CHEMICAL ENGINEERING

Our Website (http://www.che.vt.edu)

Overview

Skillful and creative applications of the principles of chemistry, biochemistry, biology, mathematics, and physics are needed to solve the problems now confronting society. Whether these problems involve energy, food, health, materials or environmental quality, the modern chemical engineer is the professional concerned with finding economically and socially acceptable solutions. The program includes specific tracks relating to energy and climate solutions, data analytics in the chemical engineering domain, and human health. The program prepares graduates for employment in a great variety of industries including specialty chemicals, petroleum, pharmaceutics, paper, fibers, plastics, food, electronics, consumer products, and environmental remediation and lays a strong foundation for those who choose to pursue higher education, whether in chemical engineering or other disciplines such as business, medicine, or law. Students may customize their academic program around an industry of interest by judiciously selecting electives. Courses in chemistry, polymers, biotechnology, marketing, and green engineering are common choices.

Accreditation

The Bachelor of Science in Chemical Engineering (BSCHE) degree program at Virginia Tech is accredited by the Engineering Accreditation Commission of ABET (https://catalog.vt.edu/undergraduate/college-engineering/chemical-engineering/www.abet.org), under the commission's General Criteria and Program Criteria for Chemical, Biochemical, Biomolecular and Similarly Named Engineering Programs.

Program Educational Objectives

Within five years of completing their BS degrees, graduates will be successful in a variety of professional careers, including those outside of traditional chemical engineering fields as evidenced by one or more of the following achievements:

- Sustaining a career as a problem solver in engineering or other fields that require analytical skills.
- Professional advancement in positions of increasing leadership and/or responsibility.
- Advanced training in engineering, science, business, law, medicine, or education.
- Bettering society and promoting community through professional or personal service in the spirit of Ut Prosim (that I may serve).

Student Outcomes

Upon completion of the undergraduate program curriculum in Chemical Engineering, students will attain the following outcomes:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Curriculum

The curriculum has been developed to meet the department goal and the objectives for the graduates. The curriculum is demanding and a GPA of at least 3.0 is recommended for transfer into the program at the sophomore level. An average GPA of at least 2.00 in all CHE courses attempted (except CHE 4144 Business and Marketing Strategies for the Process Industries) is required for continued enrollment in the department. The department has specific grade policies for continuation in the program and for graduation. For further information on these policies, please contact the department.

The chemical engineering curriculum integrates studies in thermodynamics, fluid mechanics, heat transfer, mass transfer, process control, reaction kinetics, plant and process design, verbal and written communications, and reaction kinetics, along with professional ethics and environmental awareness. Throughout this curriculum students learn the fundamentals of chemical processing equipment design and operation. In addition, students gain hands-on experience with the equipment during the summer Unit Operations Laboratory. The experience culminates in participation in either a national senior-level design contest or a design project with a local industrial mentor. The laboratory and the senior design courses are recognized as two of the high points in the undergraduate program. The computer is a necessary tool in all the courses and the same software used in industry is used in the design courses.

In addition to the basic undergraduate program outlined here, more sophisticated and specialized programs leading to the M.S. and Ph.D. in chemical engineering also are offered (see Graduate Catalog (https://catalog.vt.edu/graduate/)).

The department participates in the Cooperative Education Program whereby qualified students may alternate periods of study with periods of professional employment. Students who plan to co-op should consult with their academic advisor to plan their academic progress appropriately.

The following are special Tracks of study that students can pursue through judicious selection of technical and chemical engineering electives. Lists of approved courses for these tracks are available in the Department of Chemical Engineering.

- Climate and Energy Solution
- Computational and Data Sciences
- Healthcare Technologies

For **additional information** about the Chemical Engineering curriculum, please contact Dr. Goldstein.

- Chemical Engineering Major (https://catalog.vt.edu/undergraduate/college-engineering/chemical-engineering/chemical-engineering-bs/)

Head: S.P. Wrenn
Alumni Distinguished Professor and Frank C. Vilbrandt Professor: Y.A. Liu
Robert E. Hord Jr. Professor: W.A. Ducker and P. Rajagopalan
Fred W. Bull Professor: C. Lu
Professors: L.E.K. Achenie, R.M. Davis, and E. Kiran
Associate Professors: M Bortner, S. Deshmukh, A.S. Goldstein, S.M. Khatib, S.M. Martin[3,4], R. Tong, H. Xin, and A.R. Whittington
Assistant Professor: S. Samira
Professor of Practice: C. McDowell

Affiliate Professor: R.-H. Yoon
Emeritus Professors: D.F. Cox and S.T. Oyama

Emeritus Professor of Practice: G. Whiting
Alexander F. Giacco Professor Emeritus: D.G. Baird

Footnotes:

1 Award for Excellence in Undergraduate Advising
2 Academy of Teaching Excellence inductee
3 Wine Award recipient
4 Sporn Award recipient
5 Alumni Award for Extension Excellence
6 Alumni Award for Research Excellence
7 Alumni Award for Teaching Excellence
8 Academy of Faculty Service
9 Commonwealth of Virginia Outstanding Faculty Award
10 Diggs Teaching Scholar Awards

Undergraduate Course Descriptions (CHE)

CHE 2004 - Chemical Engineering Sophomore Seminar (1 credit)
Career opportunities and current topics of interest in the Chemical Engineering profession.
Instructional Contact Hours: (1 Lec, 1 Crd)

CHE 2114 - Mass and Energy Balances (3 credits)
Stoichiometric and composition relationships, behavior of gases, vapor pressures, solubility, mass balances, recycling operations, energy balances, first law of thermodynamics, thermophysics, thermochemistry, fuels and combustion, application to chemical operations.
Prerequisite(s): MATH 1226 and (CHEM 1036 or CHEM 1036H or CHEM 1056 or CHEM 1056H)
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 2164 - Chemical Engineering Thermodynamics (3 credits)
First and Second Laws, properties of fluids, properties of homogeneous mixtures; phase equilibria, chemical-reaction equilibria. Grade of C- or better required in prerequisite CHE 2114.
Prerequisite(s): CHE 2114 and MATH 2204 and PHYS 2306
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 2974 - Independent Study (1-19 credits)
Instructional Contact Hours: Variable credit course

CHE 2984 - Special Study (1-19 credits)
Instructional Contact Hours: Variable credit course

CHE 3015 - Process Measurement & Control (3 credits)
3015: Common process measurements; applications to theory and practice of automatic control of chemical processes; 3016: Design and laboratory practice underlying the automatic computer control of chemical processes.
Prerequisite(s): MATH 2214 and CHE 3114
Corequisite(s): 3124, (3184 or 3185), (3044 or 3154) for 3015
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 3044 - Heat Transfer (2 credits)
One and two dimensional conduction, convection, and diffusion of thermal energy; heat transfer rates, steady state and unsteady state conduction, convection; design of heat exchangers; forced and free convection boiling and condensation.
Prerequisite(s): CHE 2164 and CHE 3114 and MATH 4564
Instructional Contact Hours: (2 Lec, 2 Crd)

CHE 3114 - Fluid Transport (3 credits)
Fluid statics, surface tension, fluid dynamics, Newtons Law of viscosity, momentum transport, laminar and turbulent flow, velocity profiles, flow in pipes, flow around objects, non-Newtonian fluids, design of piping systems, pumps and mixing.
Prerequisite(s): CHE 2114 and PHYS 2305 and MATH 2204
Corequisite(s): MATH 2214
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 3124 - Chemical Engineering Simulations and Process Modeling (3 credits)
Development of strategies to pose and numerically solve sets of algebraic and differential equations that describe chemical engineering systems and processes. Iterative root finding and optimization approaches to solving non-linear equations, analyze data, and determine best-fit model parameters. Numerical strategies to integrate and differentiate models and data. Approaches to solve ordinary and partial differential equations that describe reaction kinetics, process control, and transport of momentum, heat and mass. Algorithm development, coding, and graphical representation of solutions. (3H,3C)
Prerequisite(s): CHE 2114 and MATH 2214
Corequisite(s): CHE 3114
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 3134 - Separation Processes (3 credits)
Binary separations and multicomponent separations, distillation, batch distillation, extraction, absorption, McCabe-Thiele and Ponchon Savaret methods, short cut methods, design of plate columns, plate and column efficiencies.
Prerequisite(s): CHE 2114 and MATH 2204 and PHYS 2306
Corequisite(s): CHE 2164 2164
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 3144 - Mass Transfer (3 credits)
Multidimensional molecular diffusion and convection of single and multi-component systems; mass transfer rates; steady state, quasi-steady state and transient mass transfer; effect of reactions on mass transfer; convective mass transfer coefficients; design of stage and continuous gas/liquid contractors, membrane, liquid-liquid and liquid-solid separation processes, artificial kidney and drug delivery systems.
Prerequisite(s): CHE 3114 and CHE 2164 and MATH 2214
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 3154 - Heat Transfer Analysis (3 credits)
Principles of conduction, convection, and radiation of thermal energy through one or more phases; analytical and numerical methods for modeling multi-dimensional and unsteady-state conduction; analysis of forced and free convection in conduits and around submerged bodies; design of heat exchangers; radiative heat transfer; boiling and condensation.
Prerequisite(s): CHE 2164 and CHE 3114
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 3185 - Chemical Reactor Analysis and Design (2 credits)
Introduction to mathematical frameworks for analysis and modeling of chemical reactions within different reactor configurations. 3185: Reaction equilibria, power-law rate expressions, Arrhenius law, rate constants, analysis of kinetic data, design of single and multiple isothermal reactors. 3186: Reaction mechanisms, multiple reactions, selectivity, non-isothermal reactors, catalytic reactions and design of catalytic reactors.
Prerequisite(s): CHE 2114 and (MATH 2214 or MATH 2214H)
Corequisite(s): CHE 2164, CHE 3114
Instructional Contact Hours: (2 Lec, 2 Crd)

CHE 3186 - Chemical Reactor Analysis and Design (2 credits)
Introduction to mathematical frameworks for analysis and modeling of chemical reactions within different reactor configurations. 3185: Reaction equilibria, power-law rate expressions, Arrhenius law, rate constants, analysis of kinetic data, design of single and multiple isothermal reactors. 3186: Reaction mechanisms, multiple reactions, selectivity, non-isothermal reactors, catalytic reactions and design of catalytic reactors.
Prerequisite(s): CHE 3185 and CHE 3114 and CHE 3144 and (CHE 3044 or CHE 3154)
Instructional Contact Hours: (2 Lec, 2 Crd)

CHE 3984 - Special Study (1-19 credits)
Instructional Contact Hours: Variable credit course

CHE 4014 - Chemical Engineering Laboratory (4 credits)
Practical experience in the planning of experimentation, gathering of experimental data, interpretation of data, and the preparation of written and oral reports. Use of small-scale processing equipment, automatic control, and data acquisition. Emphasis on teamwork, safety, engineering judgment, and professional behavior. Applications include fluid flow, mixing, filtration, and distillation, process control, heat transfer, mass transfer, and chemical reaction kinetics. Consideration of ethical choices in engineering practice and societal impacts of engineering solutions. In-major GPA of 2.0 or better.
Prerequisite(s): CHE 2164 and CHE 3015 and CHE 3114 and CHE 3124 and CHE 3134 and CHE 3144 and (CHE 3044 or CHE 3154) and CHE 3185 and ENGL 3764
Instructional Contact Hours: (12 Lab, 4 Crd)

CHE 4015 - Chemical Engineering Unit Operations Laboratory (2 credits)
Practical experience in the planning of experimentation, gathering of experimental data, interpretation of data, and the preparation of written and oral reports. Use of small-scale processing equipment, automatic control, and data acquisition. Emphasis on teamwork, safety, engineering judgment, and professional behavior. 4015: Applications include fluid flow, mixing, filtration, distillation, and chemical reaction kinetics. Consideration of ethical choices in engineering practice. 4016: Applications in process control, heat transfer, mass transfer, and catalysis. Consideration of the societal impacts of engineering solutions. In-major GPA of 2.0 or better.
Prerequisite(s): CHE 2164 and CHE 3114 and CHE 3124 and CHE 3134 and (CHE 3184 or CHE 3185) and ENGL 3764
Instructional Contact Hours: (6 Lab, 2 Crd)

CHE 4016 - Chemical Engineering Unit Operations Laboratory (2 credits)
Practical experience in the planning of experimentation, gathering of experimental data, interpretation of data, and the preparation of written and oral reports. Use of small-scale processing equipment, automatic control, and data acquisition. Emphasis on teamwork, safety, engineering judgment, and professional behavior. 4015: Applications include fluid flow, mixing, filtration, distillation, and chemical reaction kinetics. Consideration of ethical choices in engineering practice. 4016: Applications in process control, heat transfer, mass transfer, and catalysis. Consideration of the societal impacts of engineering solutions. In-major GPA of 2.0 or better.
Prerequisite(s): CHE 3015 and (CHE 3044 or CHE 3154) and CHE 3124 and CHE 3134 and CHE 3144 and (CHE 3184 or CHE 3185) and ENGL 3764
Instructional Contact Hours: (6 Lab, 2 Crd)

CHE 4024 - Unit Operations and Scale-Up (1 credit)
Research of a chemical process unit, design of experiments, analysis and interpretation of experimental data, and scale-up of the unit to meet specific objectives. Teamwork, oral communication, and appropriate use of published information. Consideration of safety, and the societal and environmental impacts of an engineering design. Pre: In-major GPA of 2.0 or better is required.
Prerequisite(s): CHE 3015 and CHE 3044 and CHE 3124 and CHE 3134 and CHE 3144 and CHE 3184 and ENGL 3764
Instructional Contact Hours: (1 Lec, 1 Crd)

CHE 4104 - Process Materials (3 credits)
Basics of materials science as it relates to the interest of the chemical engineer. The course emphasizes the three fundamental areas of material science being polymer materials, metallics, and ceramic/inorganic glasses. The general molecular structure property - application behavior of each area will be presented but with a focus when possible on topics related to the field of chemical engineering.
Prerequisite(s): CHE 2164 and (CHEM 2535 or CHEM 2565)
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 4114 - Energy and Climate Change Solutions (3 credits)
Fundamentals of energy production technologies, alternative and renewable energy sources, electrochemical energy storage, direct carbon capture technologies, negative emissions technologies, and chemical process that use CO2 as a feedstock. Fundamentals of water purification technologies, the water cycle, and the impact of climate change on water resources and demands. Discussion of carbon and water economics, and how geographical, societal, and environmental factors affect energy and water management policies. Techno-economic analysis of solutions based on chemical technologies, and the communication of those solutions in the context of policy development.
Prerequisite(s): CHE 3144 and CHE 3185
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 4144 - Business and Marketing Strategies for the Process Industries (3 credits)
Business strategies and industrial marketing concepts, and their application in the chemical, pharmaceutical and related process industries. The course is designed for engineers and other students planning a career in the process industries. Junior standing required.
Instructional Contact Hours: (3 Lec, 3 Crd)
Course Crosslist: MKTG 4144

CHE 4185 - Process and Plant Design (4 credits)
Chemical process synthesis and plant design, economic analysis of alternative processes, process equipment design and specifications, computer-aided process design and simulation, design case studies, application of scientific and engineering knowledge to practical design problems. Grade of C- or better in all CHE prefix courses and in-major GPA of 2.0 or better is required.
Prerequisite(s): CHE 3015 and (CHE 3044 or CHE 3154) and CHE 3124 and CHE 3134 and CHE 3144 and (CHE 3184 or CHE 3185) and ENGL 3764
Instructional Contact Hours: (4 Lec, 4 Crd)

CHE 4186 - Process and Plant Design (4 credits)
Chemical process synthesis and plant design, economic analysis of alternative processes, process equipment design and specifications, computer-aided process design and simulation, design case studies, application of scientific and engineering knowledge to practical design problems. Grade of C- or better in all CHE prefix courses and in major GPA of 2.0 or better is required.
Prerequisite(s): CHE 4185
Instructional Contact Hours: (4 Lec, 4 Crd)

CHE 4214 - Introduction to Polymer Materials (3 credits)
Basics of polymeric materials including description and categorization of macromolecules; characterization; mechanical properties; rubbery, glassy, crystalline, and viscous flow behavior.
Prerequisite(s): CHEM 2536 and CHE 2164
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 4224 - Introduction to Polymer Processing (3 credits)
Basic principles of momentum and heat transfer applied to the analysis of polymer processing operations. Introduction to polymer rheology.
Prerequisite(s): CHE 3144 and (CHE 3044 or CHE 3154)
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 4304 - Biological Transport Phenomena (3 credits)
Engineering analysis and predictive modeling of heat and mass transport in biological systems (e.g., tissues, organs, organisms, and biomedical devices). Examination of processes that involve conduction, convection, diffusion, generation/consumption. Application of analytical and computational methods to solve differential equations that describe unsteady and/or multi-dimensional transport. Topics include oxygen transport, pharmacokinetic analysis, kidney function, blood perfusion, burns, and cryopreservation.
Prerequisite(s): (CHE 3114 and CHE 3154 and CHE 3144) or (ME 3304 and ME 3414)
Instructional Contact Hours: (3 Lec, 3 Crd)
Course Crosslist: ME 4344

CHE 4334 - Introduction to Colloidal and Interfacial Science (3 credits)
Properties and behavior of colloidal systems, primarily in liquid environments. Size characterization and description, Brownian motion, interparticle forces, dispersion stability, and experimental techniques for characterizing these systems.
Prerequisite(s): CHEM 3615 or CHE 2164
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 4404 - Machine Learning in Chemical Sciences and Engineering (3 credits)
Development and application of data-driven computational models. Focus on applications in chemical sciences and engineering (e.g., materials discovery, property prediction, anomaly detection, process optimization). Preprocessing, data management and visualization, clustering, classification, and regression algorithms, and common pitfalls and practices in training and evaluation of data-driven models. Pre: 3124
Prerequisite(s): CHE 3124
Instructional Contact Hours: (3 Lec, 3 Crd)

CHE 4544 - Protein Separation Engineering (3 credits)
Concepts, principles and applications of various unit operations used in protein separations. Properties of biological materials, such as cells and proteins, and their influences on process design. Design of processes for protein purification based on the impurities to be eliminated. Concepts and principles of scale-up of unit operations. Case studies in practical protein recovery and purification issues, with a focus on enhanced protein purification by genetic engineering. Protein purification process simulation and optimization using process simulation software.
Prerequisite(s): BSE 3504 or CHE 3144
Instructional Contact Hours: (3 Lec, 3 Crd)
Course Crosslist: BSE 4544

CHE 4904 - Project and Report (1-19 credits)
Instructional Contact Hours: Variable credit course

CHE 4974 - Independent Study (1-19 credits)
Instructional Contact Hours: Variable credit course

CHE 4984 - Special Study (1-19 credits)
Instructional Contact Hours: Variable credit course

CHE 4994 - Undergraduate Research (1-19 credits)
Instructional Contact Hours: Variable credit course

CHE 4994H - Undergraduate Research (1-19 credits)
Honors course
Instructional Contact Hours: Variable credit course