

CHEMICAL AND LIFE SCIENCE ENGINEERING, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN CHEMICAL ENGINEERING

The department offers a Bachelor of Science in Chemical and Life Science Engineering, and includes a chemical engineering concentration and a life science engineering concentration. Each student must choose the desired concentration upon initial registration.

As part of the B.S. degree in chemical and life science engineering, all students complete an approved internship or cooperative education experience.

Learning outcomes

Upon completing this program, students will know and know how to do the following:

1. Apply knowledge of mathematics, science and engineering
2. Design and conduct experiments, as well as to analyze and interpret data
3. Design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability
4. Function on multidisciplinary teams
5. Identify, formulate and solve engineering problems
6. Gain an understanding of professional and ethical responsibility
7. Communicate effectively
8. Complete the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context
9. Recognize the need for, and an ability to engage in, lifelong learning
10. Gain knowledge of contemporary issues
11. Use the techniques, skills and modern engineering tools necessary for engineering practice
12. Understand hazards associated with chemical, physical and/or biological processes

Special requirements

Students must receive a grade of C in all engineering courses in order to graduate. Minimum grades of C in CLSE 115, CLSE 201 and CLSE 202 are required before students may take additional CLSE courses. After passing CLSE 202 with a minimum grade of C, students are allowed to continue with one D grade in any CLSE course. They must retake that course in order to graduate, but may continue taking other CLSE courses. Students are not allowed to continue with two grades of D in CLSE courses and must successfully retake at least one of those courses with a minimum grade of C to take additional 300- and 400-level CLSE courses.

Degree requirements for Chemical and Life Science Engineering, Bachelor of Science (B.S.) with a concentration in chemical engineering

General Education requirements

Course	Title	Hours
University Core Education Curriculum		
UNIV 111 Play course video for Focused Inquiry I	Focused Inquiry I	3
UNIV 112 Play course video for Focused Inquiry II	Focused Inquiry II	3
UNIV 200	Inquiry and the Craft of Argument	3
Approved humanities/fine arts		3
Approved natural/physical sciences		3-4
Approved quantitative literacy		3-4
Approved social/behavioral sciences		3-4
Total Hours		21-24

Course	Title	Hours
General Education requirements		
PHYS 207	University Physics I	5
PHYS 208	University Physics II	5
Total Hours		10

Collateral requirements

Course	Title	Hours
BIOL 151	Introduction to Biological Sciences I	3
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	4
CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II	4
CHEM 301 & CHEZ 301	Organic Chemistry and Organic Chemistry Laboratory I	5
CHEM 302 & CHEZ 302	Organic Chemistry and Organic Chemistry Laboratory II	5
ECON 205	The Economics of Product Development and Markets	3
MATH 201	Calculus with Analytic Geometry II	4
MATH 301	Differential Equations	3
MATH 307	Multivariate Calculus	4
Technical electives (300+ level science, math, business or management course)		6
STAT 441	Applied Statistics for Engineers and Scientists	3
Total Hours		44

Major requirements

Course	Title	Hours
CLSE 101	Introduction to Engineering	3
CLSE 115	Introduction to Programming for Chemical and Life Science Engineering	4

CLSE 201	Chemical Engineering Fundamentals I: Material Balances	4
CLSE 202	Chemical Engineering Fundamentals II: Energy Balances and Engineering Thermodynamics	4
CLSE 301	Transport Phenomena I	3
CLSE 302	Transport Phenomena II	4
CLSE 305	Thermodynamics of Phase Equilibria and Chemical Reactions	3
CLSE 312	Chemical Reaction Engineering	3
CLSE 320	Instrumentation Laboratory	3
CLSE 402	Senior Design Studio I (Laboratory/Project Time) (Laboratory/Project Time)	2
CLSE 403	Senior Design Studio II (Laboratory/Project Time) (Laboratory/Project Time)	2
CLSE 409	Process Control in Chemical and Life Science Engineering	3
CLSE 440	Unit Operations Laboratory	3
ENGR 395	Professional Development	1
ENGR 402	Senior Design Studio (Seminar) (Seminar)	1
ENGR 403	Senior Design Studio (Seminar) (Seminar)	1
Approved internship or cooperative education experience		0
ENGR 296	Part-time Internship Experience	
or ENGR 396	Internship Experience	
or ENGR 398	Cooperative Education Experience	
Review of internship or cooperative education experience		0
ENGR 496	Internship Review	0
or ENGR 498	Review of Cooperative Education Experience	
Engineering elective (300+ level)		6
Total Hours		50

The minimum total of credit hours required for this degree is 126.

Technical electives

Technical electives are satisfied by completing courses that meet all of the following criteria:

1. 300 level or greater
2. Offered in BIOC, BIOL, BIOZ, BNFO, BUSN, CHEM, CHEZ, ENVZ, ENVZ, FRSC, FRSZ, INNO, LFSC, MATH, MEDC, MGMT, OPER, PHIS, or STAT
3. Three or more credit hours
4. Not otherwise required for the major by the effective Bulletin

Other courses may be used to satisfy the technical elective requirements with prior written approval from the department chair.

Engineering electives

Engineering electives are satisfied by completing courses that meet all of the following criteria:

1. 300-level or greater
2. Offered in the College of Engineering (CLSE, CMSC, EGMN, EGRB, EGRC, EGRE, EGRM, EGRN or ENGR)
3. Three or more credit hours
4. Not otherwise required for the major by the effective Bulletin

Note: A minimum of four credits of ENGR 497 must be completed to use the course to satisfy an engineering elective requirement. Other courses may be used to satisfy the engineering elective requirements with prior written approval from the department chair.

What follows is a sample plan that meets the prescribed requirements within a four-year course of study at VCU. Please contact your adviser before beginning course work toward a degree.

Freshman year

Fall semester		Hours
BIOL 101	Biological Concepts (satisfies University Core natural/physical sciences)	3
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	4
CLSE 101	Introduction to Engineering	3
MATH 200	Calculus with Analytic Geometry I (satisfies University Core quantitative literacy)	4
UNIV 111	Focused Inquiry I	3
Play course video for Focused Inquiry I		
Term Hours:		17

Spring semester

CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II	4
CLSE 115	Introduction to Programming for Chemical and Life Science Engineering	4
ENGR 395	Professional Development	1
MATH 201	Calculus with Analytic Geometry II	4
UNIV 112	Focused Inquiry II	3
Play course video for Focused Inquiry II		
Term Hours:		16

Sophomore year

Fall semester

CHEM 301 & CHEZ 301	Organic Chemistry and Organic Chemistry Laboratory I	5
CLSE 201	Chemical Engineering Fundamentals I: Material Balances	4
MATH 301	Differential Equations	3
PHYS 207	University Physics I	5
Term Hours:		17

Spring semester

CHEM 302 & CHEZ 302	Organic Chemistry and Organic Chemistry Laboratory II	5
CLSE 202	Chemical Engineering Fundamentals II: Energy Balances and Engineering Thermodynamics	4
MATH 307	Multivariate Calculus	4
PHYS 208	University Physics II	5
Term Hours:		18

Summer semester

ENGR 396 or ENGR 398	Internship Experience or Cooperative Education Experience	0
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Term Hours: 0

Junior year

Fall semester

BIOL 151	Introduction to Biological Sciences I	3
CLSE 301	Transport Phenomena I	3
CLSE 305	Thermodynamics of Phase Equilibria and Chemical Reactions	3
UNIV 200	Inquiry and the Craft of Argument	3
Engineering elective (300+ level)		3

Term Hours: 15

Spring semester

CLSE 302	Transport Phenomena II	4
CLSE 312	Chemical Reaction Engineering	3
CLSE 320	Instrumentation Laboratory	3
ECON 205	The Economics of Product Development and Markets	3
STAT 441	Applied Statistics for Engineers and Scientists	3

Term Hours: 16

Senior year

Fall semester

CLSE 402	Senior Design Studio I (Laboratory/Project Time) (Laboratory/Project Time)	2
CLSE 409	Process Control in Chemical and Life Science Engineering	3
CLSE 440	Unit Operations Laboratory	3
ENGR 402	Senior Design Studio (Seminar) (Seminar)	1
ENGR 496 or ENGR 498	Internship Review or Review of Cooperative Education Experience	0
PHIL 201	Critical Thinking About Moral Problems (satisfies University Core humanities/fine arts)	3
Technical elective (300+ level science, math, business or management course)		3

Term Hours: 15

Spring semester

CLSE 403	Senior Design Studio II (Laboratory/Project Time) (Laboratory/Project Time)	2
ECON 101	Introduction to Political Economy (Approved social/behavioral sciences)	3
ENGR 403	Senior Design Studio (Seminar) (Seminar)	1
Engineering electives (300+ level)		3
Technical elective (300+ level science, math, business or management course)		3

Term Hours: 12

Total Hours: 126

- Chemical and life science engineering (p. 3)
- Engineering (p. 5)

Chemical and life science engineering

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 with a minimum grade of C, CHEM 102 and MATH 201. 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.

The minimum total of credit hours required for this degree is 126.

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: EGRC 201 and EGRC 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, fabrications, 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, and CHEM 302, or equivalents. 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.

Engineering

ENGR 100. Engineering Student Success. 0 Hours.

Semester course; seminar hours. 0 credits. Enrollment is restricted to new first-year students in the School of Engineering; required for students admitted conditionally. Students will meet for a 90-minute class once per week for five weeks. The course is dedicated to helping students understand the expectations and responsibilities of being a college student. Presentations will center on planning the semester, academic professionalism, study skills and test-taking strategies, financial literacy, health and wellness, time management, and the Honor Code. Seminars will be supplemented throughout the semester with online assignments to reinforce the discussions. Graded as pass/fail.

ENGR 101. Introduction to Engineering. 4 Hours.

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: admission to the School of Engineering or permission of instructor. Introduces basic circuits including resistors, diodes, transistors, digital gates and motors. Simple electromechanical systems are considered including motors, gears and wheels. The laboratory introduces fundamental circuit testing and measurement, and proper laboratory notebook writing; students are required to analyze, build and test a digitally controlled robot.

ENGR 111. Innovation Shop Training I. 0.5 Hours.

Semester course; 1 laboratory hour. 0.5 credits. Enrollment restricted to students in the School of Engineering. The course provides training on innovation shop safety, includes a tour of the shop, measuring and layout tools and techniques, use of general manual and powered hand tools. Students will be instructed on the use of a bench-top drill press, deburring and finishing tools, 3D printing, laser engraving and thermoforming equipment. Students need to achieve a minimum score of 76% in the class to attain Level I (Blue) certification. Only certified students have permission to use tools and equipment covered in this training. Graded as Pass/Fail.

ENGR 121. Engineering Fundamentals. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisite: permission of instructor. Open only to non-engineering majors in Certificate in Product Innovation program. Introduces engineering fundamentals to students from non-engineering disciplines. Particular focus is the engineering problem-solving process as applied to open-ended problems. Students will be introduced to the different types of engineering, examine engineering issues and apply the engineering problem-solving process.

ENGR 211. Innovation Shop Training II. 1 Hour.

Semester course; 2 laboratory hours. 1 credit. Prerequisite: ENGR 111. Enrollment restricted to students in the School of Engineering. The course provides training on machine/innovation shop safety, blueprint reading, measuring and layout tools and techniques, and use of general and powered hand tools. Students will be instructed on sawing, sanding, drilling and tapping operations, 3D printing and laser engraving/cutting equipment. Hands-on graded assignment is the part of the course.

ENGR 291. Special Topics in Engineering. 1-5 Hours.

Semester course; variable hours. 1-5 credits. Prerequisite: to be determined by the instructor. Specialized topics in engineering designed to provide a topic not covered by an existing course or program. General engineering or multidisciplinary. May be repeated with different content. Graded as pass/fail or normal letter grading at the option of the instructor. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

ENGR 296. Part-time Internship Experience. 0 Hours.

Semester course; 0 credit. Students may attempt this course a total of six times. Enrollment restricted to School of Engineering majors. The student works part time in an approved internship and must work a minimum of 90 hours, but less than 300 hours during the semester. The student works to meet learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor and student both complete evaluations of the learning experience. Graded pass/fail.

ENGR 303. Junior Seminar. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisite: permission of instructor. This course provides students an opportunity to explore business and leadership topics. Topics include the fundamentals of product design and new product development, manufacturing and quality systems, finances and financial reports, ethics in the workplace, intellectual property, teamwork, leadership and communications. Students will be assigned selected readings, written compositions and oral presentations. This course prepares the student to participate in the Engineering Laboratory/Manufacturing Internship.

ENGR 311. Innovation Shop Training III. 1 Hour.

Semester course; 2 laboratory hours. 1 credit. Prerequisite: ENGR 211. Enrollment is restricted to students with Level II (Red) certification. The Level III (Green) course provides basic training on set-up and operation of manual milling machines and the lathe. The course covers cutting tool, speed and feed calculation. Students must develop a technological process and machine metal parts per assigned drawings on vertical mill and lathe. They will also use other techniques and equipment that were covered in previous levels. Students need to achieve a minimum score of 76 % in the class to attain Level III (Green) certification. Only certified students have permission to use tools and equipment covered in this training.

ENGR 395. Professional Development. 1 Hour.

Semester course; 1 lecture and 1 workshop hour. 1 credit. Enrollment is restricted to majors in the School of Engineering. Professional development course to help prepare students to find a job and succeed in a professional environment, and specifically to work as an intern or in a cooperative education position. Topics covered include career paths; job searches; resume and cover letter writing; preparing for the interview; personal assessment of interests, values and strengths; networking; professional and ethical behavior on the job; overview of legal issues related to hiring, such as nondisclosure agreements and noncompetitiveness clauses; overview of personal finance management at the first job; workplace safety; and expectations and requirements for internships and cooperative education positions.

ENGR 396. Internship Experience. 0 Hours.

Semester course; 0 credit. Students may attempt this course a total of three times. Enrollment restricted to School of Engineering majors. The student works in an approved internship and must work a minimum of 300 hours during the semester. The student works to meet learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor and student both complete evaluations of the learning experience. Graded pass/fail.

ENGR 398. Cooperative Education Experience. 0 Hours.

Semester course; 0 credits. Students may attempt this course a total of four times. Prerequisite: ENGR 395. Restricted to School of Engineering majors in good academic standing. The student works full-time in an approved cooperative education position. The student works to meet specific learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor/mentor and student both complete midterm and final evaluations of the learning experience. Graded pass/fail.

ENGR 399. Cooperative Education Experience II. 3 Hours.

Semester course; 3 credits. Prerequisite: ENGR 398. Restricted to School of Engineering majors in good academic standing. A student that has completed at least one work term in a full-time approved cooperative education position completes an additional full-time work term. The student works to meet specific learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor/mentor and student both complete midterm and final evaluations of the learning experience.

ENGR 402. Senior Design Studio (Seminar). 1 Hour.

Continuous courses; 1 lecture hour. 1-1 credit. Prerequisites: senior standing and participation in a senior design (capstone) project; completion of ENGR 402 to enroll in ENGR 403. This weekly seminar presents and discusses topics relevant to senior-level engineering students in support of the capstone project and upcoming graduation. A single course coordinator manages and administers the course and schedules the various faculty lectures and guest speakers. Topics include, but are not limited to, the following: proposal writing, project planning and management, scheduling resources and budgeting for technical projects, patents and intellectual property, quality systems (six sigma, ISO standards, statistical process control), entrepreneurship, creativity and innovation and professional registration.

ENGR 403. Senior Design Studio (Seminar). 1 Hour.

Continuous courses; 1 lecture hour. 1-1 credit. Prerequisites: senior standing and participation in a senior design (capstone) project; completion of ENGR 402 to enroll in ENGR 403. This weekly seminar presents and discusses topics relevant to senior-level engineering students in support of the capstone project and upcoming graduation. A single course coordinator manages and administers the course and schedules the various faculty lectures and guest speakers. Topics include, but are not limited to, the following: proposal writing, project planning and management, scheduling resources and budgeting for technical projects, patents and intellectual property, quality systems (six sigma, ISO standards, statistical process control), entrepreneurship, creativity and innovation and professional registration.

ENGR 410. Review of Internship. 1 Hour.

Semester course; 1 credit. Prerequisites: chemical, electrical and computer, or mechanical engineering major and experience to satisfy the engineering internship requirements. Students complete oral presentations and written reports summarizing the internship experience.

ENGR 411. Fundamentals of Engineering Exam Preparation. 1 Hour.

Semester course; 1 lecture hour. 1 credit. Prerequisite: senior or graduate standing, or permission of instructor. This course prepares students for taking the fundamentals of Engineering Exam. Passing the FE Exam is the first step to getting a Professional Engineering license. This course is not intended to teach the various subject matters, but to review the subject areas and help students prepare as well as possible for the examination.

ENGR 490. Engineering Seminar. 1-3 Hours.

Semester course; variable hours. 1-3 credits. May be repeated with different content. Prerequisite: permission of the instructor. A series of specialized topics in engineering that are of general interest but not covered by an existing course or program. Lectures will be presented in seminar format by speakers from business, industry, government and academia. Subjects will be multidisciplinary in nature. Graded as pass/fail or normal letter grading at the option of the instructor.

ENGR 491. Special Topics in Engineering. 1-5 Hours.

Semester course; variable hours. 1-5 credits. Prerequisite: determined by the instructor. Specialized topics in engineering designed to provide a topic not covered by an existing course or program. General engineering or multidisciplinary. May be repeated with different content. Graded as pass/fail or normal letter grading at the option of the instructor. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

ENGR 492. Independent Study in Engineering. 1-5 Hours.

Semester course; variable hours. 1-5 credits. May be repeated with different content. Prerequisite: permission of the instructor. Students must submit a written proposal to be approved by the supervising instructor prior to registration. Investigation of specialized engineering problems that are multidisciplinary or of general interest through literature search, mathematical analysis, computer simulation and/or laboratory experimentation. Written and oral progress reports as well as a final report and presentation are required. Graded as pass/fail or normal letter grading at the option of the instructor.

ENGR 496. Internship Review. 0 Hours.

Semester course; 0 credits. Prerequisite: ENGR 296 or ENGR 396. Restricted to School of Engineering majors. This course is to be taken following the completion of a minimum of 300 hours of approved internship experience relevant to the student's major and documents that a student has fulfilled all internship requirements, including a final evaluation by the employer, a final self-evaluation, a final report describing the experience and a final oral presentation about the experience. Graded pass/fail.

ENGR 497. Vertically Integrated Projects. 1,2 Hour.

Semester course; 3 or 6 laboratory hours. 1 or 2 credits. May be repeated for a maximum total of 8 credits Prerequisites: permission of the project faculty adviser. This course provides undergraduate students the opportunity to participate in multiyear, multidisciplinary projects under the guidance of faculty and graduate students in their areas of expertise. As they address research and development issues, students learn and practice many different professional skills, make substantial technical contributions to the project, and experience many different roles on a large, multidisciplinary design/discovery team. Students must earn a minimum of 4 credits in ENGR 497 with a minimum grade of C in order for these credits to be eligible to count toward a technical or departmental elective. More restrictive requirements may be imposed by individual departments.

ENGR 498. Review of Cooperative Education Experience. 0 Hours.

Semester course; 0 credits. Prerequisite: ENGR 398. Restricted to School of Engineering majors. This course is completed following the final work term of a cooperative education experience and is required to obtain transcript notation to document that a student has fulfilled all the requirements of the school's cooperative education program. The requirements include a final evaluation by the employer, a final self-evaluation, a final report describing the experience and a final oral presentation about the experience.