CHEMICAL AND LIFE SCIENCE ENGINEERING (CLSE)

CLSE 101. Introduction to Engineering. 3 Hours.
Semester course; 2 lecture and 3 laboratory hours. 3 credits.
Prerequisites: course open to first-year students majoring in chemical and life science engineering. Introduction to chemical and life science engineering. Topics covered include ethics and social responsibility; engineering design process; engineering solutions; estimations and approximations; dimensions, units and conversions; mathematics and computer solutions; life-long learning; introduction to the interface between engineering, biology and medicine.

CLSE 102. Methods in CLSE. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Prerequisite: CLSE 101.
An introduction to problem formulation and solution methods for chemical and life science engineering. Typical chemical and life science engineering scenarios will be presented. Emphasis will be placed on identifying and formulating problems based on presented scenarios.

CLSE 115. Introduction to Programming for Chemical and Life Science Engineering. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: MATH 200. Introduction to the concepts and practice of structured programming. Topics include problem-solving, top-down design of algorithms, objects, basic syntax, control structures, functions and arrays.

CLSE 201. Chemical Engineering Fundamentals I: Material Balances. 4 Hours.
Semester course; 3 lecture and 1 recitation hours. 4 credits. Prerequisites: CLSE 115, CHEM 101 and CHEM 102, and MATH 200 and MATH 201, or equivalents, all with minimum grades of C. The first of two introductory chemical and life science engineering courses. Covers material balances on steady-state chemical processes.

CLSE 202. Chemical Engineering Fundamentals II: Energy Balances and Engineering Thermodynamics. 4 Hours.
Semester course; 3 lecture and 1 recitation hours. 4 credits. Prerequisites: CLSE 201 with a minimum grade of C, CHEM 101-102 and MATH 200-201 or equivalents. The second of two introductory chemical and life science engineering courses. Covers energy balances on steady-state chemical processes, computer-aided balance calculations, balances on transient processes and introduction to thermodynamics.

CLSE 301. Transport Phenomena I. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CLSE 202 with a minimum grade of C, PHYS 208 and MATH 301. Basic concepts of transport phenomena as applied to chemical and life science engineering. Topics include transport of mass momentum and energy in single and multidimensions.

CLSE 302. Transport Phenomena II. 4 Hours.
Semester course; 3 lecture and 1 recitation hours. 4 credits. Prerequisites: CLSE 301 and CLSE 305. Concepts of transport phenomena as applied to chemical and life science engineering. Topics include advanced multicomponent, multiphase systems, integral analysis, and an integrated view of momentum, heat and mass transport in unit operations.

CLSE 305. Thermodynamics of Phase Equilibria and Chemical Reactions. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CLSE 202 with a minimum grade of C and MATH 307. Thermodynamic properties of fluids and mixtures, partial molar quantities, phase equilibria, activity coefficients and correlations, equations-of-state, chemical reaction equilibria for liquid, vapor and multiphase reactions, and the use of equations-of-state and activity/fugacity correlations to obtain the thermodynamic functions required for the calculation of chemical reaction equilibrium constants. Computing using Excel VBA is a required component of this course.

CLSE 306. Industrial Applications of Inorganic Chemistry. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CHEM 302 and CHEZ 302. Chemical engineering students: EGR 201 and EGR 205. A study and analysis of the most important industrial applications of inorganic chemistry, with emphasis on structure/properties correlation, materials and energy balance, availability and logistics of starting materials, economic impact and environmental effects. Crosslisted as: CHEM 306.

CLSE 312. Chemical Reaction Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CLSE 301 and 305. Introduces the student to the analysis of reactors via coupling of empirical reaction rates and thermodynamic constraints with reactor material and energy balances. The behavior of the ideal reactor types (batch, CSTR and PFR) is emphasized with attention given to departure from these ideals by real systems.

CLSE 320. Instrumentation Laboratory. 3 Hours.
Semester course; 1 lecture and 6 laboratory hours. 3 credits. Prerequisites: CLSE 301 and CLSE 305. This laboratory introduces students to a variety of measurement instruments used in modern chemical engineering laboratories and process plants. Detailed laboratory reports are required for each of the experiments undertaken by the students.

CLSE 325. Bioengineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CLSE 201 and BIOL 151 or BIOL 152. An introductory and survey level course required for all chemical engineering students. This course introduces concepts and principles of chemical engineering to problems and issues in the life sciences, biotechnology and medicine. Students apply heat and mass transfer concepts, separations and controls to topics that include clinical diagnostics, bioanalytical instrumentation, biosensors and biochips, bioprocess engineering including fermentation, biochemical pathway engineering, protein folding and aggregation, bioreactors and tissue engineering.

CLSE 402. Senior Design Studio I (Laboratory/Project Time). 2 Hours.
Semester course; 6 laboratory hours. 2 credits. Prerequisites: senior standing in chemical and life science engineering and participation in a senior design (capstone) project; CLSE 301, 302, 305 and 312. A minimum of six laboratory hours per week dedicated to the execution phase of the senior design (capstone) project, which should meet appropriate engineering standards and multiple realistic constraints. Tasks include team meetings, brainstorming, sponsor advising, designing, fabrications, assembling, reviewing, studying, researching, testing and validating projects.
CLSE 403. Senior Design Studio II (Laboratory/Project Time). 2 Hours.
Semester course; 6 laboratory hours. 2 credits. Prerequisites: senior standing in chemical and life science engineering and participation in a senior design (capstone) project; CLSE 402. A minimum of six laboratory hours per week dedicated to the execution phase of the senior design (capstone) project, which should meet appropriate engineering standards and multiple realistic constraints. Tasks include team meetings, brainstorming, sponsor advising, designing, fabricating, assembling, reviewing, studying, researching, testing and validating projects.

CLSE 405. Process Synthesis. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CLSE 302, 305 and 312. A senior technical elective. Students synthesize flowsheets for existing and newly proposed chemical and biochemical products. Quantitative tools learned in earlier courses are used to examine the technical and economic feasibility of the flowsheets. Written bi-weekly status reports are required from each student and each student completes a process synthesis and analysis as a semester project.

CLSE 409. Process Control in Chemical and Life Science Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CLSE 301 and 305. Covers process control as applied to chemical and life science engineering with many practical examples. Topics include time and frequency domain analysis, multivariable processes and applications to chemical and biochemical production and processing.

CLSE 428. Introduction to Polymer Science and Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CLSE 302, 305 and 312. A senior technical elective. The course offers an introduction to the chemistry, physical properties and processing of polymers. Topics include step and chain polymerization, structure/property relationships, mechanical properties of plastics and elastomers, solution properties, methods for polymer characterization, and processing techniques.

CLSE 440. Unit Operations Laboratory. 3 Hours.
Semester course; 1 lecture and 6 laboratory hours. 3 credits. Prerequisites: CLSE 302, CLSE 305 and CLSE 312. Students carry out experiments with chemical and biochemical reactors, energy exchangers, fluid flow networks and other unit operations. Detailed laboratory reports are required for each of the experiments undertaken.

CLSE 450. Undergraduate Research in Chemical and Life Science Engineering. 1-6 Hours.
Semester course; variable hours. Up to 6 credits. Undergraduate research under the supervision of a faculty member. Specific topics vary depending on the interests of the student and the adviser. Registration requires approval of the student’s academic adviser and research adviser.

CLSE 460. Undergraduate Honors Research in Life Sciences Engineering. 1-3 Hours.
Semester course; 1-3 lecture hours. 1-3 credits. Corequisites: BIOL 218, CLSE 302. An undergraduate honors research course for academically talented juniors and seniors requiring advanced work and an honors thesis on a topic relevant to life sciences engineering. Topics and credit hours will be chosen in consultation with a sponsoring faculty member.

CLSE 461. Stem Cell Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 218, CLSE 302. The production and behavior of adult and embryonic stem cells are studied and potential applications for the treatment of disease are surveyed. Stem cell engineering techniques including parthenogenesis, nuclear transfer stem cells and embryonic carcinoma cells are introduced. The use of stem and germ cells for cloning is covered, and ethical considerations involving the use of embryonic human stem cells are discussed.

CLSE 543. Advanced Reaction Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Provides the fundamental background needed to effectively design reactors at the macroscale exemplified by batch, pilot and plant operations or at the micro- and nanoscale exemplified by the current trend to miniaturize unit operations. A quantitative analysis is developed to explain why “real” reactor performance departs from ideal batch, CSTR and plug flow reactor performance.

CLSE 544. Applied Transport Phenomena. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Provides the basis for analyzing mass, energy and momentum transport issues in environmental, chemical, biological and industrial processes. Molecular mechanisms of momentum transport, energy transport and mass diffusion are utilized to develop an engineering analysis of a given process. This molecular approach is complemented with macroscopic mass, momentum and mechanical energy balances.

CLSE 549. Process Biotechnology. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Designed to provide a rational basis addressing engineering challenges in the emerging biotechnology area. The course material is broad in scope covering biochemical synthesis, bioreactor design and bioprocess monitoring and control. It also deals with important issues associated with separation and purification techniques used with biomaterials.

CLSE 560. Protein Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with senior or graduate standing in the School of Engineering or School of Pharmacy, or by permission of instructor. This course focuses on the structure-function characterization of proteins and the quantification of protein-protein interactions for the design of novel protein and peptide therapeutics. Additional topics include biochemistry of proteins for engineers, large scale, batch production and manufacturing techniques for biologics.

CLSE 561. Stem Cell Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 218 and CLSE 302. The production and behavior of adult and embryonic stem cells are studied and potential applications for the treatment of disease are surveyed. The importance of the extracellular matrix in cell differentiation and proliferation is established. Stem cell engineering techniques including parthenogenesis, nuclear transfer stem cells and embryonic carcinoma cells are introduced. The use of stem and germ cells for cloning, stem cells and tissue rejection, and ethical considerations in the use of embryonic human stem cells are discussed.
CLSE 562. Advanced Systems Biology Engineering. 3 Hours.  
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 218,  
CLSE 115, and CLSE 302. The system-level properties of biology will be  
surveyed to understand how DNA leads to cellular behavior through  
complex molecular interactions. Theoretical and experimental concepts  
associated with high-throughput data (genomics, transcriptomics,  
metabolomics, fluxomics, proteomics), cellular regulation and  
computational modeling will be introduced. Bioinformatic analysis,  
integration of data and current challenges are discussed.

CLSE 563. Metabolic Engineering. 3 Hours.  
Semester course; 3 lecture hours. 3 credits. Prerequisites: BIOL 218,  
CLSE 115, and CLSE 302. The principles and methods used in metabolic  
engineering of microbes will be covered. Theoretical and experimental  
concepts associated with metabolite production, strain design, strain  
construction and strain characterization will be introduced. Design  
principles, metabolic engineering challenges, metabolic engineering  
applications and ethical considerations of genomic alterations are  
discussed.

CLSE 570. Molecular Physiology and Microanatomy for Chemical and Life Science Engineering. 4 Hours.  
Semester course; 3 lecture and 2 laboratory hours. 4 credits.  
Prerequisites: BIOL 218 and CLSE 302. Understanding physiology from  
the molecular perspective of cellular biochemical mass action kinetics,  
molecular diffusion and transport, biomolecular separation processes,  
and dynamic biochemical control theory is key to the engineering and  
design strategies for medical intervention in disease and human health.  
This course explores these biomolecular dynamic events in human  
physiology with an emphasis on the application of the fundamental  
biochemical transport phenomena, kinetics and separation processes,  
and dynamic control theory. Laboratory component emphasizes living,  
single-cell manipulation and analysis methods, such as patch clamp  
deVICES, and the microanatomy of internal organs.

CLSE 575. Nanotechnology in Life Science and Engineering. 3 Hours.  
Semester course; 3 lecture hours. 3 credits. Enrollment restricted  
to students with senior or graduate standing in the School of  
Engineering or Department of Chemistry, or with permission of instructor.  
Nanobiotechnology is the application of nano- and micro-fabrication  
methods to build tools for exploring the world of biological systems.  
This course will introduce the principles and practice of microfabrication  
techniques and perspectives in the field of nanobiotechnology. Lectures  
will cover interdisciplinary topics such as biomolecules at interfaces,  
biosensors, micro- and nano-fabrication strategies, self-assembly,  
nanoparticles, micro- and nano-devices and microfluidics.

CLSE 580. Sustainable Chemical Engineering. 3 Hours.  
Semester course; 3 lecture hours. 3 credits. Prerequisite: CLSE 202 or  
permission of instructor. The course offers a survey of sustainability,  
green chemistry and green engineering considerations in chemical  
processing. Topics include quantitative analysis of green chemistry  
metrics, process intensification, renewable resources and waste  
valorization. Science communication and science policy will be  
discussed.

CLSE 585. Interfacial Phenomena. 3 Hours.  
Semester course; 3 lecture hours. 3 credits. The course offers an  
introduction to interfacial phenomena and colloid physical chemistry.  
Students will develop the ability to apply basic concepts from interface  
and colloid chemistry and physics to describe engineering applications.  
The course will also introduce modern experimental techniques and  
current literature in colloidal and interfacial phenomena.

CLSE 645. Biosensors and Bioelectronic Devices. 3 Hours.  
Semester course; 3 lecture hours. 3 credits. This course develops  
the methodologies used in the design, fabrication and application of  
biosensors and bioelectronic devices to monitoring problems in the  
environmental, medical and chemicals industries. Fundamentals of  
measurement science will be applied to optical, electrochemical, mass  
and thermal means of signal transduction. Fundamentals of surface  
science will be used to interpret bio-immobilization, biofouling and  
nonspecific interactions of enzymes, antibodies and DNA at surfaces.

CLSE 650. Quantitative Analysis in Chemical and Life Science Engineering. 3 Hours.  
Semester course; 3 lecture hours (delivered online, face-to-face or  
hybrid). 3 credits. Prerequisite: MATH 301. An understanding of the  
quantitative descriptions of chemical and biological processes is required  
for engineering analysis, including prediction and design. Analytical  
approaches are necessary to simplify and provide limits of complex  
behavior. These approaches include perturbation theory and scaling,  
density functional formulations, control theory, and stability theory. This  
course represents the applied mathematical foundations on equilibrium  
and nonequilibrium analysis of chemical and biological systems.

CLSE 654. Equilibrium Analysis in Chemical and Biological Systems. 3 Hours.  
Semester course; 3 lecture hours (delivered online, face-to-face or  
hybrid). 3 credits. Prerequisite: CLSE 305. Provides a molecular-based,  
thermodynamic framework for the quantitative equilibrium analysis  
of a broad range of biological and chemical processes. Contemporary  
equations of state, liquid solution models and elementary statistical  
mechanics are used to predict the behavior of molecules. Important  
issues addressed include the estimation of solvation and partitioning  
of molecules between phases or media, the calculation of free energy  
changes associated with cellular events and prediction of order/disorder  
phenomena.

CLSE 655. Nonequilibrium Analysis in Chemical and Life Science Engineering. 3 Hours.  
Semester course; 3 lecture hours (delivered online, face-to-face or  
hybrid). 3 credits. Prerequisites: CLSE 301, CLSE 302 and MATH 301.  
An understanding of the spatial and temporal dynamics of biological  
systems is key to many cellular events including cell signaling processes,  
second messenger systems, positive and negative feedback control,  
transcription, translation, and many more. This course introduces  
nonequilibrium (dynamic) analysis as applied to biological and chemical  
systems.

CLSE 656. Advanced Chemical Reaction Engineering. 3 Hours.  
Semester course; 3 lecture hours (delivered online, face-to-face or  
hybrid). 3 credits. Prerequisites: MATH 301 and CLSE 312. This course builds  
upon fundamental principles of chemical reaction engineering including  
integration of mass balances, reactor design equations and chemical rate  
laws. Emphasis is given to development of mathematical models and  
computational simulation of chemical reaction systems with multiple  
reactions. Additional topics include analysis of systems with unknown  
reaction parameters and mechanisms and bioprocess/biochemical  
approaches to chemical production.

CLSE 660. Biomolecular and Computational Engineering. 3 Hours.  
Semester course; 3 lecture hours. 3 credits. Prerequisite: CLSE 650.  
Dynamic analysis of interacting cellular events, including cell signal  
pathways, clock reactions, etc., often requires large-scale computational  
approaches. Furthermore, these techniques are necessarily time  
dependent requiring unique methodologies, such as multi-time scale  
methods. This course introduces the subject of real-time biomolecular  
simulations.
CLSE 675. Polymers in Medicine. 3 Hours.
Semester course; 3 lecture hours. 3 credits. This course is based on the
need for integration of engineering and materials science of polymers
with applications in life science engineering. Basic principles of polymer
science including structural concepts at the molecular-, nano-, micro-
and macro-scales are emphasized so that the student can understand
structure/function correlation. The course treats polymer synthesis,
molecular weight, morphology and surface science at an introductory
level, but quantitative correlations are emphasized. Surface science
is emphasized, as medical applications are often dependent on the
interaction of a solid polymer with an in vivo environment (tissue, blood,
membrane). The polymers chosen for emphasis include polyethylene
(hip, knee replacement), poly(vinylchloride) (blood bags, catheters),
polyurethanes (artificial heart, wound care) and silicones (implants,
catheters). The use of polymers in drug delivery applications is explored,
including osmotic-pressure-driven drug delivery. Concepts surrounding
polymeric surface modifiers are developed, including applications such
as enhanced biodurability and biocidal function.

CLSE 690. Research Seminar in Chemical and Life Science Engineering. 1
Hour.
Semester course; 1 lecture hour. 1 credit. May be repeated up to
eight times. Presentations and discussions of current problems and
developments in life science engineering by faculty and visiting lecturers.

CLSE 691. Special Topics in Chemical and Life Science Engineering. 1-4
Hours.
Semester course; 1-4 lecture hours (delivered online, face-to-face
or hybrid). 1-4 credits. Enrollment is restricted to students who
have completed at least one graduate-level engineering course and
with permission of the instructor. Lectures, tutorial studies, library
assignments in selected areas of advanced study or specialized
laboratory procedures not available in other course offerings or as part of
research training.

CLSE 692. Independent Study in Chemical and Life Science Engineering.
1-5 Hours.
Semester course; 1-3 lecture and/or 0-4 laboratory hours. 1-5 credits.
Prerequisites: graduate standing or permission of instructor. The student
must submit a prospectus to the graduate committee for approval and
identify a faculty member willing to supervise the course. Investigation of
specialized engineering problems through literature search, mathematical
analysis, computer simulation and/or experimentation. Written and oral
reports, final report and examination required.

CLSE 697. Directed Research in Chemical and Life Science Engineering.
1-15 Hours.
Semester course; 1-15 research hours. 1-15 credits. Enrollment is
restricted to graduate students or by permission of instructor. Research
directed toward completion of the requirements for the M.S. or Ph.D. in
engineering with concentration in chemical and life science engineering
under the direction of an engineering faculty member and advisory
committee. Graded S/U/F.