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

Student learning outcomes

Upon completing this program, students will demonstrate:

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 and inclusive 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
8. An understanding of the hazards associated with physical, chemical 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 life science engineering

Course	Title	Hours
General education (http://bulletin.vcu.edu/undergraduate/undergraduate-study/general-education-curriculum/)		
Select 30 credits of general education courses in consultation with an adviser.		30
Major requirements		
• Major core requirements		
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)	2
CLSE 403	Senior Design Studio II (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)	1
ENGR 403	Senior Design Studio (Seminar)	1
• Additional major requirements		
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	
or ENGR 498	Review of Cooperative Education Experience	
• Major electives		
Select engineering electives as described below.		9
Ancillary requirements		
BIOL 151 & BIOZ 151	Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I	4
BIOL 152	Introduction to Biological Sciences II	3
CHEM 101	General Chemistry I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	3
CHEZ 101	General Chemistry Laboratory I	1

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
CHEM 403	Biochemistry I	3
ECON 205	The Economics of Product Development and Markets (satisfies general education BOK for social/behavioral sciences and AOI for global perspectives)	3
MATH 200	Calculus with Analytic Geometry I (satisfies general education quantitative foundations)	4
MATH 201	Calculus with Analytic Geometry II	4
MATH 301	Differential Equations	3
MATH 307	Multivariate Calculus	4
PHIL 201	Introduction to Ethics (satisfies general education BOK for humanities/fine arts and AOI for diversities in the human experience)	3
PHYS 207	University Physics I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	5
PHYS 208	University Physics II	5
STAT 441	Applied Statistics for Engineers and Scientists	3
Total Hours		**127**

The minimum number of credit hours required for this degree is 127.

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. Offered for 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 satisfy an engineering elective requirement. Other courses may be used to satisfy the 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**
CHEM 101	General Chemistry I (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	3
CHEZ 101	General Chemistry Laboratory I	1
CLSE 101	Introduction to Engineering	3
MATH 200	Calculus with Analytic Geometry I (satisfies general education quantitative foundations)	4
UNIV 111 Play course video for Focused Inquiry I	Focused Inquiry I (satisfies general education UNIV foundations)	3
	Term Hours:	**14**
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 Play course video for Focused Inquiry II	Focused Inquiry II (satisfies general education UNIV foundations)	3
	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 (satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)	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
	Term Hours:	**0**

Junior year

Fall semester		
BIOL 151 & BIOZ 151	Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I	4
CLSE 301	Transport Phenomena I	3
CLSE 305	Thermodynamics of Phase Equilibria and Chemical Reactions	3

ECON 205	The Economics of Product Development and Markets (satisfies general education BOK for social/behavioral sciences and AOI for global perspectives)	3
UNIV 200	Advanced Focused Inquiry: Literacies, Research and Communication (satisfies general education UNIV foundations)	3
	Term Hours:	**16**
Spring semester		
BIOL 152	Introduction to Biological Sciences II	3
CLSE 302	Transport Phenomena II	4
CLSE 312	Chemical Reaction Engineering	3
CLSE 320	Instrumentation Laboratory	3
STAT 441	Applied Statistics for Engineers and Scientists	3
	Term Hours:	**16**
Senior year		
Fall semester		
CHEM 403	Biochemistry I	3
CLSE 402	Senior Design Studio I (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)	1
ENGR 496 or ENGR 498	Internship Review or Review of Cooperative Education Experience	0
PHIL 201	Introduction to Ethics (satisfies general education BOK for humanities/fine arts and AOI for diversities in the human experience)	3
	Term Hours:	**15**
Spring semester		
CLSE 403	Senior Design Studio II (Laboratory/Project Time)	2
ENGR 403	Senior Design Studio (Seminar)	1
General education course		3
Engineering electives (300+ level)		9
	Term Hours:	**15**
	Total Hours:	**127**

The minimum number of credit hours required for this degree is 127.

Accelerated B.S. and M.S.

The accelerated B.S. and M.S. program allows qualified students to earn both the B.S. in Chemical and Life Science Engineering and the M.S. in Engineering with a concentration in chemical and life science engineering in a minimum of five years by completing approved graduate courses during the senior year of their undergraduate program. Students in the program may count up to six hours of graduate courses toward both the B.S. and M.S. degrees. Thus, the two degrees may be earned with a minimum of 150 credits rather than the 156 credits necessary if the two degrees are pursued separately.

Students holding these degrees will have a head start for pursuing careers in industry or continuing in an academic setting. The M.S. degree provides formal research experience and can lead to expanded job opportunities, greater potential for job advancement and higher starting salaries.

Entrance to the accelerated program

Interested undergraduate students should consult with their adviser as early as possible to receive specific information about the accelerated program, determine academic eligibility and submit (no later than two semesters prior to graduating with a baccalaureate degree, that is, before the end of the spring semester of their junior year) an Accelerated Program Declaration Form to be approved by the graduate program director. Limited spaces may be available in the accelerated program. Academically qualified students may not receive approval if capacity has been reached.

Minimum qualifications for entrance to this accelerated program completion of 99 undergraduate credit hours including CLSE 301, CLSE 302, CLSE 305, CLSE 312 and CLSE 320; a minimum overall GPA of 3.0; and a GPA of 3.2 in chemical and life science engineering (CLSE) course work. Students who are interested in the accelerated program should consult with the graduate program director before they have completed 99 credits. Successful applicants will enter the program in the fall semester of their senior year.

Once enrolled in the accelerated program, students must meet the standards of performance applicable to graduate students as described in the "**Satisfactory academic progress**" section of the Graduate Bulletin, including maintaining a 3.0 GPA. Guidance to students admitted to the accelerated program is provided by both the CLSE undergraduate program director and the CLSE graduate program director.

Admission to the graduate program

Entrance to the accelerated program enables the student to take the approved shared courses that will apply to the undergraduate and graduate degrees. However, entry into an accelerated program via an approved Accelerated Program Declaration Form does not constitute application or admission into the graduate program. Admission to the graduate program requires a separate step that occurs through a formal application to the master's program, which is submitted through Graduate Admissions no later than a semester prior to graduation with the baccalaureate degree, that is, before the end of the fall semester of the senior year. In order to continue pursuing the master's degree after the baccalaureate degree is conferred, accelerated students must follow the admission to graduate study requirements outlined in the VCU Bulletin. One reference letter from a chemical and life science engineering faculty member must accompany the application. The GRE is waived for admission to the program.

Degree requirements

The Bachelor of Science in Chemical and Life Science Engineering degree will be awarded upon completion of a minimum of 126 credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

A maximum of six graduate credits may be taken prior to completion of the baccalaureate degree. These graduate credits will apply as required major electives or open elective credits (engineering electives) for the undergraduate degree. These courses are shared credits with the graduate program, meaning that they will be applied to both undergraduate and graduate degree requirements.

Examples of graduate chemical and life science engineering courses that may be taken as an undergraduate, once a student is admitted to the program, are:

Course	Title	Hours
CLSE 543	Advanced Reaction Engineering	3
CLSE 544	Applied Transport Phenomena	3
CLSE 549	Process Biotechnology	3
CLSE 551	Nanotoxicology	3
CLSE 560	Protein Engineering	3
CLSE 561	Stem Cell Engineering	3
CLSE 562	Advanced Systems Biology Engineering	3
CLSE 563	Metabolic Engineering	3
CLSE 570	Molecular Physiology and Microanatomy for Chemical and Life Science Engineering	4
CLSE 575	Nanotechnology in Life Science and Engineering	3
CLSE 580	Sustainable Chemical Engineering	3
ENGR 591	Special Topics in Engineering	1-4

Recommended course sequence/plan of study

What follows is the recommended plan of graduate study for students interested in the accelerated program beginning in the fall of the senior year.

Course	Title	Hours
Senior year		
Fall semester		
Required B.S. course work		
CLSE 402	Senior Design Studio I (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)	1
ENGR 496	Internship Review	0
PHIL 201	Introduction to Ethics	3
Engineering elective - CLSE 5xx (from list above)		3
Term Hours:		15
Spring semester		
Required B.S. course work		
ECON 101	Introduction to Political Economy	3
ENGR 403	Senior Design Studio (Seminar)	1
CLSE 403	Senior Design Studio II (Laboratory/ Project Time)	2
Engineering elective (300+ level)		3
Engineering elective - CLSE 5xx (from list above)		3
Term Hours:		12
Fifth year		
Fall semester		
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	3
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	3
Graduate electives (500 and 600 level) [1]		6
Term Hours:		12
Spring semester		
CLSE 654	Equilibrium Analysis in Chemical and Biological Systems	3
CLSE 656	Advanced Chemical Reaction Engineering	3
Graduate electives (500 and 600 level) [1]		6
Term Hours:		12

[1]

For example: 500-level (or higher) CLSE, ENGR, PESC, PCEU, EGRB, CHEM, NANO, PHYS, MATH, BIOL, PHIS or BIOC courses