

# CHEMICAL ENGINEERING (CHG)

## Courses in chemical engineering (CHG) are offered by the Faculty of Engineering

### CHG 1125 Chemical Engineering Fundamentals (3 units)

Chemical Engineering profession in relation to the chemical process industry. System of units, dimensions. Processes, process variables and flowcharts. Material balances: single and multiple units, recycle and bypass, reactive and non-reactive systems. Chemical equilibrium, single-phase and multi-phase systems, solutions, phase diagrams. Introduction to energy balances. Unit operations and instrumentation. Introduction to problem solving techniques and use of spreadsheets.

**Course Component:** Lecture, Tutorial

CHM 1311 or CHM 1301 is corequisite to CHG 1125.

### CHG 1371 Numerical Methods and Engineering Computation in Chemical Engineering (3 units)

Study of advanced techniques in Excel and coding in Visual Basic for Applications (VBA). Numerical methods common to chemical engineering analysis and design, including linear least squares, empirical model building, methods for solving nonlinear equations and systems of equations using programming and Excel Solver, numerical integration and the solution of differential equations. Theory behind the methods and, equally important, when and how to apply them using Excel and VBA to solve engineering problems.

**Course Component:** Lecture, Tutorial

Prerequisite: CHG 1125.

### CHG 1525 Principes de base du génie chimique (3 crédits)

Le génie chimique et son rôle dans l'industrie des procédés. Systèmes d'unités, dimensions. Procédés et variables de procédés et diagrammes de procédé. Bilans de matière: procédés à une ou plusieurs unités, recyclage, circuit alternatif, systèmes réactifs et non-réactifs. Équilibre chimique, système à une et plusieurs phases, solutions, diagrammes de phase. Introduction aux bilans d'énergie. Opérations unitaires et instrumentation. Introduction aux techniques de solutions de problèmes et l'utilisation d'un chiffrier.

**Volet :** Cours magistral, Tutoriel

Concomitant : CHM 1711 ou CHM 1701.

### CHG 1771 Méthodes numériques et programmation en génie chimique (3 crédits)

Étude des techniques avancées du logiciel Excel et la programmation dans l'environnement Visual Basic for Applications (VBA). Méthodes numériques communes à l'analyse et aux techniques de conception en génie chimique, y compris la méthode des moindres carrés, la construction de modèles empiriques, les méthodes de résolution des équations non linéaires et des systèmes d'équations par l'emploi de la programmation et de Solver de Excel, l'intégration numérique et la solution des équations différentielles. Théorie derrière les méthodes ainsi que leurs applications aux problèmes d'ingénierie en utilisant Excel et VBA.

**Volet :** Cours magistral, Tutoriel

Préalable: CHG 1525.

### CHG 2312 Fluid Flow (3 units)

Application of fluid flow principles to the solution of engineering problems. Macroscopic mass, momentum, and energy balances. Newtonian and non-Newtonian fluids, compressible and incompressible fluids. Friction factors and Reynolds numbers for flow in conduits, around submerged objects, in packed beds and porous media. Fluidization. Flow measurement, dimensional analysis.

**Course Component:** Lecture, Tutorial

Prerequisite: CHG 1125.

### CHG 2314 Heat Transfer Operations (3 units)

Steady-state heat conduction in solids with and without extended surfaces. Natural and forced convective heat transfer. Transient heat conduction. Heat exchangers. Boiling heat transfer. Condensation. Evaporation. Thermal radiation.

**Course Component:** Lecture, Tutorial

Prerequisites: CHG 2312, MAT 2384.

### CHG 2317 Introduction to Chemical Process Analysis and Design (3 units)

Process analysis and design using mass and energy balances. Thermodynamic data and relationships. Simultaneous mass and energy balances on reactive and non-reactive systems. Mixing and solutions. Balances on transient processes. Introduction to computer-aided process calculations and design.

**Course Component:** Lecture, Tutorial

Prerequisite: CHG 1125.

### CHG 2324 Fundamentals and Applications of Chemical Engineering Thermodynamics (3 units)

First and second laws of thermodynamics. PVT behaviour of fluids. Equations of state. Thermal chemical effects. Estimation of physical-chemical properties. Applications of thermodynamics to various processes in the field of chemical engineering.

**Course Component:** Lecture, Tutorial

Prerequisite: CHG 2317.

### CHG 2712 Mécanique des fluides (3 crédits)

Applications des principes d'écoulement des fluides pour la résolution des problèmes d'ingénierie. Bilans macroscopiques de conservation de la matière, de la quantité de mouvement et de l'énergie. Fluides newtoniens et non newtoniens. Fluides compressibles et incompressibles. Facteurs de friction et nombres de Reynolds pour les écoulements dans des conduites, autour des objets et dans les lits fixes. Fluidisation. Mesures des débits. Analyse adimensionnelle.

**Volet :** Cours magistral, Tutoriel

Préalable : CHG 1525.

### CHG 2714 Transfert de chaleur (3 crédits)

Conduction de la chaleur en régime stationnaire dans les solides avec et sans ailettes. Convection naturelle et assistée. Conduction de la chaleur en régime transitoire. Échangeurs de chaleur. Transfert de chaleur par ébullition. Condensation. Évaporation. Rayonnement thermique.

**Volet :** Cours magistral, Tutoriel

Préalables : CHG 2712, MAT 2784.

### **CHG 2717 Introduction à l'analyse et la conception des procédés chimiques (3 crédits)**

Analyse et conception des procédés en utilisant des bilans de matière et d'énergie. Relations et données thermodynamiques. Bilans simultanés de matière et d'énergie pour des systèmes réactifs et non-réactifs. Mélanges et solutions. Bilans sur des procédés transitoires. Introduction aux calculs et conception des procédés assistés par ordinateur.

**Volet :** Cours magistral, Tutoriel

Préalable : CHG 1525.

### **CHG 2724 Principes et applications de thermodynamique en génie chimique (3 crédits)**

Première et deuxième lois de la thermodynamique. Comportement PVT des fluides. Équations d'état. Effets chimiques-thermiques. Évaluation des propriétés physico-chimiques. Application de la thermodynamique à divers procédés dans le domaine du génie chimique.

**Volet :** Cours magistral, Tutoriel

Préalable: CHG 2717.

### **CHG 3111 Unit Operations (3 units)**

Design of industrial equipment for evaporation, drying, humidification, absorption and stripping in plate and packed towers, distillation, liquid-liquid extraction and adsorption.

**Course Component:** Lecture, Tutorial

Prerequisite: CHG 3316.

### **CHG 3112 Process Synthesis, Design and Economics (3 units)**

Flowsheet synthesis including process, and piping and instrumentation diagrams (PFD, P&ID). Synthesis of process design structure, separation systems, and heat-exchange networks. Process design heuristics. Plant capital and operating cost estimation. Use of commercial process simulation software.

**Course Component:** Laboratory, Lecture

Prerequisites: (CHG 2324 or CHG 3324), (ECO 1192 or GNG 2101).

CHG 3111 is corequisite to CHG 3112.

### **CHG 3122 Chemical Engineering Practice (3 units)**

Laboratory course intended to demonstrate practical aspects of chemical engineering and to develop skills in written communication and engineering judgment. Students carry out experiments dealing with fluid mechanics, heat transfer and thermodynamics, with emphasis on computerized data acquisition and analysis techniques. Effective technical report writing. Principles of professional engineering practice and ethics, the societal and environmental obligations of the engineer, and workplace health and safety.

**Course Component:** Laboratory, Lecture

Prerequisites: CHG 2312, CHG 2314, (CHG 2324 or CHG 3324).

### **CHG 3127 Chemical Reaction Engineering (3 units)**

The principles of reaction engineering, including a systematic approach to the design of reactors housing single and multiple reactions.

Techniques for sizing and evaluating the performance of continuous flow and batch reactors under isothermal and non-isothermal conditions, as well as during significant pressure drop. Introduction to catalysis and techniques for determining rate expressions for catalytic reactions.

**Course Component:** Lecture, Tutorial

Prerequisites: CHG 1371, CHG 2314.

### **CHG 3305 Advanced Materials in Chemical Engineering (3 units)**

An introduction to the fundamentals of materials science with special emphasis on materials and applications of interest to chemical engineers. Biocompatibility and biomedical applications. Corrosion. Conductivity. Structure/property relationships in polymers, metals, ceramics, semiconducting materials, nanoporous materials and composites.

**Course Component:** Lecture, Tutorial

Prerequisite: CHG 2314.

### **CHG 3316 Transport Phenomena (3 units)**

Use of fundamental chemical engineering principles to solve problems in momentum, heat and mass transfer applications. Shell momentum balances. Equations of motion, mass and energy balances to determine velocity, temperature and concentration profiles for different geometries for steady-state and transient systems. Evaluation of concentration profiles in the presence of a chemical reaction, with and without a catalyst. Evaluation of mass transfer coefficients.

**Course Component:** Lecture, Tutorial

Prerequisites for CHG: CHG 2312, CHG 2314, MAT 2322, MAT 2384.

Prerequisites for CVG: CVG 3132, MAT 2322, MAT 2384.

### **CHG 3324 Fundamentals and Applications of Chemical Engineering Thermodynamics (3 units)**

First and second laws of thermodynamics. PVT behaviour of fluids. Equations of state. Thermal chemical effects. Estimation of physical-chemical properties. Applications of thermodynamics to various processes in the field of chemical engineering.

**Course Component:** Lecture, Tutorial

Prerequisite: CHG 2317.

### **CHG 3326 Principles of Phase Equilibria and Chemical Reaction Equilibria (3 units)**

Properties of homogeneous mixtures. Models of solution. Fugacity and fugacity coefficient. Activity coefficient. Excess properties. Gibbs-Duhem equation and its applications. Criteria of equilibrium. Vapour-liquid equilibrium at low and high pressures. Methods of prediction. Chemical equilibrium constant, maximum conversion. Multi-reaction equilibria. Selection of operating conditions. Mathematical techniques related to the study of these topics.

**Course Component:** Lecture, Tutorial

Prerequisites: CHG 2324 or CHG 3324.

### **CHG 3331 Application of Mathematical Methods to Chemical Engineering (3 units)**

The study of numerical methods common to engineering analysis and design, including methods for solving nonlinear equations and systems of equations, function interpolation and approximation, numerical integration and the solution of differential equations. Students will learn the theory behind the methods and, equally important, when and how to apply them to engineering problems.

**Course Component:** Lecture, Tutorial

Prerequisites: CHG 2312, CHG 2314, CHG 2317, (GNG 1106 or ITI 1120), MAT 2322, MAT 2384.

### **CHG 3335 Process Control (3 units)**

Fundamental concepts involved in establishing the transient behaviour and control characteristics of processes. Process dynamics. Dynamics of measuring and control elements. Controller characteristics. Dynamics of control loops. Stability criteria. Multiple loop systems. Advanced control system design. Introduction to sampled-data systems.

**Course Component:** Lecture, Tutorial

Prerequisites: CHG 2314, CHG 2317.

### **CHG 3337 Data Collection and Interpretation (3 units)**

Combinatorial analysis; probability and random variables; discrete and continuous densities and distribution functions; expectation and variance; normal (Gaussian), distributions; statistical estimation and hypothesis testing; method of least squares, correlation and regression. Basic principles and techniques for the efficient design of experiments and effective analysis of data. Topics include: the nature and analysis of process variability, comparing processes, blocking and randomization, empirical model building for quantifying relationships between process inputs and outputs, two-level factorial and fractional factorial designs for screening out inert input variables, other designs, a practical approach to experimental design.

**Course Component:** Lecture, Tutorial

Prerequisites: CHG 1125, CHG 1371, MAT 2384.

### **CHG 3511 Opérations unitaires (3 crédits)**

Conception d'équipements industriels pour l'évaporation, le séchage, l'humidification, l'absorption et la désorption dans des tours à garnissage et à plateau, la distillation, l'extraction liquide-liquide, l'adsorption, la lixiviation et la séparation par membranes.

**Volet :** Cours magistral, Tutoriel

Préalable: CHG 3716.

### **CHG 3512 Synthèse, conception et analyse économique des procédés (3 crédits)**

Synthèse des organigrammes comprenant les schémas de procédés, de tuyauterie et d'instrumentation (PFD, P&ID). Synthèse de la structure pour la conception des procédés, des systèmes de séparation et des réseaux d'échange de chaleur. Heuristiques pour la conception des procédés. Estimation des coûts en capital et d'exploitation. Utilisation de logiciels commerciaux pour la simulation des procédés.

**Volet :** Cours magistral, Tutoriel

Préalables : CHG 2724, (ECO 1592 ou GNG 2501). Le cours CHG 3511 est concomitant à CHG 3512.

### **CHG 3522 Pratique du génie chimique (3 crédits)**

Cours de laboratoire destiné à démontrer les aspects pratiques du génie chimique et à développer des compétences en communication écrite et en jugement technique. Les étudiants réalisent des expériences portant sur la mécanique des fluides, le transfert de chaleur et la thermodynamique, en mettant l'accent sur les techniques d'acquisition et d'analyse de données informatisées. Rédaction efficace de rapports techniques. Principes de pratique et d'éthique de l'ingénierie professionnelle, obligations sociétales et environnementales de l'ingénieur et santé et sécurité au travail.

**Volet :** Laboratoire, Cours magistral

Préalables: CHG 2712, CHG 2714, (CHG 2724 ou CHG 3724).

### **CHG 3527 Génie des réactions chimiques (3 crédits)**

Les principes de l'ingénierie des réactions, y compris une approche systématique de la conception de réacteurs pour des réactions simples et multiples. Techniques de dimensionnement et d'évaluation des performances de réacteurs à écoulement continu et discontinu dans des conditions isothermes et non isothermes, ainsi que lors de chutes de pression importantes. Introduction à la catalyse et aux méthodes de détermination des lois de vitesse pour les réactions catalytiques.

**Volet :** Cours magistral, Tutoriel

Préalables : CHG 1771, CHG 2714.

### **CHG 3705 Matériaux avancés en génie chimique (3 crédits)**

Une introduction aux principes fondamentaux de la science des matériaux avec un accent particulier sur les matériaux et les applications d'intérêt pour les ingénieurs chimistes. Biocompatibilité et applications biomédicales. Corrosion. Conductivité. Relations structure/propriété dans les polymères, les métaux, les céramiques, les matériaux semi-conducteurs, les matériaux nanoporeux et les composites.

**Volet :** Cours magistral, Tutoriel

Préalable: CHG 2714.

### **CHG 3716 Phénomènes d'échange (3 crédits)**

Utilisation des principes fondamentaux de génie chimique pour résoudre des problèmes dans des applications de transfert de quantité de mouvement, d'énergie et de matière. Bilans différentiels de quantité de mouvement. Équations de mouvement, de continuité et d'énergie pour déterminer les profils de vitesse, de température et de concentration dans différentes géométries pour des systèmes en régime permanent et transitoire. Évaluation des profils de concentration en présence d'une réaction chimique avec ou sans catalyser. Évaluation de coefficients de transfert de matière.

**Volet :** Cours magistral, Tutoriel

Préalables pour CHG : CHG 2712, CHG 2714, MAT 2722, MAT 2784.

Préalables pour CVG : CVG 3132, MAT 2722, MAT 2784.

### **CHG 3724 Principes et applications de thermodynamique en génie chimique (3 crédits)**

Première et deuxième lois de la thermodynamique. Comportement PVT des fluides. Équations d'état. Effets chimiques-thermiques. Évaluation des propriétés physico-chimiques. Application de la thermodynamique à divers procédés dans le domaine du génie chimique.

**Volet :** Cours magistral, Tutoriel

Préalable : CHG 2717.

### **CHG 3726 Principes des équilibres de phase et des réactions chimiques (3 crédits)**

Propriétés des mélanges homogènes. Modèles de solution. Fugacité et coefficient de fugacité. Coefficient d'activité. Propriétés excédentaires. Équation de Gibbs-Duhem et ses applications. Critères d'équilibre. Équilibre vapeur-liquide à basse et haute pression. Méthodes de prédiction. Constante d'équilibre chimique, conversion maximale. Équilibres multi-réactions. Sélection des conditions de fonctionnement. Techniques mathématiques liées à l'étude de ces sujets.

**Volet :** Cours magistral, Tutoriel

Préalable : CHG 2724 ou CHG 3724.

### **CHG 3735 Contrôle des procédés (3 crédits)**

Concepts fondamentaux impliqués lors de l'établissement des caractéristiques transitoires et du contrôle des procédés. Dynamique des éléments de mesure et de commande. Caractéristiques de contrôleurs. Dynamique des boucles de contrôle. Critères de stabilité. Systèmes de boucles multiples. Conception de systèmes de contrôle avancés. Introduction aux systèmes de données prélevées.

**Volet :** Cours magistral, Tutoriel

Préalables : CHG 2714, CHG 2717.

### **CHG 3737 Collecte et interprétation de données (3 crédits)**

Analyse combinatoire, probabilités et variables aléatoires, fonctions de densité et de répartition pour les variables de type discret ou continu. Espérance mathématique et variance; distribution normale; estimation et tests d'hypothèses; méthode des moindres carrés, corrélation et régression. La théorie est illustrée par des simulations. Principes et techniques pour la conception d'expériences et l'analyse efficace des données. Les sujets traités comprennent : la nature et l'analyse de la variabilité des procédés, la comparaison de procédés, le regroupement des variables par sous-ensembles et randomisation, le développement de modèles empiriques pour quantifier les relations entre les variables d'un procédé, les plans factoriels à deux niveaux et plans factoriels fractionnaires pour filtrer les variables indépendantes non significatives, combinaison de plans expérimentaux, une approche pratique pour la conception d'expériences.

**Volet :** Cours magistral, Tutoriel

Préalables : CHG 1525, CHG 1771, MAT 2784.

### **CHG 4116 Chemical Engineering Laboratory (3 units)**

Laboratory course to demonstrate chemical engineering principles, to further develop engineering judgment, to gain hands-on experience with equipment, and to enhance oral and written communication skills. Students participate in all phases of the investigation – planning, execution, analysis, reporting. Use of the computer for simulation and data analysis.

**Course Component:** Laboratory, Lecture

Prerequisites: CHG 3122, CHG 3111, CHG 3127, CHG 3326, CHG 3335. CHG 3337 is prerequisite or corequisite to CHG 4116.

### **CHG 4244 Plant Design Project (6 units)**

A study of the engineering aspects involved in the development of an industrial plant. Capital and manufacturing cost estimates. Safety in design. Feasibility survey. Equipment design and specification. Plant layout and location. Students will work in small groups to produce a process design and economic evaluation of a complete industrial plant.

**Course Component:** Laboratory, Lecture

Prerequisites: 81 university units including CHG 3111, CHG 3112, CHG 3122, CHG 3127, CHG 3316, CHG 3324, CHG 3326, CHG 3331, CHG 3335, CHG 3337.

### **CHG 4250 Plant Design Project (9 units)**

A study of the engineering aspects involved in the development of an industrial plant. Capital and manufacturing cost estimates. Safety in design. Feasibility survey. Equipment design and specification. Plant layout and location. Students will work in small groups to produce a process design and economic evaluation of a complete industrial plant.

**Course Component:** Laboratory, Lecture

Prerequisites: CHG 3111, CHG 3112, CHG 3122, CHG 3127, CHG 3326, CHG 3335, CHG 3337 and 54 university course units.

### **CHG 4301 Air Pollution Control Processes (3 units)**

This course will review sources and types of air pollution and discuss design of equipment for use in air pollution control, e.g. grit and dust removal, sampling, equipment performance, mist removal in chemical processes, gas absorption processes, solid chemical absorbents and regeneration processes. Stack heights, dispersions and meteorological factors.

**Course Component:** Lecture

Prerequisites: 54 university units including CHG 2312, CHG 2314, CHG 2317.

### **CHG 4302 Environmental Biotechnology (3 units)**

Significance of microorganisms in the environment. Soil and aquatic environments, extreme environments. Kinetics of microbial growth and degradation of raw materials. Continuous and batch reactors. Mass and heat transfer. Aerobic and anaerobic processes. Microbial conversion of carbon, nitrogen and other elements. Microbial corrosion. Mineral leaching with microorganisms. Composting. Microbial contributions to pollution. Use of genetic techniques to engineer organisms with novel catalytic capabilities.

**Course Component:** Lecture

Prerequisites: 54 university units including CHG 2312, CHG 2314, CHG 2317.

### **CHG 4305 Advanced Materials in Chemical Engineering (3 units)**

An introduction to the fundamentals of materials science with special emphasis on materials and applications of interest to chemical engineers. Biocompatibility and biomedical applications. Corrosion. Conductivity. Structure/property relationships in polymers, metals, ceramics, semiconducting materials, nanoporous materials and composites.

**Course Component:** Lecture, Tutorial

Prerequisite: 81 university units.

### **CHG 4307 Process Risk Management and Sustainability (3 units)**

Nature of risk in chemical engineering and its societal context, the legal and regulatory framework for control of risk, technical aspects of the control of acute and chronic risk, and the sociological aspects of risk management, including how management systems can deteriorate over time and practical ways to defend against this. Discussion groups cover issues in chemical engineering practice, and how to address them. Practical guidance is also provided on how to deal with general issues students are likely to encounter in their future careers.

**Course Component:** Discussion Group, Lecture

Prerequisite: 81 university course units.

### **CHG 4331 Introduction to Polymer Reaction Engineering (3 units)**

Principles governing polymerization reactions. Mechanisms and kinetics of step-growth and chain-growth polymerization and copolymerization. Physical properties of polymers and polymer characterization. Molecular weight distribution. Polymerization reaction engineering: mathematical modelling and polymer reactor design in industrial settings.

**Course Component:** Lecture

Prerequisite: 81 university units.

### **CHG 4343 Computer-Aided Design in Chemical Engineering (3 units)**

The application of computer programming to chemical engineering process simulation and analysis. Through worked examples and assignments, students develop their skills in process modeling and simulation using a high level programming language. As part of the course, students are expected to design, develop and test their own computer-based process simulators of one or more unit operation common to the field of chemical engineering.

**Course Component:** Lecture, Tutorial

Prerequisites: CHG 3111, CHG 3127, CHG 3335, and 72 university course units.

### **CHG 4359 Selected Topics I (3 units)**

Discussion of recent progress in chemical engineering.

**Course Component:** Lecture

Prerequisites: 54 university units including CHG 2312, CHG 2314, CHG 2317.

### **CHG 4360 Selected Topics II (3 units)**

Discussion of recent progress in chemical engineering.

**Course Component:** Lecture

Prerequisites: 54 university units including CHG2312, CHG2314, CHG2317.

### **CHG 4361 Selected Topics III (3 units)**

Discussion of recent progress in chemical engineering.

**Course Component:** Lecture

Prerequisites: 54 university units including CHG 2312, CHG 2314, CHG 2317.

### **CHG 4362 Selected Topics IV (3 units)**

Discussion of recent progress in chemical engineering.

**Course Component:** Lecture

Prerequisites: 54 university units including CHG2312, CHG2314, CHG2317.

### **CHG 4364 Oil and Gas Processing (3 units)**

Overview of the technologies, processes and equipment used in the characterization and processing of natural gas, crude oils and Canadian bitumen.

**Course Component:** Lecture

Prerequisites: 54 university units including CHG2312, CHG2314, CHG2317.

### **CHG 4380 Particulate and Multiphase Systems (3 units)**

Principal elements in the design of various commercially important particulate processes including particle characterization and particles transport through pneumatic conveying. Design and operation of units including packed beds, fluidized beds, filters, cyclones, and thickener/clarifiers will be reviewed.

**Course Component:** Lecture

CHG 3111 is prerequisite or corequisite to CHG 4380.

### **CHG 4381 Biochemical Engineering (3 units)**

Elements of applied microbiology: taxonomy, morphology of microorganisms, cell composition and metabolism, growth kinetics and product formation. Application of chemical engineering principles to the analysis of industrial fermentation processes. Bioreactor design and downstream processing. Industrial applications of bioprocesses: food processing, pharmaceuticals, conversion of waste materials to useful products.

**Course Component:** Lecture, Tutorial

Prerequisites: 81 university course units including CHG 3111, CHG 3127.

### **CHG 4385 Adsorption Separations for Environmental Applications (3 units)**

Basic principles and fundamentals of adsorption. Discussion of different important design parameters for adsorbers. Gas and vapour adsorption separation applications for environmental air pollution control. Liquid adsorption separation applications for water pollution control. Different types of designs for adsorbers are discussed.

**Course Component:** Lecture

Prerequisites: 54 university units including CHG 2312, CHG 2314, CHG 2317.

### **CHG 4516 Laboratoire de génie chimique (3 crédits)**

Cours de laboratoire pour démontrer les principes du génie chimique, pour développer davantage le jugement en ingénierie, pour acquérir une expérience pratique avec l'équipement et pour améliorer les compétences en communication orale et écrite. Les étudiants participent à toutes les phases de la recherche - planification, exécution, analyse, rapport. Utilisation de l'ordinateur pour la simulation et l'analyse des données.

**Volet :** Laboratoire, Cours magistral

### **CHG 4650 Projet de conception d'usine chimique (9 crédits)**

Une étude des aspects d'ingénierie impliqués dans le développement d'une installation industrielle. Estimations des coûts d'investissement et d'opération. Aspects de sécurité dans la conception. Étude de faisabilité. Conception et spécification des équipements. Disposition et emplacement de l'usine. Les étudiants travailleront en petits groupes pour concevoir et faire une évaluation économique d'une installation industrielle complète.

**Volet :** Laboratoire, Cours magistral

### **CHG 4707 Gestion des risques et résilience des procédés (3 crédits)**

Nature du risque en génie chimique et son contexte sociétal, cadre juridique et réglementaire de la maîtrise des risques, aspects techniques de la maîtrise des risques aigus et chroniques, et aspects sociologiques de la gestion des risques, y compris comment les systèmes de gestion peuvent se détériorer dans le temps et dans la pratique les moyens de l'éviter. Les groupes de discussion couvrent les problèmes de la pratique du génie chimique et la manière de les résoudre. Des conseils pratiques sont également fournis sur la manière de traiter les problèmes généraux que les étudiants sont susceptibles de rencontrer dans leur future carrière.

**Volet :** Groupe de discussion, Cours magistral

Préalable: 81 crédits de cours universitaires.

### **CHG 4743 Conception assistée par ordinateur en génie chimique (3 crédits)**

L'application de la programmation informatique à la simulation et à l'analyse des procédés de génie chimique. Grâce à des exemples et des travaux pratiques, les étudiants développent leurs compétences en modélisation et simulation des procédés à l'aide d'un langage de programmation de haut niveau. Dans le cadre du cours, les étudiants doivent concevoir, développer et tester leurs propres simulateurs de procédés d'une ou plusieurs opérations unitaires communes au domaine du génie chimique.

**Volet :** Cours magistral, Tutoriel

Préalables: CHG 3511, CHG 3527, CHG 3735 et 72 crédits de cours universitaires.

### **CHG 4780 Systèmes particuliers et multi phases (3 crédits)**

Ce cours présente les principaux éléments de la conception de divers procédés particuliers d'importance commerciale, notamment la caractérisation des particules et leur transport par voie pneumatique. La conception et le fonctionnement des unités comprenant les lits garnis, les lits fluidisés, les filtres, les cyclones et les épaisseurs/clarificateurs seront examinés.

**Volet :** Cours magistral

CHG 3111 est préalable ou concomitant à CHG 4780.

### **CHG 4781 Génie biochimique (3 crédits)**

Éléments de microbiologie appliquée: taxonomie, morphologie des micro-organismes, composition cellulaire et métabolisme, cinétique de croissance et formation du produit. Application des principes du génie chimique à l'analyse des procédés industriels de fermentation. Conception de bioréacteurs et traitement en aval. Applications industrielles des bioprocédés: transformation des aliments, produits pharmaceutiques, conversion des déchets en produits utiles.

**Volet :** Cours magistral, Tutoriel

Préalable : 81 crédits de cours universitaires dont CHG 3511, CHG 3527.

### **CHG 4901 Thèse et séminaire I / Thesis and seminars I (3 crédits / 3 units)**

Les étudiants doivent préparer une thèse et présenter un séminaire sur un sujet approuvé. Le sujet de la thèse doit être approuvé par un professeur du département qui agira à titre de directeur de thèse. / The student must prepare a thesis and present a seminar on an approved topic. The topic must have received approval of a professor in the Department who will act as thesis supervisor.

**Volet / Course Component:** Recherche / Research

Préalables : CHG 3111, CHG 3122, CHG 3127, CHG 3716, CHG 3737 et 66 crédits de cours universitaires. Une moyenne MPC minimale exigée de 6,0. / Prerequisites: CHG 3111, CHG 3122, CHG 3127, CHG 3316, CHG 3337 and 66 university course units. Must have a minimum GPA of 6.0.

### **CHG 4902 Thèse et séminaire II / Thesis and seminars II (3 crédits / 3 units)**

Ce cours est la suite de CHG 4901. Les étudiants doivent préparer une thèse et présenter un séminaire sur un sujet approuvé qui diffère de celui de CHG 4901. Le sujet de la thèse doit être approuvé par un professeur du département qui agira à titre de directeur de thèse. / This course is the sequel to CHG 4901. The student must prepare a thesis and present a seminar on an approved topic that differs from that of CHG 4901. The topic must have received approval of a professor in the Department who will act as thesis supervisor.

**Volet / Course Component:** Recherche / Research

Préalable : Doit avoir complété CHG 4901. Une moyenne MPC minimale exigée de 6,0. / Prerequisite: Must have completed CHG 4901. Must have a minimum GPA of 6.0.

### **CHG 6000 Rapport en génie chimique / Chemical Engineering Report (6 crédits / 6 units)**

**Volet / Course Component:** Recherche / Research

### **CHG 8101S Seminar I (1 crédit / 1 unit)**

Oral presentation of selected topics and research papers. Attendance at all seminars is compulsory for MASC students.

**Volet / Course Component:** Séminaire / Seminar

### **CHG 8102S Seminar II (1 crédit / 1 unit)**

Oral presentation of selected topics and research papers. Attendance at all seminars is compulsory for PhD students.

**Volet / Course Component:** Séminaire / Seminar

### **CHG 8113 Organic Electronics (3 units)**

Ever wondered how cellphone displays work? Does the thought of tattoos that detect your sugar levels or roll-up solar panels interest you? Then you might want to learn about organic electronics. In this course students will learn the design, the fabrication and the operation of emerging printed electronics, flexible electronics and organic electronic technologies such as organic photovoltaic (OPV) devices, organic light emitting diodes (OLEDs), organic thin film transistors (OTFTs) and printed sensors. The course will cover elements of applied organic/polymer chemistry, materials engineering, physical chemistry and applied electronics. Students will touch on topics including molecular-property relationships, thin film processing, charge transport through carbon-based materials, photoexcitation of organic molecules, polymer processing, and how it all applies to emerging thin film technologies.

**Course Component:** Lecture

### **CHG 8115 Heat Transfer I (3 units)**

The general law of heat conduction. Steady and unsteady heat conduction in solids with or without internal heat sources. Radiant heat transmission.

**Course Component:** Lecture

### **CHG 8116 Advanced Transport Phenomena (3 units)**

Advanced study of momentum, heat and mass transfer relevant to chemical engineering and also to areas such as environmental engineering, medicine and other scientific disciplines. Review of the analogy between mass, momentum and thermal transport and, in particular, of the physical principles and mathematical foundations required for the analysis of fluid flow, heat transfer and mass transfer, and of the advanced methods for the analysis of transport problems. Main emphasis on formulation of a given physical problem in terms of appropriate conservation equations, and obtaining an understanding of the associated physical phenomena. Use of many chemical engineering applications to illustrate the various principles.

**Course Component:** Lecture

### **CHG 8121 Synthetic Membranes in Biomedical Engineering (3 units)**

Medical applications of synthetic membranes hemodialysis, oxygenation, hemofiltration, apheresis and plasma exchange, biofunctional membranes, biosensors, drug delivery systems and microencapsulation. Emphasis on the types and classes of membranes available, relationship between structure and properties of membranes, and other variables, techniques for fabricating membranes, and special issues involved in the design and manufacture of synthetic membranes for medical use.

**Course Component:** Lecture

### **CHG 8123 Advanced Chemical Engineering Thermodynamics (3 units)**

Presentation of the fundamentals and the contemporary research developments in chemical engineering thermodynamics. Thermodynamic properties and formulations. Properties of fluids. Stability of thermodynamic systems. Criteria of equilibrium. Evaluation of thermodynamic properties. Mathematical methods and data handling.

**Course Component:** Lecture

### **CHG 8132 Adsorption Separation Processes (3 units)**

Discussion of different microporous materials and molecular sieves as adsorbents. Adsorption equilibrium and adsorption kinetics. Equilibrium adsorption of single fluids and mixtures. Diffusion in porous media and rate processes in adsorbents. Adsorbent dynamics: bed profiles and breakthrough curves. Cyclic fluid separation processes. Pressure swing adsorption. Examples of commercial separation applications. This course is equivalent to ENVJ 5105 at Carleton University.

**Course Component:** Lecture

### **CHG 8157 Strategies for Engineering Process Analysis (3 units)**

Statistical experimental design and analysis techniques for industrial and laboratory investigations are presented. Topics include: the nature and analysis of process variation, comparisons of two or more processes, empirical modelling of processes, applications of factorial and fractional factorial designs, mixture designs, response surface methodologies and empirical optimization techniques.

**Course Component:** Lecture

### **CHG 8161 Advanced Chemical Reaction Engineering (3 units)**

Kinetics of chemical reactions and its application to chemical engineering problems. Rate expressions and heterogeneous kinetics. Preparation and evaluation of catalyst activity. Promoters and poisons. Physical properties and transfer of mass and energy in porous catalysts. Interpretation of kinetic data and determination of mechanisms of catalyzed reactions.

**Course Component:** Lecture

### **CHG 8181 Advanced Biochemical Engineering (3 units)**

Kinetics of bioreactions, growth and product formation. Batch and continuous bioprocesses. Mass and heat transfer in bioreactors. Novel bioreactor design. Industrial microbiology. Animal and plant cell culture. Downstream processing. Biosensors, biological waste-water treatment, biocorrosion, bioleaching. Nitrogen fixation. Genetic engineering. This course is equivalent to ENVJ 5501 at Carleton University.

**Course Component:** Lecture

### **CHG 8187 Introduction to Polymer Reaction Engineering (3 units)**

Introduction to principles governing polymerization reactions and the resultant physical properties of polymers. Theory and experimental methods for the characterization of polymers. Mechanism and kinetics of polymerization reactions with emphasis on chain-growth polymerizations. Mathematical modelling and polymer reactor design.

**Course Component:** Lecture

### **CHG 8188 Polymer Properties and Characterization (3 units)**

Polymer properties are described and discussed in the context of their nature, source and means of measurement. Chemical and microstructural properties; physical states and transitions; thermal properties; mechanical properties and viscoelasticity models; degradation and stability; surface, electrical and optical properties, polymer additives; structure-property relationships.

**Course Component:** Lecture

### **CHG 8191 Selected Topics Chemical Engineering (3 units)**

Selected Topics in Chemical Engineering

**Course Component:** Lecture

### **CHG 8192 Membranes in Clean Processes (3 units)**

Course emphasizing the use and development of membrane separations as clean and cleaning technologies. Applications of reverse osmosis, ultrafiltration, vapour permeation and pervaporation to the treatment of industrial process and waste streams. Discussion of the fundamentals underlying each separation process. Nanostructured membrane materials. Membrane fouling models, foulant-membrane material interactions, solvent resistant membranes, aqueous and non-aqueous separations.

**Course Component:** Lecture

### **CHG 8194 Membrane Liquid Separation Processes and Materials (3 units)**

Advanced topics of membrane separations including reverse osmosis, ultrafiltration, non-aqueous liquid separation, and membrane applications in biotechnology. Physical chemical criteria for separations, membrane materials, and membrane casting techniques. Basic transport equations for single and mixed solute systems. Prediction of membrane performance. Process design, specification, and analysis applications. Problem solving in membrane transport, membrane design, and membrane process design.

**Course Component:** Lecture

### **CHG 8195 Advanced Numerical Methods in Chemical and Biological Engineering (3 units)**

Survey course of numerical methods for solving linear and non-linear ordinary and partial differential equations. Techniques reviewed include Runge-Kutta and predictor-corrector methods, shooting techniques, control volume discretization methods and finite elements. Example problems from the field of transport phenomena. This course is equivalent to ENVJ 5505 at Carleton University.

**Course Component:** Lecture

### **CHG 8196 Interfacial Phenomena in Engineering (3 units)**

Interfacial tension and interfacial free energy; contact angles; spreading of liquids; wetting of surfaces; experimental techniques. Interfacial tension of mixtures; Gibbs equation; adsorbed and insoluble monolayers; properties of monolayers and films. Electrical phenomena at interfaces; the electrical double layer; zeta-potential; electrokinetic phenomena (electrophoresis, electro-osmosis, streaming potential); surface conductance. Dispersed systems; formation and practical uses of emulsions; spontaneous emulsification; flocculation. This course is equivalent to ENVJ 5507 at Carleton University.

**Course Component:** Lecture

### **CHG 8198 Membrane Gas Separation Processes (3 units)**

Familiarization with principles of membrane technology and engineering aspects of membrane separation processes, with emphasis on gas separation. Overview of membrane types and materials, mechanisms of gas transport in membranes, and applications. Zero stage-cut analysis and membrane characterization methods and multistage membrane module design.

**Course Component:** Lecture

### **CHG 8300 Electrochemical Engineering (3 units)**

Basic principles and laws of applied electrochemistry. Electrochemical thermodynamics. Electrode kinetics and electrochemical double layer. Electrocatalysis for fuel cells and water electrolysis. Transport phenomena in electrochemical engineering. Electrochemical reaction engineering. Examples of industrial processes: Chloralkali-electrolysis, water electrolysis, electrowinning of Nickel, Zinc, Aluminum, organic electro-synthesis. Energy conversion and storage technology: fuel cells, electrochemical capacitors and batteries.

**Course Component:** Lecture

### **CHG 8301 Renewable Fuels (3 units)**

The production and sustainability of renewable fuels: Study the various generations and types of renewable fuels. Detailed look at the processes involved in transforming renewable feedstocks into useful fuels.

Evaluation of the chemical and physical exergy of substances and process streams. Exergetic efficiency of process flowsheets. Perform well to wheel energetic and exergetic life cycle analyses of fossil and biofuels. Evaluate the environmental performance of renewable fuels.

**Course Component:** Lecture

### **CHG 8302 Oil and Gas Processing (3 units)**

Physical and chemical properties of hydrocarbons and their estimation methods. Typical technologies, processes, and unit operations used in the characterization and processing of natural gas, crude oils, and Canadian bitumen.

**Course Component:** Lecture

### **CHG 8303 Tissue Engineering and Regenerative Medicine Principles (3 units)**

The principles applied in the fields of tissue engineering and regenerative medicine to develop prospective therapeutic solution for a range of injuries and pathologies. A general discussion on the tissue engineering paradigm and building blocks (cells, biomaterials and bioactive cues) employed to engineer tissues. A range of tissue fabrication strategies using specific tissue/organ systems as examples. How engineering concepts, including bioreactor design, are exploited to drive innovation in the field. Additional aspects of regenerative medicine.

**Course Component:** Lecture

### **CHG 8304 Biomaterials: Principles and Applications (3 units)**

Classes of biomaterials, including metals, ceramics, polymers and composite materials; properties of biomaterials, characterizations of biomaterials, degradable biomaterials, modifications of biomaterials, and host responses to biomaterials. Applications of biomaterials, particularly drug delivery systems, and other applications of biomaterials in tissue engineering. Regulations on the use of biomaterials and special considerations on the use of biomaterial based implantable devices.

**Course Component:** Lecture

### **CHG 8305 Particulate and Multiphase Flow (3 units)**

The principal elements in the design and scale-up of various commercially important particulates and multiphase systems such as fixed beds, spouted beds, bubble columns and fluidized beds. Topics include flow regimes, hydrodynamics, heat and mass transfer, mixing, interfacial phenomena, chemical reaction and instrumentation.

**Course Component:** Lecture

### **CHG 8306 Biopharmaceutics and Fermentation (3 units)**

Biopharmaceutics: General concepts and new developments in biopharmaceutics. Antibiotics and alternatives to antibiotics, antibodies, vaccines, microRNA, gene therapeutics and viral therapeutics.

Fermentation and cell culture: cell growth kinetics; operation modes; expression of recombinant protein in bacteria, yeast, plant cells, insect cells, and mammalian cells. Bioseparation: solids/liquid separation (e.g., filtration, centrifugation, precipitation). Cell disruption; product recovery (distillation, membrane separation, ion exchange, affinity adsorption, solvent extraction, aqueous extraction, crystallization); concentration and drying (thin film evaporator, spray drying, frozen drying).

**Course Component:** Lecture

### **CHG 8333 Research Methodology and Communication (3 units)**

Tools and principles for efficient and proficient scientific communication and research project management. Best practices for preparing and delivering oral presentations to various audiences, and writing scientific papers, thesis and reports. Research methodology. Research project planning. Design of experiments with long-term and short-term objectives.

**Course Component:** Lecture

### **CHG 9998 Examen de synthèse (doctorat) / Comprehensive Examination (Ph.D.)**

**Volet / Course Component:** Recherche / Research