Biomedical Engineering Program General Description

The Biomedical Engineering graduate degree programs are available to full-time and part-time students seeking to improve their research and professional skills in biomedical engineering. The programs strive to provide the highest quality engineering education at the graduate level, to engage in scholarly research at the forefront of biomedical engineering, and to serve the profession of biomedical engineering. Cutting-edge research opportunities and instruction are offered in:

Bioelectrics

Encompasses the study of endogenous electrical phenomena and externally induced electromagnetic field effects in biological systems, particularly human tissue and organs. Research includes the interaction of pulsed electromagnetic fields and ionized gases with biological systems, mapping of cardiac electrophysiology, and brain-computer interfaces.

Facilities
Frank Reidy Center for Bioelectrics, Advanced Signal Processing in Engineering and Neuroscience (ASPEN) Laboratory, Cardiac Electrophysiology Laboratory, Medical Device Laboratory.

Biomechanics and BioMicro/NanoFluidics

Encompasses the study of macro, micro, and nano-scale solid and fluid mechanics in biological systems, particularly human tissue and organs. Research includes point-of-care microfluidic devices, orthopedic biomechanics, rehabilitation engineering, biomechanics of trauma, and micromechanical analysis of soft tissue.

Facilities
BioMicro Fluidics Laboratory, Center for Brain Research and Rehabilitation, Biomechanics Laboratory.

Biomedical Imaging

Utilizes ODU’s diverse resources in computer-based imaging, visualization and simulation. Research includes medical imaging and analysis, modeling of human physiology, and development of virtual medicine tools and software.

Facilities
Medical Imaging Diagnostics and Analysis (MIDA) Laboratory, Virginia Modeling Analysis and Simulation Center, Cardiac Electrophysiology Laboratory, Advanced Signal Processing in Engineering and Neuroscience (ASPEN) Laboratory.

Biomedical Instrumentation

Utilizes ODU’s significant resources in engineering design and fabrication to develop new technologies for research and clinical applications. Includes development of biosensors, fiber optic-based devices, stimulation and ablation technologies and surgical instrumentation.

Facilities
Micro-Nano Fabrication Laboratory, Photonics Laboratory, and Rapid Prototyping Laboratories.

The program also has strong ties to several other on- and off-campus laboratories including the Laser and Plasma Engineering Institute, Center for Advanced Engineering Environments, Computational Intelligence and Machine Vision Laboratory, and Applied Research Center at the Jefferson National Laboratory. These unique resources position the biomedical engineering program to be a leader in education and research in the Southeast and nationally.

List of Degrees and Certificates

• Master of Engineering – Biomedical Engineering
• Master of Science, Engineering – Biomedical Engineering
• Doctor of Philosophy, Engineering – Biomedical Engineering
• Advanced Engineering Certificate – Biomedical Engineering

Master of Engineering - Biomedical Engineering

Master of Engineering Admission Requirements

Admission to the Master of Engineering program in biomedical engineering is in accordance with Old Dominion University and Frank Batten College of Engineering and Technology requirements for master’s programs as specified in this catalog. Specific additional requirements include the following:

1. Completion of a bachelor’s degree in Engineering, Science or Mathematics from an accredited institution, although students from other educational backgrounds may apply with appropriate leveling courses.
2. A minimum GPA of 3.00 (out of 4.0) is required of most students. A student with a lower GPA meeting ODU’s graduate admission requirements and with evidence of a high level of professional capability may be eligible for admission to the program upon submission of a petition to the graduate program director.
3. Recent scores, typically, not more than five years old, on the Graduate Record Examination’s (GRE) verbal, quantitative, and analytical writing sections must be submitted by all applicants.
4. Two letters of recommendation (typically from faculty in the highest degree program completed when the application is within five years of graduation from that degree program) are required.
5. The applicant must submit a resume and a statement of purpose and goals.
6. Foundation knowledge in physics, basic chemistry, computer programming, and mathematics is expected.

Master of Engineering Degree Requirements

The Master of Engineering program requires completion of 10 three-credit courses: two BME fundamentals courses, a graduate physiology course, and seven technical electives. The seven technical electives should be chosen to meet the student’s career objectives.

BME 501 Biomedical Engineering I: Principles
BME 502 Biomedical Engineering II: Applications
BIOL 590 Advanced Human Physiology
BIOL 700 Cardiovascular Physiology
BIOL 724 Neuromuscular Physiology

BME Technical Electives (choose four)

BME 505 Biomechanics
BME 508 Microfluidics
BME 510 Biomedical Instrumentation
BME 554 Introduction to Bioelectrics
BME 630 Advanced Bioelectrics
BME 720 Modern Biomedical Instrumentation
BME 721 Quantitative Analysis of Human Physiological Systems
The Master of Science program requires completion of 8 three-credit courses as specified in this catalog. Specific additional requirements include the following:

1. Completion of a bachelor’s degree in Engineering, Science or Mathematics from an accredited institution, although students from other educational backgrounds may apply with appropriate leveling courses.
2. A minimum GPA of 3.00 (out of 4.0) is required of most students. A student with a lower GPA meeting ODU's graduate admission requirements and with evidence of high level of professional capability may be eligible for admission to the program upon submission of a petition to the graduate program director.
3. Recent scores, typically, not more than five years old, on the Graduate Record Examination’s (GRE) verbal, quantitative, and analytical writing sections must be submitted by all applicants.
4. Two letters of recommendation (typically from faculty in the highest degree program completed when the application is within five years of graduation from that degree program) are required.
5. The applicant must submit a resume and a statement of purpose and goals.
6. Foundation knowledge in physics, basic chemistry, computer programming, and mathematics is expected.

**Master of Science Degree Requirements**

The Master of Science program requires completion of 8 three-credit courses and 6 thesis research credits. The five technical electives should be chosen to meet the student’s research and career objectives.

<table>
<thead>
<tr>
<th>Approved Technical Electives **</th>
<th>9</th>
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<tbody>
<tr>
<td>Total Hours</td>
<td>30</td>
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</table>

* Students who have completed BME 401 or BME 402 as part of a previous degree, program, or minor may substitute these courses with graduate-level BME electives approved by the graduate program director.
** The technical elective courses can be selected from the biomedical engineering technical electives or a wide variety of appropriate graduate courses in engineering, biology, chemistry, psychology, computer science, modeling and simulation, mathematics, statistics, or other programs. Technical electives without the BME prefix must be approved by the graduate program director.

**Doctor of Philosophy, Engineering - Biomedical Engineering**

**Doctor of Philosophy Admission Requirements**

Admission to the Ph.D. program in biomedical engineering is in accordance with Old Dominion University and Frank Batten College of Engineering and Technology requirements for doctoral programs as specified in this catalog. Specific additional requirements include the following:

1. Completion of a master’s degree in a closely related field is expected. However, students who have completed 24 credits of graduate courses in an appropriate field from an accredited institution or have demonstrated an exceptionally high level of academic capability may petition for direct admittance into the program.
2. A minimum GPA of 3.50 (out of 4.0) is required of most students. A student with a lower GPA meeting ODU's graduate admission requirements and with evidence of high level of professional capability may be eligible for admission to the program upon submission of a petition to the graduate program director.
3. Recent scores, typically, not more than five years old, on the Graduate Record Examination’s (GRE) verbal, quantitative, and analytical writing sections must be submitted by all applicants.
4. Three letters of recommendation (typically at least two of which are from faculty in the highest degree program completed when the application is within five years of graduation from that degree program) are required.
5. The applicant must submit a resume and a statement of purpose and goals.
6. Foundation knowledge in physics, basic chemistry, computer programming, and mathematics is expected.

**Doctor of Philosophy Degree Requirements**

The Ph.D. in biomedical engineering is offered in accordance with the general requirements for doctoral degrees as specified in the Requirements for Graduate Degree Section of this catalog. Specific program of study requirements include the following:

1. Completion of a minimum of 48 hours of graduate credits to include: a minimum of 24 credits of course work beyond the master’s degree and a minimum of 24 credits of dissertation research. At least 15 credits of non-dissertation course work must be at the 800-level.
2. Successful completion of a written diagnostic examination before the end of the first academic year.
3. Successful completion of a written and oral qualifying examination near the completion of the coursework.
4. Successful presentation of a dissertation research proposal at the beginning of the dissertation research.
5. The successful completion and public defense of a dissertation representing independent, original research worthy of publication in a peer-reviewed scholarly journal.

The program of study will be developed with the approval of the graduate program director and the student's advisor. The program shall include a common core of 12 credits and 12 credits of technical electives.

### Common Core *

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BME 820</td>
<td>Modern Biomedical Instrumentation</td>
<td>2</td>
</tr>
<tr>
<td>BME 821</td>
<td>Quantitative Analysis of Human Physiological Systems I</td>
<td>3</td>
</tr>
<tr>
<td>BME 822</td>
<td>Quantitative Analysis of Human Physiological Systems II</td>
<td>3</td>
</tr>
<tr>
<td>BME 851</td>
<td>Biostatistics: Fundamentals and Applications</td>
<td>3</td>
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</table>

### Technical Electives **

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BME 501</td>
<td>Biomedical Engineering I: Principles</td>
<td>3</td>
</tr>
<tr>
<td>BME 502</td>
<td>Biomedical Engineering II: Applications</td>
<td>3</td>
</tr>
<tr>
<td>BME 505</td>
<td>Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>BME 508</td>
<td>Microfluidics</td>
<td>3</td>
</tr>
<tr>
<td>BME 510</td>
<td>Biomedical Instrumentation</td>
<td>3</td>
</tr>
<tr>
<td>BME 554</td>
<td>Introduction to Bioelectricity</td>
<td>3</td>
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<tr>
<td>BME 630</td>
<td>Advanced Bioelectricity</td>
<td>3</td>
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<tr>
<td>BME 824</td>
<td>Neural Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BME 895</td>
<td>Special Topics in Biomedical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ECE 562</td>
<td>Introduction to Medical Image Analysis (MIA)</td>
<td>3</td>
</tr>
<tr>
<td>ECE 564</td>
<td>Biomedical Applications of Low Temperature Plasmas</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total Hours** 24

* Students who have completed any of the core courses at the 700-level as part of a previous degree or program may substitute these courses with 800-level BME electives approved by the graduate program director.

** The technical elective courses provide a basis for dissertation research and future career objectives. These courses can be selected from the biomedical engineering technical electives or a wide variety of appropriate graduate courses in engineering, biology, chemistry, psychology, computer science, modeling and simulation, mathematics, statistics, or other programs. No more than six credits from course work satisfying foundation knowledge requirements may be included in the program of study for elective credit. At least 15 credits of non-dissertation course work must be at the 800-level. A minimum of 3 credits must be selected from the biomedical engineering technical electives list; the remaining credits can be selected from this list or other graduate courses with approval of the student's advisor and the graduate program director.

### Advanced Engineering Certificate - Biomedical Engineering

The Graduate Certificate in Biomedical Engineering Program offers students and professionals the opportunity to further their knowledge with advanced study in the growing area of Biomedical Engineering. The program is designed to provide well-rounded instruction in several key facets of Biomedical Engineering. Those who complete the Program receive the Advanced Engineering Certificate in Biomedical Engineering from Old Dominion University and a letter of recognition from the Batten College of Engineering and Technology. Courses taken for the certificate program may later be applied to the M.E. or Ph.D. degree in Biomedical Engineering. For complete information on the admission and certificate requirements, please refer to the Batten College of Engineering and Technology's section on graduate certificate programs at: /graduate/frankbattencollegeofengineeringandtechnology/#interdisciplinarygraduatecertificateprograms. (http://catalog.odu.edu/graduate/frankbattencollegeofengineeringandtechnology/#interdisciplinarygraduatecertificateprograms)