrical Impedance Spectroscopy; 6) Electrochemical Energy Engineering: Batteries, Fuel Cells, Electrical & Electrochemical Capacitors; 7) Industrial Electrochemical Processes: Fundamentals, Reactor Design & Parameter, Chlor-Alkali Process, Electrochemical Extraction of Metals, Hall-Heroult Process.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 210, CHEE 270, CHEE 321, or permission of the department. Corequisites: Exclusions: CHEE 461
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 30
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Define and explain the concepts of Electrical Potential, Electrical Field, Electrostatic Work, Voltage, Current, Electrochemical Potential, Activation Energy, Electrode & Electrochemical Equilibrium.
2. Formulate and calculate relevant transport phenomena such as migration and the characteristics of (diluted) electrolytesRelate the conversion of matter to the transport of electrical charge.
3. Evaluate the potential of electrochemical systems based on thermodynamic data and the concept of half-cellsApply electrical circuit elements to model electrochemical systems in order to calculate energy balances and to estimate efficiencies.
4. Apply knowledge of electrokinetic phenomena to design microfluidic unit operations.
5. Use of technical measures to characterize properties of galvanic elements and capacitors.

CHEE 371 Mitigation of Industrial Pollution Units: 3.50
Sources and characteristics of waste streams emanating from chemical and related industries are reviewed as the basis for developing appropriate abatement and treatment strategies. Treatment processes utilizing individual operations as well as integrated systems of physical, chemical and biological treatment are covered. Treatment process designs and sensitivity analyses of alternatives are undertaken for case studies involving industrial solid, liquid and gaseous wastes. Canadian guidelines and regulations are presented and implemented within the context of environmental and human health.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 221 or MINE 201, or permission of the Department. Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 30
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Identify environmental and human health issues related to waste treatment processes.
2. Determine the parameters necessary to characterize waste streams and processes associated with their physical, biological and chemical treatment.
3. Analyze waste streams design appropriate process flow diagrams and estimate appropriate size of unit operations required to meet applicable standards.
4. Apply sound engineering principles to evaluate and select appropriate abatement strategies and treatment methods to specific case studies.
5. Justify selected waste treatment strategies and analyze their strengths and limitations with respect to current guidelines, standards and regulations.

CHEE 380 Biochemical Engineering Units: 3.50
Biochemical Engineering involves the application of Chemical Engineering principles and approaches to biologically based systems and processes. Biochemical Engineering is central to the area of environmental engineering, and to biotechnology processes which produce pharmaceuticals, fine chemicals and genetically engineered products. The course involves a systematic and quantitative description of medium formulation and sterilization, microbial kinetics and bioreactor design, product isolation and purification, and examples of current industrial practices and processes.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 221 or permission of the Chemical Engineering department. Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 30
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Design culture medium based on nutritional requirements of microbial cells.
2. Specify design criteria for medium sterilization and solve problems involving both batch and continuous sterilization.
3. Apply the principles of microbial growth kinetics in bioreactors.
4. Simulate and evaluate bioreactor performance.
5. Apply mass and heat transfer correlations to bioreactor design.
6. Design a complete bioreactor based on targets, constraints and physical properties.
7. Identify suitable process instrumentation for monitoring and control of bioreactors.
8. Know and select process unit operations for product recovery and purification.

CHEE 400 Technology, Engineering & Management (TEAM) Units: 7.00
Multidiscipline teams of engineering, commerce, law, and/or science students, as appropriate, act as consultants to industrial and governmental clients. Projects include a phase of self-directed problem definition and project scope definition in the fall term, followed by project execution in the winter term. Typical projects involve evaluation of technical alternatives (with an emphasis on health, safety, and environmental), preparation of detailed recommendations, and both market and financial analysis. Project topics vary widely and are provided by a diverse list of fee paying clients. The course includes seminars on project management. There are several meetings during the fall term to organize groups and select projects, but regularly scheduled lectures do not begin until the Winter term. Teams interact regularly with clients at both a technical and a management level, and are also assigned an industrial project mentor. Students master project management skills, by managing their own budget, travel arrangements etc. The course concludes with a comprehensive report and presentation to the client. The course is managed by the Department of Chemical Engineering
COURSE DELETED 2018-2019
K7(Lec: Yes, Lab: No, Tut: No)
Requirements: Prerequisites: Permission of the instructor Corequisites: Exclusions:
Offering Term: FW
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 42
Engineering Science 0
Engineering Design 42
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

CHEE 405 Biochem/Biomed Research Projec Units: 7.00
Students will conduct research on a Biochemical/Biomedical Engineering related project. Based on the project objective provided by their faculty supervisor, the students will work independently to develop an experimental and/or modeling methodology, conduct experiments or simulations and generate data. Students will submit interim oral and written progress reports and a final oral presentation and technical report. They will be expected to present and defend their results in a conference/seminar setting. Students enrolling for this course are advised to consult with the faculty member supervisor concerned late in the winter term of their 3rd year of study.
COURSE DELETED 2019-2020
(Lec: 0.25, Lab: 6, Tut: 0.75)
Requirements: Prerequisites: Must be registered in BSCE or BASC program. Corequisites: Exclusions:
Offering Term: FW
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 84
Engineering Design 0
Offering Faculty: Smith Engineering

CHEE 406 Bioenvironmental Research Proj Units: 7.00
Students will conduct research on a Bioenvironmental Engineering related project. Based on the project objective provided by their faculty supervisor, the students will work independently to develop an experimental and/or modeling methodology, conduct experiments or simulations and generate data. Students will submit interim oral and written progress reports and a final oral presentation and technical report. They will be expected to present and defend their results in a conference/seminar setting. Students enrolling for this course are advised to consult with the faculty member supervisor concerned late in the winter term of their 3rd year of study.
COURSE DELETED 2019-2020
(Lec: 0.25, Lab: 6, Tut: 0.75)
Requirements: Prerequisites: Must be registered in BSCE or BASC program. Corequisites: Exclusions:
Offering Term: FW
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 84
Engineering Design 0
Offering Faculty: Smith Engineering

CHEE 408 Bioengineering Research Project Units: 7.00
Students will conduct research on a Biochemical/Biomedical/Bioenvironmental Engineering related project. Based on the project objective provided by their faculty supervisor, the students will work independently to develop an experimental and/or modeling methodology, conduct experiments or simulations and generate data. Students will submit interim oral and written progress reports and a final oral presentation and technical report. They will be expected to present and defend their results in a conference/seminar setting. Students enrolling for this course are advised to consult with the faculty member supervisor concerned late in the winter term of their 3rd year of study.
K7(Lec: Yes, Lab: Yes, Tut: Yes)
Requirements: Prerequisites: Must be registered in BSCE or BASC program. Corequisites: Exclusions:
Offering Term: FW
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 28
Engineering Science 0
Engineering Design 56
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Identify the knowledge/skills required, evaluate available literature, and design experiments and/or develop methodology to meet the project objective(s) safely and efficiently.
2. Apply appropriate engineering techniques, tools, and processes to accomplish the task.
3. Synthesize information from experimentation, investigation, and literature to reach substantiated conclusions.
4. Describe nature and possible causes of uncertainty in analysis, interpretation, and measurement.
5. Generate a traceable and defensible record of the project using an appropriate project records system.
6. Write and revise technical memos and reports to communicate intentions and findings using appropriate conventions and concise precise and clear language.
7. Demonstrate confidence in formal and informal oral communications with supervisor and colleagues.
8. Document and follow appropriate safety protocols to meet the project objective(s) safely.

CHEE 410 Engineering Innovation and Entrepreneurship Units: 3.50
This is a course about innovation - distinctive ideas, of value, put to practice - and entrepreneurship - the process of putting to practice and sustaining the implementation of innovations - for societal benefit and wealth creation. Curiosity of the world around us is emphasized for identifying opportunities to have an impact and make a difference, to which a discipline is imposed - one that identifies who might be interested in or benefit from our product or service, and how we can bring an idea to fruition and bring the necessary resources (e.g., financial, intellectual) to provide it to society. Legal aspects (e.g., incorporation, partnerships), raising capital, and protecting the strategic advantage of intellectual property (e.g., patents, trade secrets) are discussed, together with the importance of having a social acceptance to operate. The concept of a business model, summarized using the business model canvas methodology, is presented, together with the concept of a business plan describing how a venture will be operated over a time horizon. For-profit and not-for-profit ventures, and the elements of the business models for each, are studied and compared, and intrapreneurship/entrepreneurship are compared. Financial metrics for assessing the viability of ventures and guiding investment decisions are reviewed. Systems Thinking (recognizing the whole/parts and that which is common/distinct) is introduced. Design Thinking - a human-centered design emphasizing observation and insight - is presented, along with journey maps and personas for understanding customer segments. Diffusion of innovations is described, including the factors influencing adoption of innovations, and the manner in which innovations propagate in society. Working in groups, students identify a venture opportunity having a technological component, and propose a business model and plan as the major evaluation in the course.
K3.5(Lec: Yes, Lab: No, Tut: Yes)
Requirements: Prerequisites: Corequisites: Exclusions: CHEE 302, CHEE 310
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 42
Engineering Science 0
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Describe how technical innovation arises from advances in knowledge and the motivation of necessity or opportunity.
2. Identify problems and generate ideas using design and systems thinking tools.
3. Demonstrate how to take an innovation to

CHEE 412 Transport Phenomena Units: 3.50
The transport phenomena approach is followed to study and analyze transport of momentum, energy and mass, with special focus on combined transport problems. Solutions are developed for problems involving steady-state and unsteady flows, isothermal and non-isothermal conditions, as well as non-Newtonian liquids. This course completes the students' intellectual training in the transport sciences culminating in their mastery of combined transport problems, including fluid flow with heat transfer, or mass transport with fluid flow, or heat transfer with mass transport.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 223, CHEE 224, CHEE 330, or permission of the department Corequisites: Exclusions: CHEE 452
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 42
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Identify transport properties and analyze the mechanisms of molecular momentum energy and mass transport.
2. Select locate and orient coordinate systems for transport phenomena problems including rectangular and curvilinear.
3. Formulate the differential forms of the equations of change for momentum heat and mass transfer problems for steady state and unsteady flows.
4. Create original solutions to fluid flow heat transfer and mass transfer problems and solve problems combining these transport phenomena.

CHEE 414 Foundations of the Oil and Gas Industry Units: 3.50
Fundamentals of the oil and gas industry covering Chemical Engineering and Geological Engineering practice, and implications of Canadian and world political forces together with business practices are covered. Canada's role in global energy, including oil and gas, and the relationship to energy transition are explored. Industry practices for exploration, recovery, processing, transportation, business expansion and policy issues will be addressed through guest lectures and case studies. Environmental issues including emissions reduction, indigenous relations, and the evolving technologies of geothermal energy, CCUS, and direct lithium extraction from oilfield brines are explored and discussed.
K3.5(Lec: Yes, Lab: No, Tut: Yes)
Requirements: Prerequisites: CHEE 221, or permission of the instructor. Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 30
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Analyze global and Canadian energy and hydrocarbon supply and demand within the business and geopolitical context of the industry, current business issues, including taxes and incentives, environmental regulations and policy —including water use and CO2 emissions.
2. Examine, distinguish, and relate the six elements of a working hydrocarbon (HC) system , and recognize the geological controls of each element.
3. Analyse how these geological controls underpin the techniques used for HC exploration and reservoir characterization.
4. Apply Chemical Engineering principles to design appropriate equipment and facilities for the drilling, completion and production of oil and gas wells.
5. Assess the role of horizontal well drilling technology along with both the development of multi-stage hydraulic fracturing and SAGD, and the impact on the production of hydrocarbons in North America. Critique the environmental impacts of these technologies.
6. Appraise the different methods for how heavy oil and bitumen are produced, processed and transported along with the environmental issues involved.
7. Assess how to optimize regional refinery and gas plant flow plans through an understanding of supply chain systems including pipelines, rail, trucking and ocean tankers in respect to both crude oil, products, natural gas

CHEE 415 Engineering Chemistry Laboratory Units: 4.00
Bench- and pilot-scale laboratory exercises provide students practical experience with chemical operations involving transport phenomena, thermodynamics, reaction kinetics and process control. Working with minimal supervision, student teams plan and execute experiments, analyze acquired data according to engineering science models, and communicate key findings in concise technical reports.
DELETED 2024-2025
(Lec: 0.25, Lab: 3.5, Tut: 0.25)
Requirements: Prerequisites: CHEE 330 Corequisites: Exclusions: CHEE 315
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 48
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Demonstrate proficiency in operation and control of process and analytical equipment.
2. Demonstrate engineering judgment and an awareness of the nature and magnitude of physical and chemical effects and factors, as well as errors and uncertainties.
3. Collect and interpret data to draw meaningful conclusions and evaluate the strengths, weaknesses and limitations of current chemical engineering theory.
4. Demonstrate effective independent learning, initiative, originality and creativity in completion of pre-lab preparation and other tasks.
5. Work effectively as group member and demonstrate good leadership skills when team leader, adopting a professional approach during all project phases.
6. Document and follow appropriate safety protocols.

CHEE 418 Strategies for Process Investigations Units: 3.50
The roles of designed experiments and data analysis procedures in process investigations are discussed. Applications of two-level factorial and fractional factorial designs in screening studies and higher-order designs for response surface characterization and exploration are examined. Least squares procedures for fitting and testing mathematical models, and for assessing model predictions, are described. Empirical in-plant optimization procedures are also considered. Established and evolving approaches for quality and productivity improvement are examined. The design component of this course is the planning and execution of an experimental investigation, the analysis of the resulting data, and the formulation of recommendations on the basis of those results.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 209 and CHEE 331, or permission of the department Corequisites: Exclusions: STAT 361
Offering Term: F
CEAB Units:
Mathematics 12
Natural Sciences 0
Complementary Studies 0
Engineering Science 18
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Assess the existence of systematic relationships between variables using appropriate graphical and quantitative techniques.
2. Estimate empirical models between variables using statistical model building and machine learning techniques including multiple linear and non-linear regression.
3. Assess the quality of estimated models using graphical and quantitative techniques.
4. Evaluate and interpret estimated models taking into account sources of uncertainty and variability.
5. Propose programs of experimental investigation taking into account the goals and context of the investigation, screen and prioritize process variables using 2-level factorial designs, and higher-order experimental designs.

CHEE 420 Laboratory Projects III Units: 4.00
Students will work as teams to tackle projects that require bench and pilot plant equipment, and computer packages that simulate commercial processes. The projects will be more extensive and integrated than in previous laboratories and will require a thorough and comprehensive analysis of processes and operations. A strong emphasis is placed on project planning and management, as well as professional communication with supervisors. The design component of this course is found in the application of process analysis skills to solve problems. The projects require the students to apply critical and problem-solving skills in the operation or simulation of laboratory and process equipment with the goal of solving a problem for a fictitious industrial client. The projects may involve analysis or troubleshooting of existing equipment, or an investigation of the applicability of a concept to a new area.
K4(Lec: Yes, Lab: Yes, Tut: Yes)
Requirements: Prerequisites: CHEE 311, CHEE 321, CHEE 330, CHEE 315, CHEE 319, or permission of the department Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 16
Engineering Science 16
Engineering Design 16
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Demonstrate proficiency in operation and control of process and analytical equipment.
2. Demonstrate engineering judgment and an awareness of the nature and magnitude of physical and chemical effects and factors, as well as errors and uncertainties.
3. Collect and interpret data to draw meaningful conclusions and evaluate the strengths, weaknesses, and limitations of current chemical engineering theory.
4. Write concise, coherent, and grammatically correct lab reports that reflect critical analysis and synthesis. Deliver clear and organized formal oral presentations.
5. Demonstrate effective independent learning, initiative, originality, and creativity in completion of pre-lab preparation and other tasks.
6. Work effectively as group member and demonstrate good leadership skills when team leader adopting a professional approach during all project phases.
7. Document and follow appropriate safety procedures.
8. Design appropriate experimental protocol to reach substantiated conclusions.

CHEE 421 Research Project Units: 7.00
This course provides an opportunity for students to work on an individual basis with faculty members of the department. Students will submit interim oral and written progress reports and a final oral presentation and technical report. They will be expected to present and defend their results in a conference/seminar setting. The projects may be concerned with engineering design and development work or may be of a more fundamental research nature. Students enrolling for this course are advised to consult with the faculty member concerned late in the winter term of their 3rd year of study.
K7(Lec: Yes , Lab: Yes, Tut: Yes)
Requirements: Prerequisites: Must be registered in BSCE or BASC program. Corequisites: Exclusions:
Offering Term: FW
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 28
Engineering Science 0
Engineering Design 56
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Identify the knowledge skills required evaluate available literature and design experiments and/or develop methodology to meet the project objectives safely and efficiently.
2. Apply appropriate engineering techniques tools and processes to accomplish the task.
3. Synthesize information from experimentation investigation and literature to reach substantiated conclusions.
4. Describe nature and possible causes of uncertainty in analysis interpretation and measurement.
5. Generate a traceable and defensible record of the project using an appropriate project records system.
6. Write and revise technical memos and reports to communicate intentions and findings using appropriate conventions and concise precise and clear language.
7. Demonstrate confidence in formal and informal oral communications with supervisor and colleagues.

CHEE 426 Design of Electrochemical Sensors Units: 3.50
This capstone course for the chemical diagnostics spine of the Engineering Chemistry program applies knowledge of electrochemistry, analytical chemistry, basic electronics, and data processing to design and test an electrochemical diagnostic instrument. Students will work in teams to develop a sample pretreatment method, a microfluidic device for analyte transport, an electrochemical reaction for analyte concentration determinations, and an appropriate electrochemical cell. Instrument calibration, performance and cost analyses are also required. The development of your team's electrochemical sensor will be supported in this course through readings and instrumentation tutorials.
NOT OFFERED 2024-2025
K3.5 (Lec: Yes, Lab: Yes, Tut: Yes)
Requirements: Prerequisites: CHEE 270, CHEE 363
Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 14
Engineering Design 28
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

CHEE 434 Advanced Control of Multivariable Linear Systems Units: 3.50
This course presents methods for dynamic analysis and controller design for multivariable process control problems, and discrete time control. Control techniques, including feedforward and cascade control, are discussed further, and the concept of model predictive control is presented. Multivariable controller design and the problem of control loop interaction are examined. State space models for processes are introduced. Mathematical tools for analyzing the dynamics of sampled data systems are developed, and the design of discrete time controllers is introduced. Techniques discussed in the course are applied to the control of various chemical process units.
NOT OFFERED 2024-2025
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 319, or permission of the department Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 30
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Recognize the importance of modeling errors and uncertainties in controller design.
2. Apply modern control theory to design a controller for uncertain SISO and MIMO linear dynamical systems.
3. Understand the tradeoff in performance that arise in the design of a controller.

CHEE 436 System Identification Units: 3.50
The course focuses on the theory and application of linear time series methods for system identification. Time domain and frequency domain methods for analyzing dynamic data will be presented. Standard process plus disturbance models encountered in the identification literature will be investigated from both statistical and physical perspectives. Methods for structural identification, incorporation of exogenous variables, parameter estimation, inference and model adequacy will be examined in detail. The design of dynamic experiments and incorporation of model uncertainty into the intended model and use, such as prediction or control, will be discussed. Assignments will include the analysis of industrial data sets. Dynamic modelling using neural networks and nonlinear time series methods will be introduced.
COURSE DELETED 2018-2019
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 209, CHEE 418, or permission of the department. Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 12
Natural Sciences 0
Complementary Studies 0
Engineering Science 30
Engineering Design 0
Offering Faculty: Smith Engineering

CHEE 440 Pharmaceutical Technology Units: 3.50
Pharmaceutics and the industrial manufacture of pharmaceutical dosage forms are introduced. Topics include the design and preparation of a successful dosage form with respect to the route of administration, and large-scale manufacture in a sterile and clean environment. Aspects of chemical kinetics, physical chemistry, physiology, cell biology, mass and heat transfer, and fluid dynamics will be described as they relate to the manufacture of effective dosage forms. This course applies engineering concepts, such as mass transfer, unit operations, thermodynamics, and basic chemistry and is recommended for students in their 3rd or 4th year of studies.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: Must be registered in BSCE or BASC program. Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 12
Complementary Studies 0
Engineering Science 30
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Explain the physiological routes of absorption for drugs and the advantages and limitations of each route.
2. Describe and mathematically analyze the absorption, distribution, and elimination of drugs from various dosage forms.
3. Analyze and solve problems involving unit operations in the context of the design and manufacture of tablets, capsules, solutions, suspensions and emulsions.
4. Describe the ethics, safety and regulatory standards around manufacture and regulatory approval of pharmaceutical products.

CHEE 452 Transport Phenomena in Physiological Systems Units: 3.50
This course applies the principles of mass, momentum and heat transfer in physiological systems. The students will examine the role of transport phenomena in the function of organs and organ systems in the body, and develop the skills necessary to analyze models of biological transport processes in the context of the design of biomedical devices.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 223 and CHEE 330, or permission of the department Corequisites: Exclusions: CHEE 412
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 42
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Identify transport properties and analyze the mechanisms of molecular momentum, energy and mass transport.
2. Select, locate and orient coordinate systems for transport phenomena problems (including rectangular and curvilinear).
3. Formulate the differential forms of the equations of change for momentum, heat and mass transfer problems for steady#state and unsteady flows.
4. Create original solutions to fluid flow, heat transfer and mass transfer problems.
5. Develop original solutions to fluid flow in compliant and oscillatory systems.
6. Create original solutions to combined fluid flow and heat transfer, heat and mass transfer and fluid flow and mass transfer problems.
7. Understand and appreciate physiology of the pulmonary, cardiovascular, and renal systems and how they can be modeled.

CHEE 460 Applied Surface and Colloid Science Units: 3.50
The course covers four major topics. 1. The thermodynamic properties of interfaces (surface energy, wetting, surface area and porosity, capillary effects, work of adhesion/cohesion). 2. Models of adsorption/desorption phenomena. 3. The amphiphilic behaviour of surfactants. 4. The stability and characterization of colloidal systems. Student appreciation for the importance of these phenomena is cultivated using examples drawn from industrial processes/products including inks, paints, foods, polymer blends, and nanocomposites.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 210 or permission of the department. Corequisites: Exclusions: CHEM 347
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 12
Complementary Studies 0
Engineering Science 30
Engineering Design 0
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Explain the origin of "long#range', non#covalent colloidal forces (van der Waals, electrostatic, etc.) and preparation of quantitative DLVO and XDLVO plots for a number of colloidal systems using the proper mathematical models.
2. Explain the link between liquid surface tension and contact angle, and demonstrate how certain experimental techniques can be used for the assessment of liquid surface tension (or, equivalently, surface energy of solids).
3. Apply knowledge on thermodynamics of micellization in surfactant solutions describe the influence of physical variables such as temperature, molecular structure of surfactant, and solvent characteristics on parameters such as critical micellization concentration (CMC), association number, micelle structure, etc.
4. Describe the thermodynamics of emulsion formation and calculate the kinetic and thermodynamic stability of such emulsions.
5. Calculate adsorbate concentration and area per molecule on a solid surface using various adsorption models.
6. Design colloidal systems or engineered surfaces of high industrial or technological interest (liquid detergents, nanocomposites, eco#paints, superhydrophobic materials, etc.)
7. Explain the interactions between colloids and visible light, as well as the principles of static and dynamic light scattering.

CHEE 463 Electrochemical Energy Systems Units: 3.50
This engineering science and design course examines and analyzes electrochemical energy generation, conversion and storage technologies of emerging importance to modern society. Methods of generating electrical power will be examined in terms of efficiency, cost, environmental footprint, greenhouse gas emissions and current and potential applications. Integration of these power generation systems with energy conversion and storage technologies will be assessed in terms of their compatibility with the supply and demand model of the electricity grid and their potential for use in remote off-grid communities. The electrification of transportation technologies will also be examined. The design element of this course involves hands-on prototyping of an integrated energy system for a specified application.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 363 Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 28
Engineering Design 14
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Utilizes knowledge of thermodynamics, electrochemistry and electrical circuits to analyze and design power generation and energy systems.
2. Analyzes the influence of thermodynamic, equilibrium and second law limitations on the overall efficiency of power generation systems.
3. Considers technical, financial, social, environmental and legal factors, safety and sutainability issues when solving engineering problems.
4. Develops equipment specifications, process or product design incorporating performance requirements and constraints such as quality, yield, reliability, economics, safety and standards and codes as appropriate.

CHEE 470 Design Of Manuf Process Units: 7.00
This course will consolidate the necessary skills and knowledge for a working chemical engineer by carrying out an industrial process design and developing a Front End Engineering Design (FEED) document. The students will develop proficiency in the following: Process selection and synthesis, the use and recognition of the limitations of process simulation software, development of Piping and Instrumentation diagrams, analysis of process safety, equipment sizing, materials selection, and economic analysis, including the estimation of capital and operating cost along with optimization.
COURSE DELETED 2020-2021
K7(Lec: Yes, Lab: No, Tut: Yes)
Requirements: Prerequisite CHEE 331, CHEE 361, CHEE 321, or permission of the Department Must be registered in a BASC academic program.
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 0
Engineering Design 84
Offering Faculty: Smith Engineering

CHEE 471 Chemical Process Design Units: 7.00
This capstone course integrates skills, knowledge and experience gained from engineering science components of the Chemical Engineering and Engineering Chemistry curriculum to solve open-ended chemical process design problems. Students will develop competency in the following: process hazard analysis, appropriate use of process simulation techniques, identification and mitigation of process inefficiencies and risks, strategies for acquiring technical data, and cost estimation of process revisions.
DELETED 2024-2025
K7(Lec: Yes, Lab: No, Tut: Yes)
Requirements: Prerequisites: CHEE 321, CHEE 331, CHEE 361, or permission of the Instructor. Corequisites: Exclusions:
Offering Term: FW
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 0
Engineering Design 84
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Apply project management tools (work breakdown structures, activity lists, network diagrams, Gantt diagrams) to distribute project workload amongst team members and facilitate the timely completion of course deliverables.
2. Develop a Process Hazard Analysis (hazard identification, hazard evaluation, consequences analysis and risk analysis) from a P&ID of a unit operation and formulate recommendations for mitigating identified risks.
3. Assess a process design from the standpoint of sustainability, environmental stewardship and applicable regulations / standards.
4. Conduct a design review of a process flow diagram to identify performance limitations, health and safety issues, operational inefficiencies and unnecessary costs.
5. Identify gaps in knowledge needed to revise unit operations and develop an experimental program to acquire the necessary data.
6. Use MATLAB (or similar) to simulate the dynamics of unit operation, and HYSYS (or similar) to simulate steady state conditions of a continuous process element, while recognizing the limitations of process modelling approaches and software.
7. Develop capital and operating cost estimates for proposed process revisions and formulate recommendations for improving process safety and economics.
8. Generate concise technical reports using appropriate terminology and documentation, with particular emphasis

CHEE 472 Chemical Process Design I Units: 3.50
This capstone course integrates skills, knowledge and experience gained from engineering science components of the Chemical Engineering and Engineering Chemistry curriculum to solve open-ended chemical process design problems. Students will develop competency in the following: process hazard analysis, appropriate use of consequence simulation techniques, identification and mitigation of process inefficiencies and risks, evaluation of alternative process routes and technologies, development of experimental program to acquire information necessary for process design.
K3.5(Lec: Yes, Lab: No, Tut: Yes)
Requirements: Prerequisites: CHEE 321, CHEE 331, CHEE 361, or permission of the Instructor. Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 0
Engineering Design 42
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. N/A

CHEE 473 Chemical Process Design II Units: 3.50
This capstone course integrates skills, knowledge and experience gained from engineering science components of the Chemical Engineering program to solve open-ended chemical process design problems. Students will develop competency in the following: process simulation and analysis, appropriate use of process simulation techniques and tools, identification and mitigation of process inefficiencies and risks, strategies for acquiring technical data, costing of process revisions, and process sustainability assessment.
K3.5(Lec: Yes, Lab: No, Tut: Yes)
Requirements: Prerequisites: CHEE 321, CHEE 331, CHEE 361, CHEE 472, or permission of the Instructor. Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 0
Engineering Design 42
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. CLOs coming soon; please refer to your course syllabus in the meantime.

CHEE 484 Bioremediation Units: 3.50
Bioremediation as an option to treat contaminated soils and ground water. Advantages and disadvantages of bioremediation compared to nonbiological processes. Factors affecting choice of in situ or ex situ processes. Assessment of biodegradability; biostimulation vs bioaugmentation; mineralization vs. partial degradation; factors affecting microbial activity (choice of electron acceptor, toxicity of pollutant, C/N/P ratio, co-substrates, soil humidity, pH and temperature); bioavailability of pollutant. Biodegradation of specific contaminants (e.g. diesel fuel, polychlorinated biphenyls, dyestuffs, aromatic and polyaromatic hydrocarbons) will be studied in detail. The design component of this course consists of learning design of appropriate laboratory and field experiments to obtain data on microbial degradation of an organic pollutant to be able to calculate bioremediation design parameters such as mass and delivery rate requirements of electron acceptors and nutrients and degradation rates in reactor and non-reactor based systems; and to be aware of limitations of these calculations.
DELETED 2024-2025
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: Must be registered in BSCE or BASC program. Corequisites: Exclusions:
Offering Term: W
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 42
Engineering Design 0
Offering Faculty: Smith Engineering

CHEE 490 Polymer Formulations and Processing Technology Units: 3.50
The design and manufacture of polymer products is reviewed, with particular emphasis on material selection and processing technology. The engineering properties of elastomers, thermoplastics, adhesives, fibres and coatings are discussed in terms of processing characteristics and end-use performance. Industrial processing operations such as extrusion, molding, mixing and film manufacture are presented in detail. The design component of the course requires students to select appropriate materials and processing methods for an engineering application. Examples include medical catheters, engine gaskets, drug capsules and biodegradable packaging.
(Lec: 3, Lab: 0, Tut: 0.5)
Requirements: Prerequisites: CHEE 223 or MECH 241, or permission of the department Corequisites: Exclusions:
Offering Term: F
CEAB Units:
Mathematics 0
Natural Sciences 0
Complementary Studies 0
Engineering Science 30
Engineering Design 12
Offering Faculty: Smith Engineering
Course Learning Outcomes:

1. Classification of polymers, identification of their physical properties and establishing structure-property relations.
2. Formulation of polymeric compounds to meet specific product properties.
3. Knowledge of polymer processing operations and choice of operation depending on the material and final product requirements.
4. Interpretation and analysis of rheological data using models for non-Newtonian fluids.
5. Identification of methods for rheological measurements and analysis of the results.
6. Solution of simple flow problems and calculations in extrusion and injection molding.