BIOMEDICAL ENGINEERING,
DOCTOR OF PHILOSOPHY (PH.D.)

Program mission
The mission of the Doctor of Philosophy in Biomedical Engineering is to educate biomedical engineering students to be significant contributors in health care and in research and development in biomedicine and bioengineering. The curriculum closely links technical fundamentals in science, engineering and the life sciences, together with the ability to function on multidisciplinary teams, to communicate effectively and to achieve the knowledge tools necessary for lifelong learning.

Program goals
1. Provide students with a graduate education that prepares them for current and future challenges in biomedical engineering
2. Produce graduates who possess the necessary advanced analytical and technical skills in engineering and sciences — responds directly to the higher goals of fulfilling the needs of industry for effective, productive engineers and of providing economic development for the region, state and nation
3. Produce graduates who possess a facility with both written and oral communications — emanates from the requirement that engineers must be able to interact and share ideas with others in the work environment, and at a higher level, be capable of creative self-expression and leadership
4. Produce graduates who demonstrate creativity and innovation in solving technological problems — stems from the realization that new knowledge and new solutions to existing problems are necessary to meet the needs of our changing society and to advance the quality of human life

Graduates possess the ability to formulate, analyze and solve problems, analytically and/or experimentally, in the biomedical engineering industry, in the clinical setting or in biomedical research. Graduates can work effectively in teams to solve biomedical and/or clinical problems including the interconnection of engineering and clinical personnel toward the solution of problems of compelling clinical and biomedical interest and need, with particular reference to the biomedical engineering industry, in the clinical setting or in biomedical research. The career paths of BME graduates in these arenas would be enhanced as a result of these skills.

Student learning outcomes
1. Graduates will demonstrate an ability to apply advanced knowledge of mathematics, biomedical sciences and engineering.
2. Graduates will demonstrate an ability to communicate effectively.
3. Graduates will demonstrate an ability to identify, formulate and solve biomedical engineering problems.
4. Graduates will demonstrate an ability to conduct independent research.

VCU Graduate Bulletin, VCU Graduate School and general academic policies and regulations for all graduate students in all graduate programs
The VCU Graduate Bulletin website documents the official admission and academic rules and regulations that govern graduate education for all graduate programs at the university. These policies are established by the graduate faculty of the university through their elected representatives to the University Graduate Council.

It is the responsibility of all graduate students, both on- and off-campus, to be familiar with the VCU Graduate Bulletin as well as the Graduate School website (http://www.graduate.vcu.edu) and academic regulations in individual school and department publications and on program websites. However, in all cases, the official policies and procedures of the University Graduate Council, as published on the VCU Graduate Bulletin and Graduate School websites, take precedence over individual program policies and guidelines.

Visit the academic regulations section for additional information on academic regulations for graduate students. (http://bulletin.vcu.edu/academic-regcs)

Degree candidacy requirements
A graduate student admitted to a program or concentration requiring a final research project, work of art, thesis or dissertation, must qualify for continuing master’s or doctoral status according to the degree candidacy requirements of the student’s graduate program. Admission to degree candidacy, if applicable, is a formal statement by the graduate student’s faculty regarding the student’s academic achievements and the student’s readiness to proceed to the final research phase of the degree program.

Graduate students and program directors should refer to the following degree candidacy policy as published in the VCU Graduate Bulletin for complete information and instructions.

Visit the academic regulations section for additional information on degree candidacy requirements. (http://bulletin.vcu.edu/academic-regcs/grad/candidacy)

Graduation requirements
As graduate students approach the end of their academic programs and the final semester of matriculation, they must make formal application to graduate. No degrees will be conferred until the application to graduate has been finalized.

Graduate students and program directors should refer to the following graduation requirements as published in the Graduate Bulletin for a complete list of instructions and a graduation checklist.

Visit the academic regulations section for additional information on graduation requirements. (http://bulletin.vcu.edu/academic-regcs/grad/graduation-info)

Other information
Student handbook (http://www.egr.vcu.edu/current-students/graduate-student-services/resources-forms) is available on the School of Engineering website.
Apply online at graduate.admissions.vcu.edu (http://graduate.admissions.vcu.edu).

Admission requirements

<table>
<thead>
<tr>
<th>Degree</th>
<th>Semester(s) of entry</th>
<th>Deadline dates</th>
<th>Test requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph.D.</td>
<td>Fall (preferred)</td>
<td>Jun 1 (Jan 15 for financial assistance)</td>
<td>GRE-General</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>Oct 1</td>
<td>International students require TOEFL</td>
</tr>
</tbody>
</table>

Special requirements

- Acceptance of an applicant is based upon the recommendation of the admissions committee with approval of the department chair and the associate dean for graduate studies.

In addition to the general admission requirements of the VCU Graduate School (http://bulletin.vcu.edu/graduate/study/admission-graduate-study/admission-requirements), biomedical engineering has the following admission criteria for all entering graduate students:

1. Minimum GPA of 3.0 during the previous 60 credit hours (for applicants with a B.S.)
2. Minimum GRE score of 300 (combined verbal reasoning and quantitative reasoning) including a minimum 150 on the quantitative reasoning
3. Minimum TOEFL score of 101 Internet-based for students whose first or native language is not English

Biomedical engineering will accept a maximum of six credit hours for transfer into either the M.S. or Ph.D. program if the original grades for such courses are B or higher (or equivalent).

Degree requirements

In addition to the VCU Graduate School graduation requirements (http://bulletin.vcu.edu/academic-reg/grad/graduation-info), students must meet the following requirements:

The Ph.D. in Biomedical Engineering program is nominally a three-year program. Prior evidence of completion of physiology and/or statistics may result in a waiver of the requirements for these courses as determined by the graduate program director and/or the department chair. These credit hours would be replaced by other graduate-level didactic course work reflective of the field of study. A period of residence of at least three consecutive terms is required. Residency is defined as registration for at least nine credit hours per term. A time limit of eight calendar years, beginning at the time of first registration, is placed on work to be credited toward the Doctor of Philosophy degree.

At the conclusion of the first year of doctoral study (or when the core course requirements have been satisfied), each doctoral student must successfully complete written and oral portions of a comprehensive examination. This examination is designed to test the student on fundamental knowledge in engineering as evidenced by the core (and related elective) courses within the curriculum. Upon completion of this examination, a doctoral student is permitted to initiate a doctoral research project and to complete additional course work consisting of biomedical engineering, clinical and science electives.

Upon completion of all course work and the intended research, a doctoral student must prepare a dissertation describing the completed research. A dissertation defense, under the direction of the advisory committee, will be scheduled to examine the student’s research, dissertation documentation and underlying fundamental knowledge needed to complete the research. Upon successful completion of the defense and dissertation, the doctoral student may apply for graduation from Virginia Commonwealth University with the Doctor of Philosophy in Biomedical Engineering.

Curriculum requirements

Required biomedical engineering courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>EGRB 507</td>
<td>Biomedical Electronics and Instrumentation</td>
<td>3</td>
</tr>
<tr>
<td>EGRB 511</td>
<td>Fundamentals of Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>EGRB 603</td>
<td>Biomedical Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>EGRB 613</td>
<td>Biomaterials</td>
<td>3</td>
</tr>
</tbody>
</table>

Required courses in other departments

- Physiology and statistics (PHIS 501; BIOS or STAT at 500 level or above) 8

Minimum elective courses

e.g. EGRB, EGRM, ENGR, PHYS, MATH, BIOL, PHIS, BIOC at 500 level or above 15

Research

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGRB 690</td>
<td>Biomedical Engineering Research Seminar</td>
<td>4</td>
</tr>
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</table>
| EGRB 697    | Directed Research in Biomedical Engineering (required at a level to be determined by each student’s graduate advisory committee) 33

Total Hours 72

Total graduate credit hours required (minimum) 72

Graduate program director
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Program website: biomedical.egr.vcu.edu (http://biomedical.egr.vcu.edu)