# 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 (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 | | |
| 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 | Introduction to 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 Focused Inquiry I | Focused Inquiry I (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 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 (http://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 | Inquiry and the Craft of Argument ((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 | Inquiry and the Craft of Argument ((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 |