BIOMEDICAL ENGINEERING, BACHELOR OF SCIENCE (B.S.)

Biomedical engineering applies engineering expertise to analyze and solve problems in biology and medicine in order to enhance health care. Students involved in biomedical engineering learn to work with living systems and to apply advanced technology to the complex problems of medical care. Biomedical engineers work with other health care professionals including physicians, nurses, therapists and technicians toward improvements in diagnostic, therapeutic and health delivery systems. Biomedical engineers may be involved with designing medical instruments and devices, developing medical software, tissue and cellular engineering, developing new procedures or conducting state-of-the-art research needed to solve clinical problems.

There are numerous areas of specialization and course work within biomedical engineering. These include:

1. Bioinstrumentation: the application of electronics and measurement techniques to develop devices used in the diagnosis and treatment of disease, including heart monitors, intensive care equipment, cardiac pacemakers and many other electronic devices.
2. Biomaterials: the development of artificial and living materials used for implantation in the human body, including those used for artificial heart valves, kidney dialysis cartridges, and artificial arteries, hips and knees.
3. Biomechanics: the study of motion, forces and deformations in the human body, including the study of blood flow and arterial disease, forces associated with broken bones and their associated repair mechanisms, mechanisms of blunt trauma including head injuries, orthopedic systems, and the forces and movement associated with human joints such as the knee and hip.
4. Tissue and cellular engineering: the application of biochemistry, biophysics and biotechnology toward the development of new cellular and tissue systems and an understanding of disease processes, including development of artificial skin and organs, cell adherence to artificial materials to prevent rejection by the body, and the development of new genetic cellular systems to treat diseases.
5. Medical imaging: the development of devices and systems to image the human body to diagnose diseases, including the development and data processing of the CAT scan, MRI (magnetic resonance imaging), medical ultrasound, X-ray and PET (positron emission tomography).
6. Rehabilitation and human factors engineering: the development of devices and prosthetics to enhance the capabilities of disabled individuals, including design of wheelchairs, walkers, artificial legs and arms, enhanced communication aids, and educational tools for people with disabilities.

A unique aspect to the undergraduate biomedical engineering is the practicum series, EGRB 101 and EGRB 301, which involves biomedical engineering students participating in medical rounds at the VCU Medical Center's MCV Hospitals, in medical research laboratories throughout the medical center and the Virginia BioTechnology Research Park, and in medical seminars, case studies and medical laboratories. This unique opportunity is the only one of its kind in the nation and involves the cooperation of the VCU Medical Center, one of the nation's largest and most prestigious medical centers.

Student learning 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 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

Degree requirements for Biomedical Engineering, Bachelor of Science (B.S.)

Course	Title	Hours
General education (https://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		
EGRB 101	Biomedical Engineering Practicum	2
EGRB 104	Introduction to Biomedical Engineering Laboratory	1
EGRB 111	Introduction to Biological Systems in Engineering	3
EGRB 203	Statics and Mechanics of Materials	3
EGRB 209	Applied Physiology for Biomedical Engineers	4
EGRB 215	Computational Methods in Biomedical Engineering	3
or CMSC 210	Computers and Programming	
EGRB 301	Biomedical Engineering Design Practicum	3
EGRB 307	Biomedical Instrumentation	4
EGRB 310	Biomechanics	4
EGRB 315	Device Design Methods	3
EGRB 401 & EGRB 402	Biomedical Engineering Senior Design Studio and Biomedical Engineering Senior Design Studio	6
EGRB 427	Biomaterials	3
EGRE 206	Electric Circuits	4
ENGR 395	Professional Development	1
• Additional major requirements		

EGRB 303	Biotransport Processes [1]	3-4
or EGRB 308	Biomedical Signal Processing	
• Major electives		
Science or engineering elective		3-4
Technical electives within declared track		21
Ancillary requirements		
EGRB 102	Introduction to Biomedical Engineering (satisfies AOI for scientific and logical reasoning)	3
CHEM 101	General Chemistry I	3
CHEZ 101	General Chemistry Laboratory I	1
CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II	4
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 310	Linear Algebra	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		**128**

[1] EGRB 303 is required for the cellular, tissue and regenerative engineering track; EGRB 308 is required for the biomedical instrumentation and imaging track.

The minimum number of credit hours required for this degree is 128.

Technical electives

Biomedical engineering students must select 21 credits of electives from one of the three technical elective tracks: cellular, tissue and regenerative engineering; biomechanics and rehabilitation engineering; or biomedical instrumentation and imaging.

Cellular, tissue and regenerative engineering track

Course	Title	Hours
CHEM 301	Organic Chemistry	3
CHEM 302	Organic Chemistry	3
CHEM 310	Medicinal Chemistry and Drug Design	3
CHEM 403	Biochemistry I	3
CHEZ 301	Organic Chemistry Laboratory I	2
EGRB 403	Tissue Engineering	3
EGRB 410	Cellular Engineering	3
EGRB 411	Cell Mechanics and Mechanobiology	3
or EGRB 517	Cell Mechanics and Mechanobiology	
EGRB 412	Regenerative Engineering and Medicine	3
or EGRB 512	Regenerative Engineering and Medicine	
EGRB 415	Cellular and Molecular Engineering Techniques	3
EGRB 491	Special Topics (if subject is appropriate; see adviser for approval)	1-4
or EGRB 591	Special Topics in Biomedical Engineering	
EGRB 513	Cellular Signal Processing	3
EGRB 515	Manufacturing of Biomaterials	3
EGRE 334	Introduction to Microfabrication	4
ENGR 291	Special Topics in Engineering (This course may be used for up to three credits of undergraduate research in the track area as approved by the undergraduate coordinator.)	1-3
ENGR 497	Vertically Integrated Projects (ENGR 497 may be repeated for up to four credits)	1-4
or INNO 460	Product Innovation: da Vinci Project	
MATH 380	Introduction to Mathematical Biology	4

Biomechanics and rehabilitation engineering track

Course	Title	Hours
CMSC 257	Computer Systems	4
EGMN 201	Dynamics and Kinematics	3
EGMN 416	Mechatronics	3
EGRB 406	Artificial Organs	3
or EGRB 506	Artificial Organs	
EGRB 420	Assistive Technology	3
EGRB 421	Human Factors Engineering	3
or EGRB 521	Human Factors Engineering	
EGRB 422	Human Performance Measurement Engineering	3
EGRB 423	Rehabilitation Engineering and Prostheses	3
EGRB 491	Special Topics (if subject is appropriate; see adviser for approval)	1-4
or EGRB 591	Special Topics in Biomedical Engineering	
EGRB 511	Fundamentals of Biomechanics	3
EGRB 524	Assistive Technology Design	3
EGRB 525	Modeling and Simulation of Human Movement	3
EGRE 245	Engineering Programming	4
or CMSC 255	Object-oriented Programming	
EGRE 246	Advanced Engineering Programming	3
or CMSC 256	Introduction to Data Structures	
EGRE 541	Medical Devices	3
ENGR 291	Special Topics in Engineering (This course may be used for up to three credits of undergraduate research in the track area as approved by the undergraduate coordinator.)	1-3
ENGR 497	Vertically Integrated Projects (ENGR 497 may be repeated for up to four credits)	1-4
or INNO 460	Product Innovation: da Vinci Project	
IDDS 300	Applications of Disability Studies	3
PSYC 406	Perception	3

Biomedical instrumentation and imaging track

Course	Title	Hours
EGRB 407	Physical Principles of Medical Imaging	3
EGRB 408	Advanced Biomedical Signal Processing	3
EGRB 409	Microcomputer Applications in Biomedical Engineering	3
or EGRB 509	Microcomputer Technology in the Biomedical Sciences	
EGRB 491	Special Topics (if subject is appropriate; see adviser for approval)	1-4
or EGRB 591	Special Topics in Biomedical Engineering	
EGRB 507	Biomedical Electronics and Instrumentation	3
EGRB 528	Fundamentals and Applications of Artificial Intelligence in Medical Imaging	3
EGRE 207	Electric Circuits II	4
EGRE 245	Engineering Programming	4
EGRE 246	Advanced Engineering Programming	3
EGRE 254	Digital Logic Design	4
EGRE 306	Introduction to Microelectronics	4
EGRE 307	Integrated Circuits	4
EGRE 334	Introduction to Microfabrication	4
EGRE 335	Signals and Systems	4
EGRE 337	Statistical Information Processing	3
EGRE 364	Microcomputer Systems	4
EGRE 365	Digital Systems	4
EGRE 454	Automatic Controls	4
EGRE 541	Medical Devices	3
ENGR 291	Special Topics in Engineering (This course may be used for up to three credits of undergraduate research in the track area as approved by the undergraduate coordinator.)	1-3
ENGR 497	Vertically Integrated Projects (ENGR 497 may be repeated for up to four credits)	1-4
or INNO 460	Product Innovation: da Vinci Project	
PHYS 422	Optics	3

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	3
CHEZ 101	General Chemistry Laboratory I	1
EGRB 101	Biomedical Engineering Practicum	2
EGRB 111	Introduction to Biological Systems in Engineering	3
MATH 200	Calculus with Analytic Geometry I (satisfies general education quantitative foundations)	4
UNIV 111 Play course video for Introduction to Focused Inquiry: Investigation and Communicatio	Introduction to Focused Inquiry: Investigation and Communication (satisfies general education UNIV foundations)	3
	Term Hours:	**16**

Spring semester

CHEM 102 & CHEZ 102	General Chemistry II and General Chemistry Laboratory II	4
EGRB 102	Introduction to Biomedical Engineering (satisfies general education AOI for scientific and logical reasoning)	3
EGRB 104	Introduction to Biomedical Engineering Laboratory	1
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

EGRB 209	Applied Physiology for Biomedical Engineers	4
EGRE 206	Electric Circuits	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:	**16**

Spring semester

EGRB 203	Statics and Mechanics of Materials	3
EGRB 215 or CMSC 210	Computational Methods in Biomedical Engineering or Computers and Programming	3
MATH 310	Linear Algebra	3
PHYS 208	University Physics II	5
General education course (select BOK for social/behavioral sciences and AOI for global perspectives)		3
	Term Hours:	**17**

Junior year

Fall semester

EGRB 307	Biomedical Instrumentation	4
EGRB 310	Biomechanics	4
EGRB 427	Biomaterials	3
General education course (select BOK for humanities/fine arts and AOI for diversities in the human experience)		3
Technical elective		3
	Term Hours:	**17**

Spring semester		
EGRB 301	Biomedical Engineering Design Practicum	3
EGRB 303 or EGRB 308	Biotransport Processes or Biomedical Signal Processing	3-4
EGRB 315	Device Design Methods	3
General education course		3
Science or engineering elective		3-4
	Term Hours:	**16**
Senior year		
Fall semester		
EGRB 401	Biomedical Engineering Senior Design Studio	3
STAT 441	Applied Statistics for Engineers and Scientists	3
UNIV 200	Advanced Focused Inquiry: Literacies, Research and Communication (satisfies general education UNIV foundations)	3
Technical electives		6
	Term Hours:	**15**
Spring semester		
EGRB 402	Biomedical Engineering Senior Design Studio	3
Technical electives		12
	Term Hours:	**15**
	Total Hours:	**128**

The minimum total of credit hours required for this degree is 128.

Accelerated B.S. and M.S.

The accelerated B.S. and M.S. program allows qualified students to earn both the B.S. and M.S. in Biomedical 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 (non-thesis option) or 12 hours (thesis option) of graduate courses toward both the B.S. and M.S. degrees. Thus, the two degrees may be earned with a minimum of 155 credits (non-thesis option) or 149 credits (thesis option) rather than the 161 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 academia. 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 include completion of 95 undergraduate credit hours including EGRB 307, EGRB 310, EGRB 315, and either EGRB 303 or EGRB 308; an overall GPA of 3.0; and a GPA of 3.2 in biomedical engineering course work. Additionally, for students pursuing the thesis option of the master's program, a letter of endorsement from a prospective thesis adviser from the biomedical engineering faculty must accompany the application. Students who are interested in the accelerated program should consult with the faculty adviser to the biomedical engineering graduate program before they have completed 95 credits. Successful applicants would 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 undergraduate biomedical engineering adviser and the faculty adviser to the graduate program.

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. The GRE is waived for admission to the program for all students.

Degree requirements

The Bachelor of Science in Biomedical Engineering degree will be awarded upon completion of a minimum of 131 credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

For students entering the non-thesis option, a maximum of six graduate credits may be taken prior to the completion of the baccalaureate degree. For students entering the thesis option, a maximum of 12 graduate credits may be taken. These graduate credits will count as open or technical elective credits 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.

The graduate biomedical engineering courses that may be taken as an undergraduate toward the master's degree are shown in the table below.

Course	Title	Hours
EGRB 506	Artificial Organs	3
EGRB 507	Biomedical Electronics and Instrumentation	3
EGRB 509	Microcomputer Technology in the Biomedical Sciences	3
EGRB 511	Fundamentals of Biomechanics	3
EGRB 512	Regenerative Engineering and Medicine	3
EGRB 517	Cell Mechanics and Mechanobiology	3
EGRB 513	Cellular Signal Processing	3

EGRB 521	Human Factors Engineering	3
EGRB 591	Special Topics in Biomedical Engineering	1-4

Recommended plan of study for thesis master's

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

Course	Title	Hours
Senior year		
Fall semester		
Required B.S. course work		
EGRB 401	Biomedical Engineering Senior Design Studio	3
STAT 210	Basic Practice of Statistics	3
or STAT 441	Applied Statistics for Engineers and Scientists	
Approved natural/physical sciences		3
Technical electives		3
EGRB 5XX from list above (counted toward B.S. and M.S.)		3
Open elective (counted toward B.S. and M.S.) [1]		3
Term Hours:		18
Spring semester		
Required B.S. course work		
EGRB 402	Biomedical Engineering Senior Design Studio	3
Technical electives		6
EGRB 5XX from list above (counted toward B.S. and M.S.)		3
EGRB 5XX from list above (counted toward B.S. and M.S.)		3
Term Hours:		15
Fifth year		
Fall semester		
EGRB 601	Numerical Methods and Modeling in Biomedical Engineering	4
EGRB 697	Directed Research in Biomedical Engineering	3
Open elective [1]		3
Term Hours:		10
Spring semester		
EGRB 602	Biomedical Engineering Systems Physiology	4
EGRB 690	Biomedical Engineering Research Seminar	1
EGRB 697	Directed Research in Biomedical Engineering	3
Term Hours:		8

1

EGRB, EGMN, ENGR, PHYS, MATH, CMSC, BIOL, PHIS or BIOC at 500-level or above

Recommended plan of study for non-thesis master's

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

Course	Title	Hours
Senior year		
Fall semester		
Required B.S. course work		
EGRB 401	Biomedical Engineering Senior Design Studio	3
STAT 210	Basic Practice of Statistics	3
or STAT 441	Applied Statistics for Engineers and Scientists	
Approved natural/physical sciences		3
Technical electives		6
EGRB 5XX (from list above, counted toward B.S. and M.S.)		3
Term Hours:		18
Spring semester		
Required B.S. course work		
EGRB 402	Biomedical Engineering Senior Design Studio	3
Technical electives		9
EGRB 5XX (from list above, counted toward B.S. and M.S.)		3
Term Hours:		15
Fifth year		
Fall semester		
EGRB 601	Numerical Methods and Modeling in Biomedical Engineering	4
EGRB technical elective (500-level or above)		3
Open elective [1]		6
Term Hours:		13
Spring semester		
EGRB 602	Biomedical Engineering Systems Physiology	4
EGRB 690	Biomedical Engineering Research Seminar	1
Open elective [1]		6
Term Hours:		11

1

EGRB, EGMN, ENGR, PHYS, MATH, CMSC, BIOL, PHIS or BIOC at 500-level or above

Accelerated B.S. and M.S.

The accelerated B.S and M.S program allows academically talented students to earn both the B.S in Biomedical Engineering and M.S in Computer Science (thesis or non-thesis option) 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 12 hours of graduate courses toward both the B.S and M.S. degrees. Thus, the two degrees may be earned with a minimum of 146 credits rather than the 158 credits necessary if the two degrees are pursued separately.

Students holding these degrees can qualify for more advanced professional positions in industry and enhance knowledge of specific areas.

Entrance to the accelerated program

Interested undergraduate students should consult with their adviser as early as possible (sophomore year is recommended) 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 include an overall GPA of 3.0; and a GPA of 3.0 in biomedical engineering course work. For acceptance into this accelerated pathway, students must have completed CMSC 257, CMSC 311, CMSC 355, and CMSC 401 courses or equivalent with a GPA of at least 3.4.

Once enrolled in the accelerated program, students must meet the standards of performance applicable to graduate students as described in the "Satisfactory academic progress (https://bulletin.vcu.edu/academic-regs/grad/satisfactory-academic-progress/)" section of the Graduate Bulletin, including maintaining a 3.0 GPA. Guidance to students in an accelerated program is provided by both the undergraduate biomedical engineering adviser and the graduate program director for the master's degree in computer science.

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. 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.

Degree requirements

The Bachelor of Science in a Biomedical Engineering degree will be awarded upon completion of a minimum of 128 credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

A maximum of 12 graduate credits may be taken prior to completion of the baccalaureate degree. These graduate credits will be utilized to fulfill technical electives requirements 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.

The graduate courses that may be taken as an undergraduate, once a student is admitted to the program, must be approved by the adviser or graduate program director and include 500-level courses from the following subject areas: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR.

Recommended course sequence/plan of study for students pursuing a thesis master's

What follows is the recommended plan of study for students interested in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year.

Course	Title	Hours
Junior year		
Fall semester		
EGRB 307	Biomedical Instrumentation	4
EGRB 310	Biomechanics	4
EGRB 427	Biomaterials	3
General education course (select BOK for humanities/fine arts and AOI for diversities in the human experience)		3
Technical elective		3
Term Hours:		17
Spring semester		
EGRB 301	Biomedical Engineering Design Practicum	3
EGRB 303	Biotransport Processes	3-4
or EGRB 308	Biomedical Signal Processing	
EGRB 315	Device Design Methods	3
General education course		3
Science or engineering elective		3-4
Term Hours:		15-17
Senior year		
Fall semester		
EGRB 401	Biomedical Engineering Senior Design Studio	3
STAT 441	Applied Statistics for Engineers and Scientists	3
UNIV 200	Advanced Focused Inquiry: Literacies, Research and Communication	3
Approved technical electives (Consider CS courses for accelerated pathway) [1]		6
Term Hours:		15
Spring semester		
EGRB 402	Biomedical Engineering Senior Design Studio	3
Approved technical electives (Consider CS courses for accelerated pathway)		12
Term Hours:		15
Fifth year		
Fall semester		
CMSC 697	Directed Research	3
M.S. foundational area courses (theory and systems) [1]		6
Term Hours:		9
Spring semester		
CMSC 697	Directed Research	6
M.S. foundational area course (applied) [1]		3
Term Hours:		9

1

select 500-level courses from: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR.

[2]

See the Graduate Bulletin for the list of theory, systems and applied foundational area courses.

Recommended course sequence/plan of study for students pursuing a non-thesis master's

What follows is the recommended plan of study for students interested in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year.

Course	Title	Hours
Junior year		
Fall semester		
EGRB 307	Biomedical Instrumentation	4
EGRB 310	Biomechanics	4
EGRB 427	Biomaterials	3
General education course (select BOK for humanities/fine arts and AOI for diversities in the human experience)		3
Technical elective		3
Term Hours:		17
Spring semester		
EGRB 301	Biomedical Engineering Design Practicum	3
EGRB 303	Biotransport Processes	3-4
or EGRB 308	Biomedical Signal Processing	
EGRB 315	Device Design Methods	3
General education course		3
Science or engineering elective		3-4
Term Hours:		15-17
Senior year		
Fall semester		
EGRB 401	Biomedical Engineering Senior Design Studio	3
STAT 441	Applied Statistics for Engineers and Scientists	3
UNIV 200	Advanced Focused Inquiry: Literacies, Research and Communication	3
Approved technical electives (Consider CS courses for accelerated pathway)		6
Term Hours:		15
Spring semester		
EGRB 402	Biomedical Engineering Senior Design Studio	3
Approved technical electives (Consider CS courses for accelerated pathway)		12
Term Hours:		15
Fifth year		
Fall semester		
M.S. foundational area courses (theory, systems and applied) [1]		9
Term Hours:		9
Spring semester		
Graduate didactic course work		9
Term Hours:		9

[1]

See the Graduate Bulletin for the list of theory, systems and applied foundational area courses.

Accelerated B.S. and M.S.

The accelerated B.S.-to-M.S. program allows qualified students to earn both the B.S. in Biomedical Engineering and the M.S. in Engineering, concentration in aerospace engineering; chemical and life science engineering; electrical and computer engineering; engineering management; environmental and sustainable engineering; rehabilitation engineering; systems engineering; or tissue engineering and regenerative medicine 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 12 hours of graduate courses toward both the B.S. and M.S. degrees.

Students holding these degrees will have a head start for pursuing careers in industry or continuing in academia. 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 any accelerated program include completion of 95 undergraduate credit hours and a minimum overall GPA of 3.0. Students who are interested in the accelerated program should consult with the faculty adviser to the graduate program before they have completed 95 credits. Successful applicants would enter the program in the following semester after graduation with the bachelor's degree..

Once enrolled in the accelerated program, students must meet the standards of performance applicable to graduate students as described in the "Satisfactory academic progress (https://bulletin.vcu.edu/academic-regs/grad/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 undergraduate program adviser and the 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. The GRE and application fee is waived for admission to the program for all students. Additionally, for students pursuing the thesis option of the master's program, a letter of endorsement from a prospective thesis adviser from a faculty member in the relevant department may accompany the application.

Degree requirements

The Bachelor of Science in Biomedical Engineering degree will be awarded upon completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

A maximum of 12 graduate credits may be taken prior to completion of the baccalaureate degree. These graduate credits will count as open or technical elective credits 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.

The graduate courses that may be taken as an undergraduate, once a student is admitted to the program, must be approved by the adviser or graduate program director and include 500-level courses from the following subject areas: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC, INNO and OVPR.

Curriculum requirements

Concentration in aerospace engineering

Thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the advisory committee: This component allows the student to take courses in either engineering or science with approval of the student's adviser.		12
Concentration component		
EGMN 604	Mechanical and Nuclear Engineering Materials	3
EGMN 605	Mechanical and Nuclear Engineering Analysis	3
EGMN 606	Mechanical and Nuclear Engineering Continuum Mechanics	3
EGMN 607	Heat and Mass Transfer Theory and Applications	3
Directed research component		
This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.		
EGMN 697	Directed Research in Mechanical and Nuclear Engineering	6
Total Hours		**30**

Non-thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser: This component allows the student to take courses in either engineering or science with approval of the student's adviser.		15
Concentration component		
EGMN 604	Mechanical and Nuclear Engineering Materials	3
EGMN 605	Mechanical and Nuclear Engineering Analysis	3
EGMN 606	Mechanical and Nuclear Engineering Continuum Mechanics	3
EGMN 607	Heat and Mass Transfer Theory and Applications	3
EGMN 661	Computational Fluid Dynamics	3
Total Hours		**30**

Concentration in chemical and life science engineering

Thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 6 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE, PESC) approved by the advisory committee: This component allows the student to take courses in either engineering or science with approval of the student's adviser.		9
Concentration component - CLSE course work		
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	3
CLSE 654	Equilibrium Analysis in Chemical and Biological Systems	3
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	3
CLSE 656	Advanced Chemical Reaction Engineering	3
Choose additional CLSE course work at the 500 level or higher		3
Directed research		
Select six credit hours from the following:		6
CLSE 690	Research Seminar in Chemical and Life Science Engineering	
CLSE 697	Directed Research in Chemical and Life Science Engineering	
Total Hours		**30**

Non-thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE, PESC) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.		12
Concentration component - CLSE course work		
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	3
CLSE 654	Equilibrium Analysis in Chemical and Biological Systems	3
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	3
CLSE 656	Advanced Chemical Reaction Engineering	3
Choose additional CLSE course work at the 500 level or higher		6
Total Hours		**30**

Concentration in electrical and computer engineering

Thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the advisory committee: This component allows the student to take courses in either engineering or science with approval of the student's adviser.		12
Concentration component		
EGRE course work (EGRE 500-level or higher or courses approved by the advisory committee): This component allows the student to pursue a series of courses that focus on a specific field of engineering and serve as the student's primary engineering discipline.		12
Directed research component		
This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.		
EGRE 697	Directed Research in Electrical and Computer Engineering	6
Total Hours		**30**

Non-thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser: This component allows the student to take courses in either engineering or science with approval of the student's adviser.		15
Concentration component		
EGRE course work (EGRE 500-level or higher or courses approved by the adviser): This component allows the student to pursue a series of courses that focus on a specific field of engineering and serve as the student's primary engineering discipline.		15
Total Hours		**30**

Concentration in engineering management

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.		18
Concentration component		
EGMN 507	Law and Engineering	3
ENGR 601	Engineering Project Management	3
ENGR 602	Engineering Contracts and Effective Negotiations	3
ENGR 696	Engineering Products and Economic Considerations	3
Total Hours		**30**

Concentration in environmental and sustainable engineering

Thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the advisory committee: This component allows the student to take courses in either engineering or science with approval of the student's adviser.		12
Concentration component		
CLSE 545	Water Essentials	3
CLSE 580	Sustainable Chemical Engineering	3
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	3
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	3
Directed research component		
This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.		
CLSE 697	Directed Research in Chemical and Life Science Engineering	6
Total Hours		**30**

Non-thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.		18
Concentration component		
CLSE 545	Water Essentials	3
CLSE 580	Sustainable Chemical Engineering	3
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	3
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	3
Total Hours		**30**

Concentration in rehabilitation engineering

Thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 6 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the advisory committee: This component allows the student to take courses in either engineering or science with approval of the student's adviser.		8
Concentration component		
EGRB 520	Assistive Technology	3
EGRB 521	Human Factors Engineering	3
EGRB 523	Rehabilitation Engineering and Prostheses	3
EGRB 603	Biomedical Signal Processing	3
ANAT 610	Systems Neuroscience	4
Directed research		
EGRB 697	Directed Research in Biomedical Engineering	6
Total Hours		**30**

Non-thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.		14
Concentration component		
EGRB 520	Assistive Technology	3
EGRB 521	Human Factors Engineering	3
EGRB 523	Rehabilitation Engineering and Prostheses	3
EGRB 603	Biomedical Signal Processing	3
ANAT 610	Systems Neuroscience	4
Total Hours		**30**

Concentration in systems engineering

Thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the advisory committee: This component allows the student to take courses in either engineering or science with approval of the student's adviser.		12
Concentration component		
EGRE 510	Introduction to Internet of Things	3
EGRE 512	Intelligent Autonomous Systems	3
EGRE 513	Fundamentals of Modern Systems Engineering	3
EGRE 615	Systems Modeling	3
Directed research component		
This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.		
EGRE 697	Directed Research in Electrical and Computer Engineering	6
Total Hours		**30**

Non-thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.		18
Concentration component		
EGRE 510	Introduction to Internet of Things	3
EGRE 512	Intelligent Autonomous Systems	3
EGRE 513	Fundamentals of Modern Systems Engineering	3
EGRE 615	Systems Modeling	3
Total Hours		**30**

Concentration in tissue engineering and regenerative medicine

Thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the advisory committee: This component allows the student to take courses in either engineering or science with approval of the student's adviser.		12
Concentration component - TERM course work		

EGRB 512	Regenerative Engineering and Medicine	3
EGRB 613	Biomaterials	3
EGRB 614	Tissue Engineering	3
EGRB 616	Cell Engineering	3
Directed research		
EGRB 697	Directed Research in Biomedical Engineering	6
Total Hours		**30**

Non-thesis option

Course	Title	Hours
Required graduate-level coursework		
Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.		15
Concentration component - TERM course work		
EGRB 512	Regenerative Engineering and Medicine	3
EGRB 613	Biomaterials	3
EGRB 614	Tissue Engineering	3
EGRB 616	Cell Engineering	3
Choose additional course work at the 500 level or higher		3
Total Hours		**30**

Recommended course sequence/plan of study

What follows is the recommended plan of study for students interested in the accelerated program beginning in the fall of the junior/senior year prior to admission to the accelerated program in the senior year.

Course	Title	Hours
Junior year		
Fall semester		
EGRB 307	Biomedical Instrumentation	4
EGRB 310	Biomechanics	4
EGRB 427	Biomaterials	3
General education course		3
Technical elective		3
Term Hours:		17
Spring semester		
EGRB 301	Biomedical Engineering Design Practicum	3
EGRB 303	Biotransport Processes	3
or EGRB 308	Biomedical Signal Processing	
EGRB 315	Device Design Methods	3
General education course		3
Science or engineering elective		3-4
Term Hours:		15-16
Senior year		
Fall semester		
EGRB 401	Biomedical Engineering Senior Design Studio	3
STAT 210	Basic Practice of Statistics	3
or STAT 441	Applied Statistics for Engineers and Scientists	
UNIV 200	Advanced Focused Inquiry: Literacies, Research and Communication	3
Technical elective (from undergraduate list)		3
Approved technical electives [1]		6
Term Hours:		18
Spring semester		
EGRB 402	Biomedical Engineering Senior Design Studio	3
Open elective		3
Technical elective (from undergraduate list)		3
Approved technical electives [1]		6
Term Hours:		15

1

EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR at 500-level or above

Concentration in aerospace engineering

Course	Title	Hours
Fifth year		
Thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGMN 604	Mechanical and Nuclear Engineering Materials	
EGMN 605	Mechanical and Nuclear Engineering Analysis	
EGMN 606	Mechanical and Nuclear Engineering Continuum Mechanics	
EGMN 607	Heat and Mass Transfer Theory and Applications	
Directed research [2]		3
EGMN 697	Directed Research in Mechanical and Nuclear Engineering	
Term Hours:		12
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGMN 604	Mechanical and Nuclear Engineering Materials	
EGMN 605	Mechanical and Nuclear Engineering Analysis	
EGMN 606	Mechanical and Nuclear Engineering Continuum Mechanics	
EGMN 607	Heat and Mass Transfer Theory and Applications	
Directed research [2]		3

EGMN 697	Directed Research in Mechanical and Nuclear Engineering	
Term Hours:		12
Non-thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGMN 604	Mechanical and Nuclear Engineering Materials	
EGMN 605	Mechanical and Nuclear Engineering Analysis	
EGMN 606	Mechanical and Nuclear Engineering Continuum Mechanics	
EGMN 607	Heat and Mass Transfer Theory and Applications	
EGMN 661	Computational Fluid Dynamics	
Term Hours:		9
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGMN 604	Mechanical and Nuclear Engineering Materials	
EGMN 605	Mechanical and Nuclear Engineering Analysis	
EGMN 606	Mechanical and Nuclear Engineering Continuum Mechanics	
EGMN 607	Heat and Mass Transfer Theory and Applications	
EGMN 661	Computational Fluid Dynamics	
Term Hours:		9

[1] Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.

[2] This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.

Concentration in chemical and life science engineering

Course	Title	Hours
Fifth year		
Thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	
CLSE 654	Equilibrium Analysis in Chemical and Biological Systems	
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	
CLSE 656	Advanced Chemical Reaction Engineering	
Directed research [2]		3
CLSE 690	Research Seminar in Chemical and Life Science Engineering	
CLSE 697	Directed Research in Chemical and Life Science Engineering	
Term Hours:		12
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	
CLSE 654	Equilibrium Analysis in Chemical and Biological Systems	
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	
CLSE 656	Advanced Chemical Reaction Engineering	
Choose additional CLSE course work at the 500 level or higher		
Directed research [2]		3
CLSE 690	Research Seminar in Chemical and Life Science Engineering	
CLSE 697	Directed Research in Chemical and Life Science Engineering	
Term Hours:		12
Non-thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	
CLSE 654	Equilibrium Analysis in Chemical and Biological Systems	
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	
CLSE 656	Advanced Chemical Reaction Engineering	
Term Hours:		9
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	
CLSE 654	Equilibrium Analysis in Chemical and Biological Systems	
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	
CLSE 656	Advanced Chemical Reaction Engineering	
Term Hours:		9

[1]

Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.

[2]

This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.

Concentration in electrical and computer engineering

Course	Title	Hours
Fifth year		
Thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specifc courses [2]		6
Directed research [3]		3
EGRE 697	Directed Research in Electrical and Computer Engineering	
Term Hours:		12
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses [2]		6
Directed research [3]		3
EGRE 697	Directed Research in Electrical and Computer Engineering	
Term Hours:		12
Non-thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific courses [2]		6
Term Hours:		9
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses [2]		6
Term Hours:		9

[1]

Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.

[2]

EGRE course work (EGRE 500-level or higher or courses approved by the advisory committee): This component allows the student to pursue a series of courses that focus on a specific field of engineering and serve as the student's primary engineering discipline.

[3]

This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.

Concentration in engineering management

Course	Title	Hours
Fifth year		
Fall semester		
Required graduate-level courses [1]		3
Concentration specifc courses		6
EGMN 507	Law and Engineering	
ENGR 601	Engineering Project Management	
ENGR 602	Engineering Contracts and Effective Negotiations	
ENGR 696	Engineering Products and Economic Considerations	
Term Hours:		9
Spring semester		
Required graduate-level courses		3
Concentration specific courses		6
EGMN 507	Law and Engineering	
ENGR 601	Engineering Project Management	
ENGR 602	Engineering Contracts and Effective Negotiations	
ENGR 696	Engineering Products and Economic Considerations	

[1]

Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.

Concentration in environmental and sustainable engineering

Course	Title	Hours
Fifth year		
Thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific		6
CLSE 545	Water Essentials	
CLSE 580	Sustainable Chemical Engineering	
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	
Directed research [2]		3
CLSE 697	Directed Research in Chemical and Life Science Engineering	
Term Hours:		12
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6

CLSE 545	Water Essentials	
CLSE 580	Sustainable Chemical Engineering	
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	
Directed research [2]		3
CLSE 697	Directed Research in Chemical and Life Science Engineering	
Term Hours:		12
Non-thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
CLSE 545	Water Essentials	
CLSE 580	Sustainable Chemical Engineering	
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	
Term Hours:		9
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
CLSE 545	Water Essentials	
CLSE 580	Sustainable Chemical Engineering	
CLSE 650	Quantitative Analysis in Chemical and Life Science Engineering	
CLSE 655	Nonequilibrium Analysis in Chemical and Life Science Engineering	
Term Hours		9

1

Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.

2

This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.

Concentration in rehabilitation engineering

Course	Title	Hours
Fifth year		
Thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specifc courses		6
EGRB 520	Assistive Technology	
EGRB 521	Human Factors Engineering	
EGRB 523	Rehabilitation Engineering and Prostheses	
EGRB 603	Biomedical Signal Processing	
ANAT 610	Systems Neuroscience	
Directed research [2]		3
EGRB 697	Directed Research in Biomedical Engineering	
Term Hours:		12
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGRB 520	Assistive Technology	
EGRB 521	Human Factors Engineering	
EGRB 523	Rehabilitation Engineering and Prostheses	
EGRB 603	Biomedical Signal Processing	
ANAT 610	Systems Neuroscience	
Directed research [2]		3
EGRB 697	Directed Research in Biomedical Engineering	
Term Hours:		12
Non-thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGRB 520	Assistive Technology	
EGRB 521	Human Factors Engineering	
EGRB 523	Rehabilitation Engineering and Prostheses	
EGRB 603	Biomedical Signal Processing	
ANAT 610	Systems Neuroscience	
Term Hours:		9
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGRB 520	Assistive Technology	
EGRB 521	Human Factors Engineering	
EGRB 523	Rehabilitation Engineering and Prostheses	
EGRB 603	Biomedical Signal Processing	
ANAT 610	Systems Neuroscience	
Term Hours:		9

1

Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.

2

This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.

Concentration in systems engineering

Course	Title	Hours
Fifth year		
Thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGRE 510	Introduction to Internet of Things	
EGRE 512	Intelligent Autonomous Systems	
EGRE 513	Fundamentals of Modern Systems Engineering	
EGRE 615	Systems Modeling	
Directed research		3
EGRE 697	Directed Research in Electrical and Computer Engineering	
Term Hours:		12
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGRE 510	Introduction to Internet of Things	
EGRE 512	Intelligent Autonomous Systems	
EGRE 513	Fundamentals of Modern Systems Engineering	
EGRE 615	Systems Modeling	
Directed research [2]		3
EGRE 697	Directed Research in Electrical and Computer Engineering	
Term Hours:		12
Non-thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGRE 510	Introduction to Internet of Things	
EGRE 512	Intelligent Autonomous Systems	
EGRE 513	Fundamentals of Modern Systems Engineering	
EGRE 615	Systems Modeling	
Term Hours:		9
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGRE 510	Introduction to Internet of Things	
EGRE 512	Intelligent Autonomous Systems	
EGRE 513	Fundamentals of Modern Systems Engineering	
EGRE 615	Systems Modeling	
Term Hours		9

1

Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.

2

This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.

Concentration in tissue engineering and regenerative medicine

Course	Title	Hours
Fifth year		
Thesis option		
Fall semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGRB 512	Regenerative Engineering and Medicine	
EGRB 613	Biomaterials	
EGRB 614	Tissue Engineering	
EGRB 616	Cell Engineering	
Directed research [2]		3
EGRB 697	Directed Research in Biomedical Engineering	
Term Hours:		12
Spring semester		
Required graduate-level courses [1]		3
Concentration specific courses		6
EGRB 512	Regenerative Engineering and Medicine	
EGRB 613	Biomaterials	
EGRB 614	Tissue Engineering	
EGRB 616	Cell Engineering	
Directed research [2]		3
EGRB 697	Directed Research in Biomedical Engineering	
Term Hours:		12
Non-thesis option		
Fall semester		
Required graduate-level courses		3
Concentration specific courses		6
EGRB 512	Regenerative Engineering and Medicine	
EGRB 613	Biomaterials	
EGRB 614	Tissue Engineering	
EGRB 616	Cell Engineering	
Term Hours:		9
Required graduate-level courses		
Concentration specific courses		
EGRB 512	Regenerative Engineering and Medicine	
EGRB 613	Biomaterials	
EGRB 614	Tissue Engineering	
EGRB 616	Cell Engineering	
Term Hours:		9

1

Engineering or other relevant graduate course work (including a minimum of 9 credit hours from 500-level or higher courses in EGRE, ENGR, EGRB, EGMN, CMSC, CLSE) approved by the adviser. This component allows the student to take courses in either engineering or science with approval of the student's adviser.

2

This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.

Accelerated B.S. and M.S.

The accelerated B.S and M.S program allows academically talented students to earn both the B.S in Biomedical Engineering and M.S in Mechanical and Nuclear Engineering (thesis or non-thesis option) 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 12 hours of graduate courses toward both the B.S and M.S. degrees. Thus, the two degrees may be earned with a minimum of 149 credits rather than the 161 credits necessary if the two degrees are pursued separately.

Students holding these degrees can qualify for more advanced professional positions in industry and enhance knowledge of specific areas.

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 include completion of 80 or more credits in biomedical engineering undergraduate credit hours including EGRB 307, EGRB 310 and EGRB 427; an overall GPA of 3.0; and a GPA of 3.0 in biomedical engineering course work.

Once enrolled in the accelerated program, students must meet the standards of performance applicable to graduate students as described in the "Satisfactory academic progress (https://bulletin.vcu.edu/academic-regs/grad/satisfactory-academic-progress/)" section of the Graduate Bulletin, including maintaining a 3.0 GPA. Guidance to students in an accelerated program is provided by both the undergraduate biomedical engineering adviser and the graduate program director for the master's degree in mechanical and nuclear engineering.

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. 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.

Degree requirements

The Bachelor of Science in a Biomedical Engineering degree will be awarded upon completion of a minimum of 131 credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

A maximum of 12 graduate credits may be taken prior to completion of the baccalaureate degree. These graduate credits will be utilized to fulfill technical electives requirements 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.

The graduate courses that may be taken as an undergraduate, once a student is admitted to the program, must be approved by the adviser or graduate program director and include 500-level courses from the following subject areas: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR.

Recommended course sequence/plan of study

What follows is the recommended plan of study for students interested in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year.

For students pursuing the non-thesis option

Course	Title	Hours
Junior year		
Fall semester		
EGRB 307	Biomedical Instrumentation	4
EGRB 310	Biomechanics	4
EGRB 427	Biomaterials	3
General education course		3
Technical elective		3
Term Hours:		17
Spring semester		
EGRB 301	Biomedical Engineering Design Practicum	3
EGRB 303	Biotransport Processes	3
or EGRB 308	Biomedical Signal Processing	
EGRB 315	Device Design Methods	3
General education course		3
Science or engineering elective		3-4
Term Hours:		16
Senior year		
Fall semester		
EGRB 401	Biomedical Engineering Senior Design Studio	3
STAT 210	Basic Practice of Statistics	3
or STAT 441	Applied Statistics for Engineers and Scientists	
UNIV 200	Advanced Focused Inquiry: Literacies, Research and Communication ((satisfies general education UNIV foundations))	3
Technical elective (from undergraduate list)		3

Approved technical electives (Shared; select 500-level courses from: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR.)		6
Term Hours:		18
Spring semester		
EGRB 402	Biomedical Engineering Senior Design Studio	3
Open elective		3
Technical elective (from undergraduate list)		3
Approved technical electives (Shared; select 500-level courses from: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR)		6
Term Hours:		15
Fifth year		
Fall semester		
EGMN 605	Mechanical and Nuclear Engineering Analysis	3
EGMN 606	Mechanical and Nuclear Engineering Continuum Mechanics	3
EGMN 610	Topics in Nuclear Engineering	3
Term Hours:		9
Spring semester		
Technical electives (Select 600-level courses from: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR.)		6
Technical elective (Select 500- or 600-level course from: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR.)		3
Term Hours:		9

For students pursuing the thesis option

Course	Title	Hours
Junior year		
Fall semester		
EGRB 307	Biomedical Instrumentation	4
EGRB 310	Biomechanics	4
EGRB 427	Biomaterials	3
General education course		3
Technical elective		3
Term Hours:		17
Spring semester		
EGRB 301	Biomedical Engineering Design Practicum	3
EGRB 303	Biotransport Processes	3
or EGRB 308	Biomedical Signal Processing	
EGRB 315	Device Design Methods	3
General education course		3
Science or engineering elective		3-4
Term Hours:		16
Senior year		
Fall semester		
EGRB 401	Biomedical Engineering Senior Design Studio	3
STAT 210	Basic Practice of Statistics	3
or STAT 441	Applied Statistics for Engineers and Scientists	
UNIV 200	Advanced Focused Inquiry: Literacies, Research and Communication ((satisfies general education UNIV foundations))	3
Technical elective (from undergraduate list)		3
Approved technical electives (Shared; select 500-level courses from: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR.)		6
Term Hours:		18
Spring semester		
EGRB 402	Biomedical Engineering Senior Design Studio	3
Open elective		3
Technical elective (from undergraduate list)		3
Approved technical electives (Shared; select 500-level courses from: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR.)		6
Term Hours:		15
Fifth year		
Fall semester		
EGMN 605	Mechanical and Nuclear Engineering Analysis	3
EGMN 606	Mechanical and Nuclear Engineering Continuum Mechanics	3
EGMN 610	Topics in Nuclear Engineering	3
Term Hours:		9
Spring semester		
EGMN 697	Directed Research in Mechanical and Nuclear Engineering	6
Technical electives (Select 600-level courses from: EGMN, EGRM, ENGR, EGRN, EGRB, EGRE, CLSE, CMSC, PHYS, MATH, NANO, CHEM, BIOL, GRAD, LFSC and OVPR.)		3
Term Hours:		9