Chemical and Biochemical Engineering

Interim Chair
• Jun Wang

Undergraduate major: chemical engineering (BSE)
Graduate degrees: MS in chemical and biochemical engineering; PhD in chemical and biochemical engineering

Facilities

Undergraduate Core Laboratory
Materials Science Laboratory
The Materials Science Laboratory allows students in ENGR:2720 Materials Science to further explore the concepts they learn in the classroom. It is equipped with tensiometers, hardness testers, an Izod impact tester, a contact angle goniometer, and heat treatment/sintering furnaces to characterize and examine the mechanical properties in a variety of materials. Optical microscopes, metallography specimen kits, and crystallography packages are used to facilitate understanding of structure-property relationships.

Required Undergraduate Laboratories
Chemical Engineering Laboratory
The Chemical Engineering Laboratory provides hands-on instruction for undergraduate students in CBE:3150 Thermodynamics/Transport Laboratory and CBE:3155 Chemical Reaction Engineering/Separations Laboratory. It is equipped for student experimentation in thermodynamics, fluid flow, heat transfer, mass transfer, chemical reaction engineering, and separations. All key equipment pieces in the lab, such as a distillation column, a wiped film evaporator, and multiple heat exchangers are constructed of transparent materials, allowing students to visually inspect the inner workings of this equipment. Additional equipment includes a fluid friction apparatus, a jacketed kettle, and a membrane gas separator. Students study this equipment using state-of-the-art portable analytical equipment such as densimeters, polarimeters, and refractometers.

Additionally, a wide array of small equipment is available to support laboratory projects and demonstrations in chemical engineering courses, and for use by students performing independent investigations or student groups competing in national chemical engineering contests.

Chemical Process Safety Laboratory
The Chemical Process Safety Laboratory is an integral part of CBE:3125 Chemical Process Safety. The laboratory is equipped with two MiniFlash automatic flash point testers (closed cup), an advanced reactive system screening tool (ARSST), a minimum ignition energy (MIE) apparatus, a flammability chamber, a modified Hartmann tube, a Hartmann bomb, a liquid conductivity apparatus, a powder chargeability apparatus, a powder volume resistivity apparatus, a Van de Graaff generator, two high impedance electrometers, a field meter, a Faraday cage, and relief sizing software. Equipment is used in a series of experiments to demonstrate principles of flammability, reactivity, explosions, relief valve sizing, and electrostatics relevant to industry.

Biochemical Engineering Laboratory
The Biochemical Engineering Laboratory is an integral part of CBE:3205 Introduction to Biochemical Engineering. It is equipped with two controlled New Brunswick BioFlo/CelliGen 115 bioreactors, electrophoresis apparatus, and a thermocycler. This equipment is used for recombinant DNA experiments and to study the growth and metabolism of microorganisms.

Process Control Laboratory
The Process Control Laboratory is used in CBE:4105 Process Dynamics and Control in Design and CBE:5199 Contemporary Topics: Chemical and Biochemical Engineering. The laboratory consists of modern computer-controlled flow, level, composition, and temperature systems that operate using DeltaV (widely used industrial control system) and LabVIEW software/hardware. The laboratory equipment helps students become familiar with control hardware and practical applications in control. The lab focuses on student teamwork and assignments are structured to achieve high-performance teamwork. The lab allows students to practice the skills of industrial process engineering. Furthermore, the concepts are applicable to many related industrial, scientific, and product development applications in areas such as environmental and climate science, finance, transportation, biology, precision medicine, and automation.

The required CBE:4105 Process Dynamics and Control in Designlab provides hands-on practice with actuators (e.g., valves and motors), valve positioners, sensors, SCADA (supervisory control and data acquisition) software, state-of-art distributed control system software, control block diagrams, piping and instrumentation diagrams, mathematical modeling of dynamic systems, and specification of transfer functions for chemical, physical, and control operations. Students select and tune PID control parameters for these systems. Students work with cascade and ratio control. Students gain exposure to cabling, networks, and protocols for industrial process control communication. The lab allows students to practice and develop intuition at troubleshooting industrial processes, and at appreciating the linkages between process inputs, control systems, process disturbances, and how these factors into process outputs, reliability, safety, quality, and overall performance.

The elective Process Control II topic CBE:5199 Contemporary Topics: Chemical and Biochemical Engineering is an introduction to the design and programming of DeltaV-based control systems. Students create a DeltaV operator screen for hardware selected from the process control lab. This allows students to integrate hardware and software and achieve computer control by implementing all project phases: (i) design, (ii) programming, (iii) hardware integration, and (iv) testing and troubleshooting.
Graduate Facilities and Laboratories

The department offers a wide variety of facilities to support and develop research activities.

Air Pollution Computational, Field, and Laboratory Studies

The department maintains extensive facilities for computational, field, and laboratory studies of air pollution, carbon cycle gases, aerosols, and nanoparticles at the Center for Global and Regional Environmental Research (CGRER). The center occupies 5,000 square feet of lab and office space on the fourth floor of the Iowa Advanced Technology Laboratories.

CGRER houses one R2 ImmersaDesk Portable Large Scale Visualization System and is linked on campus to two more R2 ImmersaDesk units.

The center's computer laboratory for environmental and spatial data analysis provides numerous Windows and UNIX workstations, sophisticated software packages, and workstations with a file server necessary to run intensive visualization programs. The network backbone is university supported with high-speed wireless throughout. A variety of digital environmental databases and an extensive library of documentation and related references are available. There are four Beowulf Linux clusters on site and Linux clusters of 4, 16, 18, and 20 nodes for large computations and data assimilation. CGRER retains 15 TB of redundant storage and 50 TB of total storage; local storage space is scalable and expandable. Multiple software packages and programming languages are available for data analysis and display, including ArcInfo, ArcView, NCAR Graphics, MATLAB, S-PLUS, and Vis5D, as well as geographical information software. The Esri software suite is part of a university-wide site license.

Laboratory and field equipment includes aerosol samplers, including scanning mobility particle sizers for aerosols from 3 nanometer to 1 micron with time resolution to 30 seconds; aerosol particle sizers for aerodynamic measurements of in situ particles with time resolution to 1 second; and varied condensation particle counters for measuring total particle counts. Several hygroscopic tandem differential mobility analyzers are used, as well as varied aerosol generation devices and unique aerosol inlets for relative humidity (RH) and temperature modification and control. Cloud droplet number can be measured in the lab or in the field using a Droplet Measurement Technologies cloud condensation nuclei detector. Advanced computer control of instruments is available through LabVIEW.

Selected instruments are field deployable in a custom air-conditioned trailer. Through collaboration with the IIHR—Hydroscience and Engineering, access to micrometeorology sensors, 1D and 2D elastic and Raman lidar, and gas sensors is available, including multichannel ammonia monitors.

Biochemical Engineering

Biochemical engineering laboratories provide facilities for preparation of biological media and cultivation of organisms as well as for separation and analysis of biomolecules. This equipment includes biological incubators and floor incubator shakers, agitated and airlift bioreactors, light microscopes, autoclaves, Vi-Cell cell counter, thermocycler for polymerase chain reaction (PCR) amplification of DNA, high- and low-speed centrifuges, UV-Vis spectrophotometers, a lyophilizer, biological safety cabinets, and an anaerobic glove box. Phase-contrast and epifluorescence microscopes, gel electrophoresis systems, gas chromatography units with flame ionization and electron capture detectors, and several high-performance liquid chromatography systems with refractive index and photodiode array detectors are available for characterization of microorganisms and constituent biomolecules.

Through collaborative research agreements, graduate students also have access to specialized facilities for electron microscopy, large-scale fermentation, protein structure, recombinant DNA research, and tissue culture/hybridoma; the Flow Cytometry Facility; and the High Resolution Mass Spectrometry Facility.

Biomedical Engineering

The biomedical engineering laboratories house particle technology equipment including microemulsion equipment for drug encapsulation, sonicators, benchtop scale spray dryers, laser diffraction particle sizer, zetapotentimeter; DNA preparation equipment, gel electrophoresis apparatus; interfacial stress rheometer, surface tensiometer, UV-Vis/fluorescent plate reader, high performance liquid chromatogaph, luminometer, lyophilizer, custom-built simulated cough machine, microscopes, incubators, wet chemistry equipment, rotary shakers, incubated plate shakers, autoclave, centrifuges, and laboratory computers. Cell culture and bacterial culture facilities are housed adjacent to the laboratories.

Graduate students also have access to core research facilities including the Central Microscopy Research Facility, Flow Cytometry Facility, Iowa Institute of Human Genetics, Electron Spin Resonance Facility, Nuclear Magnetic Resonance Facility, High Resolution Mass Spectrometry Facility, and the Center for Gene Therapy.

Computer Facilities

The departmental computer facilities contain a variety of laptops, desktop workstations, and printers. The department is supported by the college's Engineering Technology Center, which maintains a large network of high-performance Linux and Windows workstations along with extensive commercial and public domain software. The department has access to the university's central high-performance research computing facility through ITS–Research Services. The University of Iowa also has access to the ACCESS and Blue Waters national supercomputing resources and is a founding member of the Great Lakes Consortium for Petascale Computing. Locally hosted long-term data storage services are available.

Fundamentals and Applications of Photopolymerization

The Photopolymerization Center was established to advance a fundamental understanding of the kinetics and mechanisms of photopolymerizations. To this end, the center provides unique opportunities for collaborations by industrial and academic investigators to explore photopolymerization processes and develop novel applications based on photopolymerizations.

The center provides equipment and instrumentation for the characterization of photopolymerization systems on the molecular, microscopic, and macroscopic levels. Center researchers pursue an understanding of fundamental photophysical and photochemical processes involved in the photoinitiation reaction, characterization of high-speed propagation and termination kinetics that lead to the polymer structure, and evaluation of material properties through the
course of the photopolymerization reaction. Both radical and cationic photopolymerizations are studied with state-of-the-art experimental techniques to elucidate the complex chemical and physical mechanisms that control the initiation, propagation, and termination of the active centers.