RESOLUTION TO APPROVE BACHELOR OF SCIENCE DEGREE IN BIOMEDICAL ENGINEERING

Documents included:
1. Resolution to Establish Bachelor of Science Degree in Biomedical Engineering
2. Supporting Documentation- Bachelor of Science Degree in Biomedical Engineering
3. Presentation – slides
RESOLUTION TO ESTABLISH A BACHELOR OF SCIENCE DEGREE IN
BIOMEDICAL ENGINEERING

WHEREAS, biomedical engineering is a rapidly emerging field that draws on engineering principles to provide training to undergraduate students so that they may tackle emerging societal issues related to engineering aspects of the growing field of health care; and

WHEREAS, graduates with a degree in biomedical engineering will analyze and design solutions to problems in biology and medicine with the goal of improving the quality of patient care through jobs at universities, hospitals, manufacturers, government agencies, and research facilities; and

WHEREAS, Virginia Tech is uniquely suited for such a degree program due to its established partnerships unavailable to other universities in Virginia or in the United States, including ties with prestigious groups such as the Edward Via College of Osteopathic Medicine, Virginia-Maryland College of Veterinary Medicine, Virginia Tech Transportation Institute, Institute for Critical Technology and Applied Science, Virginia Tech Carilion School of Medicine, Virginia Tech Carilion Research Institute and the Wake Forest School of Medicine; and

WHEREAS, the addition of a degree in biomedical engineering aligns with President Sands' goal that the university should strive to increase Virginia Tech’s US rankings, become a top-100 global research university and continue to attract high-quality students with world-leading interdisciplinary programs and research opportunities. The College of Engineering is the only program in the top 50 across the U.S. without a biomedical engineering undergraduate program; and

WHEREAS, the biomedical engineering degree meets goals set in the Virginia Tech 2012-2018 Strategic Plan that proposes major growth in the fields of "science, technology, engineering, mathematics, and health sciences (STEM-H)". This degree will help Virginia Tech grow as a high-ranking institution and make its graduating students and alumni highly attractive to employers in the Commonwealth and beyond;

THEREFORE, BE IT RESOLVED, that the Bachelor of Science Degree in Biomedical Engineering be established, effective Fall 2017.

RECOMMENDATION:

That the above resolution recommending the establishment of the Bachelor of Science Degree in Biomedical Engineering be approved.

April 3, 2017
Virginia Tech Degree Proposal  
Biomedical Engineering Bachelor of Science Degree 
CIP: 14.0501  

Type of degree action (circle one):  New  Spinoff  Revision  Discontinuance  

Program Description  

Virginia Polytechnic Institute and State University requests approval for the following degree: Bachelor of Science (B.S.) in Biomedical Engineering (BME). This degree will be offered by the Department of Biomedical Engineering and Mechanics (BEAM) in the College of Engineering (COE) at Virginia Tech and implemented in the fall of 2017. The purpose of this BME degree is to provide state-of-the-art academic training to undergraduate students so that they may tackle emerging societal issues related to engineering aspects of the growing field of health care. The new Bachelor of Science in Biomedical Engineering degree addresses anticipation of the US Department of Labor Statistics\(^1\) for a 27% job growth from 2012-2022. This is more than double the 11% outlook for all occupations. Ten year data from the American Society of Engineering Education\(^2\) (2002-2011) showed that even though the discipline is newer as compared to other engineering areas, the large interest in BME has allowed it to maintain a sizable growth rate in comparison to the other engineering fields in both undergraduate and graduate programs. Finally, biomedical engineering programs represent the largest growth in new engineering programs accredited by the Accreditation Board for Engineering and Technology (ABET)\(^3\) in recent years. The BME program will provide a new and exciting degree opportunity for undergraduates. Graduates from this degree program will have the critical thinking skills and laboratory competencies necessary to become leaders capable of addressing career opportunities that include, but are not limited to:  

**Design of Medical Devices:** As the aging baby-boom generation lives longer and stays active, there is a pressing need to design systems and products that interact with and replace body parts. Novel technologies are needed to diagnose and treat medical problems more accurately than at present.  

**Optimize and Train on Biomedical Equipment:** Providing technical assistance and training to clinicians as to the safety, efficiency, effectiveness and proper use of biomedical equipment will be a significant commitment as the health care industry expands with the aging population.  

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Pharmaceutical and Medicine Manufacturing: The demand for personalized health care will require advancement in medical therapeutics such as nanomedicine and drug delivery systems capable of targeting specific diseases.

Translational Scientific Research: Rapid advancement in technology will continue to create opportunities for biomedical engineers. Further translational research is needed to understand the engineering aspects of biological systems of humans and animals in order to advance prevention of injury and disease.

As evidenced by these select examples, the importance of training in biomedical engineering is reflected directly by a worldwide increase of health care needs. With the goal of designing solutions to problems in biology and medicine, biomedical engineers will have the opportunity to improve the quality and effectiveness of patient care. Due to the multidisciplinary nature of the biomedical engineering community, graduates with a degree in biomedical engineering are recruited into a broad range of health, industrial and educational activities. Individuals with a Bachelor of Science degree in Biomedical Engineering will be prepared to enter the job markets associated with these issues. Moreover, graduates with a Bachelor of Science degree in Biomedical Engineering will be prepared and competitive for entry into professional and graduate schools.

Based on these motivating factors and the department’s unique capabilities, this program strives to develop Biomedical Engineering and Mechanics (BEAM) as a national leader in biomedical engineering undergraduate education. This will be accomplished by the following three objectives:

- **Educate and train the future biomedical engineers** for a complex, diverse and global workplace. The department will provide a high quality, relevant educational program using the latest technology and educational techniques.
- **Expose students and allow opportunities for students to conduct state-of-the-art research** that embraces societal challenges.
- **Capitalize on the department’s biomedical partnerships** with: Virginia Tech Carilion and Virginia Tech Carilion Research Institute, Institute for Critical Technology and Sciences, Virginia-Maryland College of Veterinary Medicine, Biocomplexity Institute of Virginia Tech, Virginia Tech Transportation Institute, and Edward Via College of Osteopathic Medicine.

**Curriculum Summary**

A total of 122 credit hours will be required for the Biomedical Engineering degree. The Biomedical Engineering curriculum will include all requirements for the curriculum for General Engineering (29 credits) which include: Foundations of Engineering I and II (4), First-Year Writing I and II (6), Calculus of a single Variable I and II (8), General Chemistry and Lab (4), Foundations of Physics I with lab (first portion) (4), and 6 additional credits of Curriculum for Liberal Education (CLE)\(^4\) courses in areas 2, 3, 4 or in the Pathways Curriculum if that is adopted by the time of the major’s estimated start date.

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Additional entry-level math and engineering courses will be required (21 credits). These should include Multivariable Calculus (3), Statics (3), Dynamics (3), Introduction to Differential Equations (3), Mechanics of Deformable Bodies (3), Introduction to Linear Algebra (3), and Statistics (3).

Additional entry-level science courses will also be required (19 credits). These should include Introduction to Biomedical Engineering (3), Foundation of Physics I with Lab (2nd portion) (4), Principles of Biology (3), Electrical Theory (3), Elements of Materials Engineering (3), and a programming course (3).

Collectively the 1000 and 2000-level courses will provide the necessary background that students will need in order to be successful their junior and senior year with the 3000 and higher courses. After successful completion of these courses with a grade of C- or higher, students should have a broad appreciation and understanding for the biomedical engineering field as well as the foundation for the Biomedical Engineering courses. The required coursework is designed to give students advanced critical thinking skills and exposure and practice related to research problems, laboratory and writing skills, and professional development.

In their junior and senior years, students will be required to take upper level BME classes (16 credits) which include BME Cellular Lab and Design (2); Fluid Mechanics I (3); Introduction to Medical Physiology (3); Bioinstrumentation and Design for Living Systems (2); Problem Solving in Biomedical Engineering (3); and Global Societal and Ethics in Biomedical Engineering (3). Additionally, they will be required to take 21 credits of special technical electives in the field and 10 credits in the Curriculum for Liberal Education (CLE) requirements (areas 2, 3, 6, and 7). Note: The proposed Pathways Requirements will replace the Curriculum for Liberal Education should it be adopted by the start of this proposed degree. Finally, students must complete 6 capstone senior design project credits in order to be awarded the Biomedical Engineering Degree.

The degree core for the Bachelor of Science in Biomedical Engineering (22 credits) will include Introduction to Biomedical Engineering (3); BME Cellular Lab and Design (2); Introduction to Medical Physiology (3); Bioinstrumentation Laboratory & Design (2); Problem Solving in BME (3); 6 credits of BME Senior Design and Project (6); and Global, Societal and Ethics in BME (3).

Working with their academic advisors, students will be able to customize their degree program to focus on sub-discipline areas within the broader field of biomedical engineering and prepare them for specific career objectives as well as graduate school. A capstone project in senior year along with the previous coursework will prepare students for networking with companies and provide a unique skillset and practice to enhance marketability after graduation. All of these requirements build upon the current BME minor which requires 6 credits of BME introductory course work, 6 credits of BME electives and 6 credits of BME research in addition to the College of Engineering and Virginia Tech course prerequisites. (See Appendix A)

Relevance to University Mission and Strategic Planning
The Virginia Tech Mission Statement⁵ states, "Virginia Tech is a public land-grant university serving the Commonwealth of Virginia, the nation, and the world community. The discovery and dissemination of new knowledge are central to its mission. Through its focus on teaching and learning, research and discovery, and outreach and engagement, the university creates, conveys, and applies knowledge to expand personal growth and opportunity, advance social and community development, foster economic competitiveness, and improve the quality of life." The proposed B.S. in Biomedical Engineering degree supports the instructional mission of the Department of Biomedical Engineering and Mechanics by creating a signature educational experience at Virginia Tech.

The Virginia Tech 2012-2018 Strategic Plan⁶ proposes major growth in the fields of "science, technology, engineering, mathematics, and health sciences (STEM-H)". Three principle strategies for improving undergraduate education are "Increase ... experiential learning opportunities by adopting a hands-on, minds-on philosophy that promotes connecting real-life experience with academic concepts, ... develop ways to integrate computational science / informatics and digital fluency for managing and analyzing complex data sets," and "Increase the quality and availability of academic advising for all students from orientation through graduation." A Bachelor of Science in Biomedical Engineering degree will provide students with the necessary tools to help Virginia Tech grow as a high-ranking institution and make its graduating students and alumni highly attractive to employers in the Commonwealth and beyond.

President Sands noted⁷ that the university should strive to increase Virginia Tech’s US rankings, become a top-100 global research university and continue to attract high-quality students with world-leading interdisciplinary programs and research opportunities. A new Biomedical Engineering degree can help achieve these goals. A Biomedical Engineering degree would allow students to pursue a superior education that focuses on multidisciplinary research and global discovery. Analyses of research and economic projections clearly indicate that Biomedical Engineering is a leading growth area world-wide. In addition, implementing a degree in Biomedical Engineering will help recruit, educate, and graduate a talented and diverse undergraduate student body, which is a university priority. The Department of Biomedical Engineering and Mechanics expects that students graduating from Virginia Tech with a Biomedical Engineering degree will serve as key members of research, development, and manufacturing teams and translate ideas that grow from basic biomedical and clinical sciences into systems, devices, and techniques that can be patented, produced, and marketed to improve health care outcomes.

Justification for the Proposed Program

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Biomedical engineering has become one of the fastest growing fields of engineering worldwide. The Bureau of Labor Statistics states that employment of biomedical engineers is expected to grow by 62% from 2010 to 2020, much quicker than the average for all engineering professions. At Virginia Tech, many undergraduate students are interested in BME, as evidenced by the number of students who are enrolled in the BME Minor Program (170 students as of January 2016). Currently, VT undergraduates who are interested in BME are advised to pursue a major in chemical, biological systems, or mechanical engineering, taking technical electives in the BME area. However, a dedicated undergraduate program will allow this opportunity to be marketed to bring additional opportunities within the College of Engineering.

Although gender diversity is poor in engineering as a whole, the BME discipline has historically been attractive to women. The fraction are those receiving BS degrees in BME who are women is approximately 40%. BME is a challenging program - integrating engineering and the biomedical sciences. Admission to the Virginia Tech BME program will be competitive. It is anticipated that such a program will attract many outstanding students, yet, the addition of a new undergraduate program in Biomedical Engineering at VT needs to be developed and implemented so that students within the program receive the same outstanding education as their fellow COE peers.

Virginia Tech is in a premier position to offer this new degree. A recent survey by Gallup indicated that “Virginia Tech alumni are more likely than the national college graduate comparison group as well as graduates in peer institution and research university cohorts to be thriving in every element of well-being.” Gallup defines the five elements as purpose, social, financial, community, and physical well-being. An undergraduate degree in Biomedical Engineering will help the Department’s future alumni achieve well-being in these five domains, increase Virginia Tech’s prestige, and invite more alumni donations as the Department’s students graduate with the ability to gain BME-related jobs.

Since the Department of Biomedical Engineering merged with the Department of Engineering Science and Mechanics, the new Department of Biomedical Engineering and Mechanics (BEAM) has seen tremendous growth both inside and outside of the department. This Department has unique partnerships unavailable to other universities in Virginia or in the United States, including ties with prestigious groups such as the Edward Via College of Osteopathic Medicine, Virginia-Maryland College of Veterinary Medicine, Virginia Tech Transportation Institute (VT TI), Institute for Critical Technology and Applied Science (ICTAS), Virginia Tech Carilion School of Medicine (VTCSOM), and Virginia Tech Carilion Research Institute (VTCRI). The existing Biomedical Engineering graduate degree program and Biomedical Engineering undergraduate minor have already benefited from these unique partnerships and it is expected that a new undergraduate BME degree program will likewise benefit.

Students in this program will have access to world renowned researchers in specialized fields of biomechanics, tissue engineering, neuroengineering, biomedical imaging, translational cancer research, cardiovascular engineering, nanomedicine, and nanobiotechnology. The department’s teaching and research expertise position it for a smooth transition from the BME minor to the B.S. in BME. Some of Virginia Tech’s most prestigious faculty are affiliated with the Department of Biomedical Engineering and Mechanics including the Dean and University Center Directors.

Both faculty and student interest has steadily increased within the existing minor and graduate degree programs. By creating an undergraduate Biomedical Engineering degree, students will have the opportunity to study biomedical engineering fields intensively as well as double-major in BME and a wide variety of related degree programs such as Physics and other Engineering disciplines. This program will also prepare undergraduate students who want to pursue a graduate education in biomedical engineering, medicine, or other areas of science and engineering. As one of the top institutions in the United States, Virginia Tech’s hands-on, engaged approach to education and preparation of scholars to be leaders in their fields and communities is an excellent foundation for a B.S. in Biomedical Engineering, a field that reflects the Virginia Tech motto Ut Prosim (That I May Serve).

**Student Demand**

There is tremendous student interest in the field of biomedical engineering at Virginia Tech. Because of expressed interest, a Biomedical Engineering minor was created in 2012. Enrollment in the minor has grown steadily and currently has 170 students enrolled. The student interest in biomedical engineering at Virginia Tech reflects the national trend showing strong interest among undergraduate students in biomedical engineering. As shown in Figure 1, data from the American Society for Engineering Education (ASEE)\(^\text{10}\), reveal that biomedical engineering is the 8\(^{th}\) top major for undergraduate students in engineering colleges.

**Figure 1. Undergraduate Enrollment by Discipline (2012-2013)**\(^\text{10}\)

Figure 2. Percentage of Bachelor’s Degrees Awarded to Women by Discipline (2012-2013)\textsuperscript{10}

Although gender diversity is poor in engineering as a whole, the field of biomedical engineering has historically attracted more women than other engineering specialties. Approximately 40% of those receiving a B.S. degree in Biomedical Engineering are women, as shown in Figure 2. Therefore, adding this degree can help attract and recruit women, contributing to increasing the gender diversity of undergraduate engineering students at Virginia Tech.

In 2012, Forbes\textsuperscript{11} ranked Biomedical Engineering as the number one major that was worth student’s tuition, time, and effort: “These aren’t majors that anyone could do. They’re hard, …there is high demand for them and a low supply of people with the skills, so it drives up the labor market price.” Spontaneous inquiries and expressions of interest from potential students has been another indicator of student interest. The department has archived the numerous emails from potential students interested in pursuing a B.S. in Biomedical Engineering. Many of these students are high school juniors and seniors who are considering enrollment at Virginia Tech. These students voice disappointment when they hear that Virginia Tech does not offer a B.S. in Biomedical Engineering. Virginia Tech is potentially losing bright and talented students to other universities in the country due to a lack of availability of a B.S. in Biomedical Engineering. This potential loss also affects the Biomedical Engineering graduate program when the department has to spend extra funds on recruitment efforts to bring these highly sought-after students at other universities to Virginia Tech, as well as our graduates that wish to pursue a higher degree.

Market/Employer Demand

Analyses of every research and economic projection clearly indicate that the Biomedical Engineering field is a leading growth area. The following reports from news and journals show the critical motivating factors that justify the development of this undergraduate biomedical education program at Virginia Tech.

National Demand: The US News and World Report\textsuperscript{12} reported that according to the U.S. Department of Labor, “employment of biomedical engineering is expected to grow by 62 percent between 2010 and 2020”. Additionally, the Bureau of Labor Statistics states: “Employment of Biomedical Engineers is projected to grow 27 percent from 2012 to 2022, much faster than the average for all occupations”. Other news sites such as Boston.com\textsuperscript{13} go on to say that “The aging of the population and a growing focus on health issues will drive demand for better medical devices and equipment designed by biomedical engineers.” Biomedical Engineering undergraduates often go on to pursue industry (1/3), medical school (1/3), or graduate school in engineering or law (1/3). As a degree, Biomedical Engineering is quickly becoming one of the most valuable majors with places like Forbes listing Biomedical Engineering as the No. 1 most valuable college major in America.\textsuperscript{14}

Major news outlets and the Department of Labor are not the only ones noticing the growing trend in Biomedical Engineering. Several research journals have also published findings that support a future need for growth in Biomedical Engineering programs. The Annals of Biomedical Engineering\textsuperscript{15} found that:

“Financial opportunities, expansion of research applications for engineering methods and techniques to biomedical problems, and the associated eruption of the quantity and quality of quantitative life science investigations have driven the growth of academic BME programs. So, too, has intense student interest...Since 2010, 17 additional BME programs have been accredited ... with 92 accredited programs already, one can guess that over the next 25 years, the total number of ABET accredited undergraduate programs in the US may rise to a total of 150-175”

Another article that was published in Nature, spoke of the increased commercial interest of Biomedical Engineers. They noted that students are finding themselves with multiple job offers after graduation and that “Job prospects are bright in biomedical engineering (BME), which combines engineering design skills with biological expertise, and students are flocking to enter the field”.


They go on to mention that because "biomedical engineering is made up of two fields that will never go away, and are constantly changing, and are in demand" biomedical engineers have key marketable qualities that companies such as medical-device manufacturers, pharmaceuticals, and the drug industry are "beginning to see the value of biomedical engineers...because they can move bioinformatics and computational biology forwards." Additionally, an article published in the Journal of the American Medical Association (JAMA) stated: "At each juncture along the continuum from basic biomedical research to clinical research to improved health, it is imperative that our national clinical research expertise have adequate resources and infrastructure". They went on to say that it is recommended that specific stakeholders "recognize biomedical informatics as a scientific discipline by creating educational programs and tenure track opportunities for researchers".

Local Demand: On March 1, 2016, we issued a survey which polled all undergraduate College of Engineering (COE) students at Virginia Tech who are enrolled in the Biomedical Engineering Minor Program (total 171). The poll asks only 5 questions.

1. Gender
2. Ethnicity
3. Current Major
4. Expected graduation date
5. If BME was available as an undergraduate degree at VT, would you have pursued it?

Results were collected from 113 of the 171 students. There was a 47/53% of responses from males vs. female students, respectively. The results in Table 1 depict a strong interest in pursuing a BME BS at VT.

Table 1. Survey Questions #5: If BME was available as an undergraduate degree at VT, would you have pursued it? Results indicated significant interest in BME at VT.

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>91</td>
<td>81%</td>
</tr>
<tr>
<td>2</td>
<td>Maybe</td>
<td>17</td>
<td>15%</td>
</tr>
<tr>
<td>3</td>
<td>No</td>
<td>5</td>
<td>4%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>113</td>
<td>100%</td>
</tr>
</tbody>
</table>

Without a Biomedical Engineering program, it is very likely that we will lose top quality students to other schools as they look for Biomedical Engineering programs. Historically, high school students and their parents have routinely asked about an undergraduate Biomedical Engineering programs and opportunities and have been disappointed to find out that only a graduate program and minor currently exists. In addition, Schools.com projects the career outlook for biomedical engineers in Virginia at 95.9%.

Additional Critical Motivational Factors:

- Increasing engineering diversity at Virginia Tech by recruiting at the undergraduate, graduate, and faculty levels: Approximately 40% of Biomedical Engineering students are female.
- Capitalizing on unprecedented biomedical growth at Virginia Tech through a range of new programs, institutes and partners will help create new jobs and technology.
- Virginia Tech COE is the only program in the top 50 across the U.S. without an undergraduate program in Biomedical Engineering. Adding a degree in Biomedical Engineering will also increase the university’s rankings nationally.
- Increasing Biomedical Engineering faculty will increase research expenditures.
- Increasing philanthropic donations from individuals and companies with Biomedical Engineering interests and desires for better health.

Employment Demand

Biomedical Engineering has become one of the fastest growing fields of engineering worldwide. Biomedical engineers analyze and design solutions to problems in biology and medicine with the goal of improving the quality and effectiveness of patient care through jobs in universities, hospitals, manufactures, government agencies, and research facilities. A bachelor’s degree in engineering is required for almost all entry-level engineering jobs. The Bureau of Labor Statistics 19,20 (BLS) states that employment of biomedical engineers is expected to grow by 62% from 2010 to 2020 with about 5,200 new jobs over the next 10 years, much quicker than the average for all professions. It is projected that the demand will only increase as an aging population is likely to need more medical care which there will be a need from increased biomedical engineering advances. In 2012, BLS estimated 19,400 jobs in biomedical engineering for job seekers with a bachelor’s degree. Job seekers with biomedical engineering bachelor degrees were reporting from $41.81 per hour to a median of $86,960+ per year at entry-level positions (Tables 2 and 3).

<table>
<thead>
<tr>
<th>Job Title</th>
<th>SOC Code</th>
<th>Employment 2012</th>
<th>Projected Employment 2022</th>
<th>Percentage Change</th>
<th>Median Annual Wages 2012</th>
<th>Typical Entry-Level Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomedical Engineers</td>
<td>17-2031</td>
<td>19,400</td>
<td>24,600</td>
<td>26.6%</td>
<td>$86,960</td>
<td>Bachelor’s Degree</td>
</tr>
<tr>
<td>Biomechanical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biochemical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomedical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dialysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genetic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Job Growth Projections (2012-2022) for Biomedical Related Occupations

Table 3: Job Growth Projections (2010-2020) For Biomedical-Related Occupations
(Virginia Employment Commission)

<table>
<thead>
<tr>
<th>Job Title</th>
<th>SOC Code</th>
<th>Employment 2010</th>
<th>Projected Employment 2020</th>
<th>Total Percentage Change</th>
<th>Annual Percentage Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomedical Engineer</td>
<td>17-2031</td>
<td>462</td>
<td>905</td>
<td>95.9%</td>
<td>7%</td>
</tr>
</tbody>
</table>
Resource Needs / Savings

The newly created BME program will launch with a fixed class size of 40 students per year. Based on the current faculty to student class ratio of 8:1, we anticipate to hire 2 new faculty members and 2 new instructors to help cover the required courses. The BME degree student class size may change based on a yearly evaluation of student demand and departmental resources. The BEAM department future resources will be subject to the new budgeting models being developed by the University.

<table>
<thead>
<tr>
<th>RESOURCE</th>
<th>ESTIMATED COSTS (use NA if not applicable)</th>
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</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>$429,600 (salary and benefits for 2 faculty and 2 instructors)</td>
</tr>
<tr>
<td>Administrative Staff</td>
<td>NA</td>
</tr>
<tr>
<td>Graduate Teaching/</td>
<td>NA</td>
</tr>
<tr>
<td>Graduate Research Assistants</td>
<td>NA</td>
</tr>
<tr>
<td>Space</td>
<td>Shared use of general assigned space</td>
</tr>
<tr>
<td>Library</td>
<td>NA</td>
</tr>
<tr>
<td>Equipment</td>
<td>$700,000 (part of startup)</td>
</tr>
<tr>
<td>Other</td>
<td>NA</td>
</tr>
</tbody>
</table>

# Appendix A: Sample Plans of Study

**COLLEGE OF ENGINEERING - DEPARTMENT OF BIOMEDICAL ENGINEERING AND MECHANICS**

**BACHELOR OF SCIENCE IN BIOMEDICAL ENGINEERING**

**FOR STUDENTS GRADUATING IN CALENDAR YEAR 2020**

122 CREDITS REQUIRED FOR GRADUATION

<table>
<thead>
<tr>
<th>FALL SEMESTER FRESHMAN 2016</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CHEM 1035 General Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>Co: MATH 1025 or MATH 1225</td>
<td></td>
</tr>
<tr>
<td>CHEM 1045 General Chemistry Lab</td>
<td>1</td>
</tr>
<tr>
<td>Co: CHEM 1035</td>
<td></td>
</tr>
<tr>
<td>ENGL 1105 First-Year Writing</td>
<td>3</td>
</tr>
<tr>
<td>MATH 1225 Calculus of a Single Variable</td>
<td>4</td>
</tr>
<tr>
<td>Pre: MATH 1225</td>
<td></td>
</tr>
<tr>
<td>ENGE 1215 Foundations of Engineering (C-)</td>
<td>2</td>
</tr>
<tr>
<td>Co: MATH 1225</td>
<td></td>
</tr>
<tr>
<td>CLE (Areas 2, 3, or 7)</td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>SPRING SEMESTER FRESHMAN 2017</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ENGL 1106 First-Year Writing</td>
<td>3</td>
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<tr>
<td>Pre: ENGL 1105</td>
<td></td>
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<tr>
<td>MATH 1226 Calculus of a Single Variable</td>
<td>4</td>
</tr>
<tr>
<td>Pre: MATH 1225</td>
<td></td>
</tr>
<tr>
<td>MATH 2114 Introduction to Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Pre: MATH 1225 (minimum grade of B) or MATH 1226</td>
<td></td>
</tr>
<tr>
<td>PHYS 2305 Foundations of Physic I</td>
<td>4</td>
</tr>
<tr>
<td>Pre: (MATH 1205 or MATH 1205H or MATH 1225) or (MATH 1206 or MATH 1206H or MATH 1226)</td>
<td></td>
</tr>
<tr>
<td>ENGE 1216 Foundations of Engineering (C-)</td>
<td>2</td>
</tr>
<tr>
<td>Pre: ENGE 1215</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>16</strong></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>FALL SEMESTER SOPHOMORE 2017</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BIOL 1105 Principles of Biology</td>
<td>3</td>
</tr>
<tr>
<td>Co: BIOL 1115</td>
<td></td>
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<tr>
<td>MATH 2204 Introduction to Multivariable Calculus</td>
<td>3</td>
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<tr>
<td>Pre: MATH 1226</td>
<td></td>
</tr>
<tr>
<td>MATH 2214 Introduction to Differential Equations</td>
<td>3</td>
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<tr>
<td>Pre: MATH 1114 or 2114, MATH 1226</td>
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<tr>
<td>ESM 2104 Statics</td>
<td>3</td>
</tr>
<tr>
<td>Co: MATH 2224 or MATH 2224H or MATH 2204 or MATH 2204H</td>
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</tr>
<tr>
<td>PHYS 2306 Foundations of Physics I with lab</td>
<td>4</td>
</tr>
<tr>
<td>Pre: MATH 1226, PHYS 2305</td>
<td></td>
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<tr>
<th>SPRING SEMESTER SOPHOMORE 2018</th>
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<tbody>
<tr>
<td>BMES 2104 Introduction to Biomedical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>Pre: ENGE 1216, PHYS 2305, Co: MATH 2214</td>
<td></td>
</tr>
<tr>
<td>ESM 2204 Mechanics of Deformable Bodies</td>
<td>3</td>
</tr>
<tr>
<td>Pre: ESM 2104, (MATH 2224 or MATH 2224H or MATH 2204 or MATH 2204H)</td>
<td></td>
</tr>
<tr>
<td>ESM 2304 Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>Pre: ESM 2104, (MATH 2224 or MATH 2224H or MATH 2204 or MATH 2204H), Co: MATH 2214</td>
<td></td>
</tr>
<tr>
<td>MSE 2034 Elements of Materials Engineering</td>
<td>3</td>
</tr>
<tr>
<td>Pre: CHEM 1035, Co: PHYS 2305</td>
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</tr>
<tr>
<td>ECE 3054 Electrical Theory</td>
<td>3</td>
</tr>
<tr>
<td>Pre: PHYS 2306, Co: MATH 2214</td>
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<tr>
<th>FALL SEMESTER JUNIOR 2018</th>
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<tbody>
<tr>
<td>BMES 3024 BME Cellular Lab and Design</td>
<td>2</td>
</tr>
<tr>
<td>Pre: BMES 2104</td>
<td></td>
</tr>
<tr>
<td>ESM 3234 Fluid Mechanics I – Control Volume Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Pre: ESM 2304, PHYS 2306</td>
<td></td>
</tr>
<tr>
<td>BMES/BMVS 4064 Introduction to Medical Physiology</td>
<td>3</td>
</tr>
<tr>
<td>Pre: Junior Standing</td>
<td></td>
</tr>
<tr>
<td>STAT Course</td>
<td>3</td>
</tr>
<tr>
<td>CLE (Areas 2, 3 or 7)</td>
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<th>SPRING SEMESTER JUNIOR 2019</th>
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<tr>
<td>BMES 3034 Biostatistics Laboratory &amp; Design for Living Systems</td>
<td>2</td>
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<tr>
<td>Pre: BMES 2104</td>
<td></td>
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<tr>
<td>BMES 3184 Problem Solving in BME</td>
<td>3</td>
</tr>
<tr>
<td>Pre: BMES 2104</td>
<td></td>
</tr>
<tr>
<td>BMES Technical Elective</td>
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<tr>
<td>Technical Elective</td>
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<tr>
<td>CS Programming Course</td>
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<tr>
<td>BMES 4015 BME Senior Design and Project</td>
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<tr>
<td>Pre: BMES 3184</td>
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<tr>
<td>BMES 4134 Global, Societal and Ethics in BME</td>
<td>3</td>
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<tr>
<td>Pre: BMES 4015</td>
<td></td>
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<tr>
<td>BMES Technical Elective</td>
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<tr>
<td>Technical Elective</td>
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<td>CLE (Area 2, 3 or 7)</td>
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<tr>
<td>CLE (Area 6)</td>
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<th>SPRING SEMESTER SENIOR 2020</th>
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<tbody>
<tr>
<td>BMES 4016 BME Senior Design and Project</td>
<td>3</td>
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<tr>
<td>Pre: BMES 4015</td>
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<tr>
<td>BMES Technical Elective</td>
<td>3</td>
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<tr>
<td>BMES Technical Elective</td>
<td>3</td>
</tr>
<tr>
<td>Technical Elective</td>
<td>3</td>
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<tr>
<td>CLE (Area 2, 3 or 7)</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

---

1 A total of 6 hours of Area 2 and 6 hours of Area 3 courses must be completed. Only selected courses can simultaneously satisfy both Area 2/3 & 7 requirements.

2 STAT course chosen from: STAT 3615, STAT 4604

3 STAT course chosen from: STAT 3615, STAT 4604

4 CS programming course chosen from: CS 1044, CS 1064, or CS 1114

5 BMES Technical Electives may be chosen from those listed on the Approved Technical Electives list on page 4 of checklist

6 Technical Electives may be chosen from those listed on the BMES Electives list on page 3 of checklist

7 Course satisfies BMES degree core requirement

8 BMES students are not required to take BIOL 1115 as a co-requisite to BIOL 1105
### Curriculum for Liberal Education (CLE)

Consult the CLE Alphabetical Listing at: [http://www.cle.prov.vt.edu/guides/alpha.html](http://www.cle.prov.vt.edu/guides/alpha.html). CLE courses need to be completed prior to graduation.

| CLE Area 1: Writing and Discourse (6 hrs) | ENGL 1105 (3) | ENGL 1106 (3) |
| CLE Area 2: Ideas, Cultural Traditions, Values Electives (6 hrs) | (3) | (3) |
| CLE Area 3: Society & Human Behavior electives (6 hrs) | (3) | (3) |
| CLE Area 4: Scientific Reasoning and Discovery (8 hrs) | PHYS 2305 (4) | PHYS 2306 (4) |
| CLE Area 5: Quantitative and Symbolic Reasoning (8 hrs) | MATH 1225 (4) | MATH 1226 (4) |
| CLE Area 6: Creativity & Aesthetic Experience elective (1 hr) | (1) |
| CLE Area 7: Global Issues Elective (3 hrs) | (3) |

If a CLE course is double-counted to satisfy two different CLE areas, a free elective(s) must be taken to maintain a minimum of 122 credits.

1 A total of 6 hours of Area 2 and 6 hours of Area 3 courses must be completed. Only selected courses can simultaneously satisfy both Area 2, 3, and 7 requirements. Use extra care when selecting this course.

### Electives:

**Biomedical Engineering (BMES) Technical Electives (12 credit hours required)**

Any 3-credit BMES 3/4/5000-level course not otherwise used to fulfill a BME requirement can be used as a technical elective. BMES Technical Electives may be chosen from the approved list on page 4 of the checksheet.

**Technical Electives (9 credit hours required)**

An approved 2/3/4000-level course in another discipline that has significant technical content relevant to the science or application of biomedical engineering can be used as a technical elective. Technical Electives may be chosen from the list on page 3 of the checksheet.

### Change of Major Requirements:

For change of major requirements, please see: [http://www.enge.vt.edu/undergraduate/undergraduate-changing-majors](http://www.enge.vt.edu/undergraduate/undergraduate-changing-majors)

### Foreign Language Requirements:

Students must have had 2 years of a foreign language in high school or one year at the college level (6 credit hours) of the same language. College-level credits used to meet this requirement do not count towards the degree.

### Satisfactory Progress Towards Degree:

University Policy 91 outlines university-wide minimum criteria to determine if students are making satisfactory progress towards the completion of their degrees. The BME Department fully supports this policy. Specific expectations for satisfactory progress for Biomedical Engineering majors are as follows:

- Each student must meet the minimum University-wide criteria as described in Policy 91 and summarized in the Undergraduate Catalog (under Academic Policies)
- After having completed 72 credit hours (including transfer, advanced placement, advanced standing, and credit by examination) must have:
  - Maintain an in-major GPA (in-major GPA is calculated using all courses taught under the BMES designator) and an extended in-major GPA (extended in-major GPA is calculated using all BMES courses and ESM 2104, 2204, and 2304) of 2.0 or better
  - Complete a minimum of 12 credits that apply toward the BME degree per academic year (including summer and winter sessions).

### Statement of Hidden Pre-requisites:

- There are no hidden pre-requisites in this program of study.
- Pre-requisites may change from what is indicated. Be sure to consult the University Catalog or check with your advisor for most current requirements.

### Graduation Requirements:

Each student must complete at least 122 semester credit hours with a minimum overall GPA of 2.00 and a minimum in-major GPA of 2.00.

---

**Note:** This will be replaced by the Pathways Curriculum if it is approved by the start of this proposed program.
Appendix A-2: BMES Technical Electives*

BMES 3124 – Introduction to Biomechanics Pre: BMES 2104, ESM 2204, ESM 2304
BMES 3134 – Introduction to BME Imaging Pre: BMES 2104, (MATH 2204 or 2204H), PHYS 2306
BMES 3144 - Biomedical Devices Pre: BMES 2104

Students in their senior year, with 3.0 or better GPA, may enroll in 5000-level courses satisfying undergraduate degree requirements within their department’s with the permission of the course instructor and the Department Head.

BMES 5054 – Quantitative Cell Physiology Co: BMES 5044
BMES 5064 – Quantitative Organ Systems Physiology Co: BMES 5044
BMES 5024 (cross-listed with BMVS 5224) – BME and Human Disease Pre: BMES 5004 or BMES/BMVS 4064
BMES 5044 (cross-listed with BSE 5044 and CHE 5044)– Engineering Mathematics
BMES 5124 (cross-listed with ESM 5224)– Advanced Musculoskeletal Biomechanics
BMES 5184 – Injury Physiology Pre: BMES 5004, Co: BMES 5164
BMES 5314 – Introduction to Regenerative Medicine
BMES 5714 – Biomedical Microdevices

* New courses will be developed as the demand grows.
Appendix A-3: Approved Technical Electives

Students choose from the courses listed below, noting that some courses are not available to all students because some courses have prerequisites and some are restricted to majors in the offering department.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCHM 3114</td>
<td>Biochemistry for Biotechnology and the Life Sciences</td>
<td>ESM 4245-</td>
<td>Mechanics of Animal Locomotion</td>
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<tr>
<td>BIOL 2004</td>
<td>Genetics</td>
<td>ESM 4246</td>
<td></td>
</tr>
<tr>
<td>BIOL 3134</td>
<td>Human Genetics</td>
<td>ESM 4304</td>
<td>Hemodynamics</td>
</tr>
<tr>
<td>BIOL 4704</td>
<td>Immunology</td>
<td>HNFE 3634</td>
<td>Epidemiologic Concepts of Health and Disease</td>
</tr>
<tr>
<td>BIOL 4734</td>
<td>Inflammation Biology</td>
<td>HNFE 3824</td>
<td>Kinesiology</td>
</tr>
<tr>
<td>BMVS/BCHM</td>
<td>Environmental Health</td>
<td>HNFE 4844</td>
<td>Exercise and Neuromuscular Performance</td>
</tr>
<tr>
<td>4034</td>
<td>Toxicology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMVS 4054</td>
<td>Laboratory Animal Management</td>
<td>ISE 3614</td>
<td>Human Factors Engineering and Ergonomics</td>
</tr>
<tr>
<td>BMVS 4074</td>
<td>Pharmacology</td>
<td>ISE 4624</td>
<td>Work Physiology</td>
</tr>
<tr>
<td>BSE 3534</td>
<td>Bioprocessing Engineering</td>
<td>MATH 3214</td>
<td>Calculus of Several Variables</td>
</tr>
<tr>
<td>BES 4544/</td>
<td>Protein Separation Engineering</td>
<td>MATH 4234</td>
<td>Elementary Complex Analysis</td>
</tr>
<tr>
<td>CHE 4104</td>
<td>Processing Materials</td>
<td>MATH 4445-</td>
<td>Introduction to Numerical Analysis</td>
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<tr>
<td>CHE 4304</td>
<td>Biological Transport Phenomena</td>
<td>CHE 4446</td>
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<tr>
<td>(ME 4344)</td>
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<td></td>
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<tr>
<td>CHEM 2535</td>
<td>Organic Chemistry</td>
<td>ME 4034</td>
<td>Bio-inspired Technology</td>
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<td>CHEM 2536</td>
<td>Organic Chemistry Laboratory</td>
<td>ME 4524</td>
<td>Introduction to Robotics and Automation</td>
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<tr>
<td>CHEM 2545</td>
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<td>ME 4864</td>
<td>Micro/Nano-Robotics</td>
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<tr>
<td>CHEM 2546</td>
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<td></td>
<td></td>
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<tr>
<td>CHEM 4554</td>
<td>Drug Chemistry</td>
<td>MSE 4164</td>
<td>Principles of Materials Corrosion</td>
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<tr>
<td>CS 3824</td>
<td>Introduction to Computational Biology and Bioinformatics</td>
<td>MSE 4304</td>
<td>Metals and Alloys</td>
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<tr>
<td>CS 4884</td>
<td>Computational Biology and Bioinformatics Capstone</td>
<td>MSE 4574</td>
<td>Biomaterials</td>
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<td>ECE 4580</td>
<td>Digital Processing Imaging</td>
<td>MSE 4641</td>
<td>Nanomaterials</td>
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<td>ECE 4624</td>
<td>DSP and Filter Design</td>
<td>NEUR 3044</td>
<td>Cellular and Molecular Neuroscience</td>
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<td>ECE 4405-ECE</td>
<td>Control Systems</td>
<td>PHYS 3324</td>
<td>Modern Physics</td>
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<td>4406</td>
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<td>ESM/MSE</td>
<td>Mechanical Behavior of Materials</td>
<td>PHYS 3405-</td>
<td>Intermediate Electricity and Magnetism</td>
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<td>PHYS 3406</td>
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<td>Advanced Mechanical Behavior of Materials</td>
<td>PHYS 4455-</td>
<td>Introduction to Quantum Mechanics</td>
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<td>ESM 4044</td>
<td>Mechanics of Composite Materials</td>
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<td>ESM 4105-</td>
<td>Engineering Analysis of Physiologic Systems</td>
<td>PHYS 4504</td>
<td>Introduction to Nuclear and Particle Physics</td>
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<td>ESM 4106</td>
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<tr>
<td>ESM 4204</td>
<td>Musculoskeletal Biomechanics</td>
<td>PHYS 4574</td>
<td>Nanotechnology</td>
</tr>
<tr>
<td>ESM 4224</td>
<td>Biodynamics &amp; Control</td>
<td>PHYS 4614</td>
<td>Optics</td>
</tr>
<tr>
<td>ESM 4234</td>
<td>Mechanics of Biological Materials and Structures</td>
<td>PHYS 4714</td>
<td>Introduction to Biophysics</td>
</tr>
</tbody>
</table>
Department Letters of Support

1. Chemistry
2. English
3. Math
4. Engineering Education
5. Physics
6. Biology
7. Material Science Engineering
8. Electrical Engineering
9. Computer Science
10. Statistics
11. Chemical Engineering
12. Mechanical Engineering
13. Biological Systems Engineering
14. Neuroscience
15. Biomedical Sciences and Pathobiology
16. Human Nutrition, Food and Exercise
December 17, 2015

Pam VandeVord
BEAM
Associate Department Head for Undergraduate Studies
BEAM (0194)
Virginia Tech

Dear Pam,

The Department of Chemistry supports the use of CHEM 1035 and 1045 General Chemistry as the required chemistry course for Biomedical Engineers. We also support listing CHEM 1036, General Chemistry, CHEM 1046 General Chemistry Lab, CHEM 2535/2536 Organic Chemistry, CHEM 2545/2546 Organic Chemistry lab and CHEM 4554 Drug Chemistry as electives. This is based on an estimate of 12 students per year. If a student is pre-med, he/she will have to have all but the Drug Chem course and this represents a fairly significant request because of the labs. We can support this conditionally until we know the true numbers, but as circumstances change, we would have to revisit the question and hope that we can count on you for support of a request for additional resources.

Regards,

Gordon T. Yee
Associate Professor
Director of Undergraduate Programs
2. English

Ginny Funder

To: Parr, techs

The English department is happy to have you include English 1105, 1106, (and 1200L) in your course load.

Ginny Funder

3. Math

From: Vandahl

To: Parr

Hi Parr,

I am following up on the request for a support letter from your department for the use of MATH 1205, 1206, 2214, 2206, 3214 in our required MATH series. If you choose to include 2 pre-reqs for 2214.

and the use MATH 2014, 4514, 4445, 4444 in our elective wheel map.

Peter Vandahl

4. Engineering Education

From: Vandahl

To: Parr

Hello Stephanie and Steve,

As you may already know, the Biomedical Engineering and Bioengineering Department is developing a new E0 degree in Biomedical Engineering. Our curriculum committee has been working hard to construct a solid foundation for the students, which will include many of the existing courses. In doing so, we have focused on ensuring that our department would align well with the Biomedical Engineering

We need your support before taking the steps needed to develop a new E0 proposal. Have you any concerns about the proposed curricula? We would appreciate any feedback you could provide on this issue.

Thanks,

Peter

Regrettful Concerns

Kari Salt

From: Vandahl

To: Parr

Please consider the request to be approved. Please let me know if there are any questions or concerns.

Thanks,

Kari

On Dec 14, 2015 at 7:44 AM, Techs: 4445.4444@new.net

Timber Lodge

Associate Registrar

Engineering Education
January 15, 2016

Dear Colleagues,

This letter is in support of the proposal for a new BS degree in Biomedical Engineering. The Physics Department has no problem with including in this degree the required introductory Physics courses (PHYS 2305 and 2306) and the list of physics technical electives at the 3000 and 4000 level.

Sincerely,

John H. Simonetti
Professor, Associate Chair of Physics
Virginia Tech
January 12, 2016

Pamela VandeVord, Ph.D.
Department of Biomedical Engineering & Mechanics

Dear Dr. VandeVord,

The Department of Biological Sciences supports inclusion of BIOL 1105 Principles of Biology as a required course on the checksheet for the BS degree in Biomedical Engineering. Please note our ability to provide seats in BIOL 1105 is dependent on continued enrollment support funds.

We also support the inclusion of the following courses as technical electives on the same checksheet:

BIOL 2004: Genetics
BIOL 3134: Human Genetics
BIOL 4704: Immunology
BIOL 4734: Inflammation Biology

Please be sure students in the Biomedical Engineering BS degree are informed that one or more prerequisites are required for each of these technical elective courses and that prerequisite checking is enforced for our courses. Inclusion of these BIOL courses is not an indication that prerequisites will be waived for students in the Biomedical Engineering BS degree.

Sincerely,

Richard A. Walker
Associate Head
Department of Biological Sciences
7. MSE

Pam VanVleet - pvavleets@ee.uic.edu
In Data - spm@ee.uic.edu
In Dr. Hendricks

Happy New Year!

I wanted to follow up with you regarding the issue of your courses for MSE degree. Would you be able to send me a request letter for the requirement to MSE 253A as a required and MSE 4244, 4245, 4246 and 4248 as technical electives? Also, you may want to address the issue of the letter. Can you please forward the correct person?

Thanks!

Robert Hendricks - rhendriks@ee.uic.edu
In SCE, Engineering Park -

Jan 6

I sent it to our Undergrad CE chair and he agreed that we will be happy to allow your student to take these courses, assuming they have all the prerequisites. (If the prerequisite is a 250 level course, we will also approve the student for that course.)

Bob

8. ECE

James De La Raia - jpdla@mail.mslabs.com
In SCE, Engineering Park -

Jan 15

Happy New Year!

I have spoken with Dr. Klein - He marked ECE 4505R and 4505K with including students from your department if space is available. Also, you can include ECE 4505R in the list of Tech Electives.

Sorry for the delay. I was waiting for answers.

Best,

James

Dr. James De La Raia
Associate Professor - Electrical Engineering
UIC MSLabs, 500 South Morgan Street
Chicago, IL 60607
Office: 312-419-4912 Mobile: 773-752-2104

Dr. Klein - Assistant Professor - Electrical Engineering
UIC MSLabs, 500 South Morgan Street
Chicago, IL 60607
Office: 312-419-4912 Mobile: 773-752-2104

9. Computer Science

Pam VanVleet - pvavleets@ee.uic.edu
In Data - spm@ee.uic.edu
In Dr. Hendricks

Happy New Year!

I wanted to follow up with you regarding the issue of the course for MSE degree. Would you be able to send me a request letter for the issue of CS 4244, 4245, or 4246 as an optional course? Also, will be the internship worth it?

Send BTW, updates on becoming Department head. Does this mean that everyone will be using the UCC?

Best,

Dr. Klein - Dec 16, 2014 at 2:15 PM, Cal Willerson - willerson@uic.edu wrote

Cal Willerson - willerson@uic.edu
In SCE, Engineering Park -

Jan 6

Pam -

Thanks - have sent thousand responses to you. You'll see a few more requests for the college catalog and CA.
To whom it may concern:

The Department of Statistics is pleased to offer our conditional support for the proposed Bachelor of Science in Biomedical Engineering to be housed in the Virginia Tech Biomedical Engineering and Mechanics Department. We are excited about the promise this interdisciplinary field holds for the advancement of knowledge about the application of engineering analysis and design to clinical applications, including the considerable synergistic opportunities for research collaboration between the school and our department.

The Biomedical Engineering degree check sheet lists STAT 3615 as a required majors course. We support the inclusion of this course as part of the Biomedical Engineering degree program, though we must note that the Department of Statistics is facing increasing enrollment pressure on all of our classes, and in particular STAT 3615 which is currently significantly over-subscribed and under-resourced.

Thus, our support of this new degree is conditional on additional resources being provided to the Statistics Department so that we have the capacity to support the additional students. In particular, each additional STAT 3615 class (consisting of 60 students) will require funding for a GTA step 10 stipend and tuition waiver for the semester in which the section is taught, and these resources will need to be committed to in advance and available beginning the first year Biomedical Engineering students can enroll.

Of course, we are aware that a new funding model is under development by the Office of the Provost to support this kind of service teaching and that it may be in place by the time this degree begins enrolling students. However, in the absence of any specific funding model details, we must emphasize that without the funding just described we do not have the resources to support these students. Furthermore, at the expense of stating the obvious, a funding model in which resources lag enrollment is untenable in a situation like this were we expect to have to support multiple new sections of STAT 3615 as soon as the program is approved.

That said, we are excited to be a part of this innovative educational initiative that promises to produce graduates with skills valuable to the advancement of engineering, medicine, and societal well-being. We offer our conditional support to the program and we look forward to the opportunities for research collaboration between Department of Statistics faculty and the Biomedical Engineering and Mechanics Department faculty.

Sincerely,

R.D. Fricker, Jr.
Professor and Head,
Department of Statistics

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution
14 December, 2015

Dear Pam,

This letter is to indicate that the Chemical Engineering Department approves the listing of CHE 4104 Process Materials and CHE 4304/ME 4344 Biological Transport Phenomena as technical electives for the BME major. Please advise your students that entry into these courses will be contingent on their meeting the listed course prerequisites (or equivalent courses).

No additional resources are requested.

Please feel free to contact me at 540-231-3674 or by email at goldst@vt.edu if you have any additional questions.

Sincerely,

Aaron S. Goldstein, Associate Professor
Assistant Department Head
Department of Chemical Engineering
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061-0211
12. ME

Pam Needlman
nneedlm@kul.edu

Hi Zika

As you may already know, the Biomedical Engineering and Mechanics Department is developing a new BSE degree in Biomedical Engineering. Our curriculum committee has been working hard to construct a solid group of courses that will advance a new generation of biomedical engineers. In doing so, we have found courses within your department which would strengthen the curriculum. These courses would only be available as technical electives within the BSE BSE proposal.

I have attached a draft version of the proposed checklist for you to review. I am sure there are problems in the proposal and we would appreciate you only distributing to those who you feel need to help in the decision process.

After reviewing, please let me know if you believe you are capable of supporting the use of these courses within the BSE BSE degree curriculum. We are hoping to have the proposal to the OCE UCC this January. Your support would be greatly appreciated. If you have any questions or comments, I would be happy to meet and discuss with you.

Thank you.

Tom

Courses:
ME 5204: Heat and Mass Transfer
ME 4524: Biomechanical Technology
ME 4524: Introduction to Robotics and Automation
ME 4544: Micro/Nano-Mechanics

Officer Gately <cch@kul.edu>

12/19/15

Dear Tom,

With the exception of ME 3004 we approve of all the courses as Technical Electives on your Biomedical Degree Checklist. However, ME 3004 is a required ME course with prerequisites and we are not in a position to exempt more students in this course.

I will finalize our approval for the other courses so that you understand that all of these courses are very popular with ME students and they need to have limited enrollment capacity. So, ME students will get priority. If there is room we will accept exceptions such as your students, but enrollment in these courses is not guaranteed. Please let me know if you have any questions.

Best wishes for the holidays.

Zika

13. BSE

Tess Thompson <themay@kul.edu>

Hi Pam,

Happy New Year to you as well!

We decided this will be approving listing the following two courses as technical electives for a BSE degree in biomedical engineering:

BSE 4504: Bioprocess Engineering
BSE 4544: Metabolic Engineering

Please note that the change in the course number for BSE 4504 to BSE 3504, due to some adjustments in our biomedical engineering curriculum.

You may also wish to consider a new course, BSE 4544 Metabolic Engineering, as a technical elective. Attached is the course proposal.

Best,

Tess

Tess Thompson, PhD
Associate Professor
Assistant Head for Undergraduate Studies
Biological Sciences Engineering, Virginia Tech
Pamela VandeVord  
Program Chair, Biomedical Engineering  
Department of Biomedical Engineering & Mechanics  
Virginia Tech  

Dear Dr. VandeVord,

The Neuroscience program supports your request to include NEUR 3044 Cellular and Molecular Neuroscience and 3084 Cognitive Neuroscience as elective courses for the Bachelor of Science in Biomedical Engineering degree. Since these are required courses for all Neuroscience majors and with the demand growing, first preference for enrollment in these courses will be given to Neuroscience majors. Biomedical Engineering students in the Biomedical Engineering degree will be able to enroll in these NEUR courses subject to availability.

Sincerely,

Harald Sontheimer  
I.D. Wilson Chair and Professor  
Executive Director, School of Neuroscience
16. HNFET

Selberg-Eaton, Renee <renee@metro.edu>
To: Matt and Pam
Hi Matt and Pam,
I'm not able to see the syllabus right now, but as long as the students have appropriate background, I don't see an issue with adding them to your check sheet.
Renee S. Eaton
Sent from my iPhone

<BMVFNS466_Fall16_Final1.pdf>
COVER SHEET - NEW and REVISED CHECKSHEETS, OPTIONS, CONCENTRATIONS and DEGREES

Commission on Undergraduate Studies and Policy/ Commission on Graduate Studies and Policies
Effective September 2010

*SEE APPENDIX FOR NOTES, EXPLANATIONS AND ADDITIONAL GUIDELINES*
*PRINT CLEARLY, TYPE or COMPLETE ELECTRONICALLY*

PROPOSAL DATE: 03/29/16
15-DAY REVIEW END DATE:

DEPARTMENT: Biomedical Engineering and Mechanics

DEGREE NAME: Biomedical Engineering

☑ MAJOR ☐ MINOR ☐ OPTION/CONCENTRATION

☐ DEAN and/or DEPARTMENTAL CONTACT: Pam VandeVord CONTACT MAILCODE: 0298

CONTACT PHONE: 540-231-1994 CONTACT E-MAIL: pword@vt.edu

CHECK ONLY ONE OF THE FOLLOWING BOXES

☐ NEW UNDERGRADUATE CHECKSHEET ☐ REVISED CHECKSHEET [Revision>20% Revision<20%]
(Attach copy of current APPROVED checksheet)

☐ NEW MINOR ☐ REVISED MINOR (Attach copy of current APPROVED checksheet)
☐ DISCONTINUED MINOR (Attach Transition Plan)

☐ NEW OPTION ☐ REVISED OPTION (Attach copy of current APPROVED checksheet)
☐ DISCONTINUED OPTION (Attach Transition Plan)

☐ NEW UNIVERSITY CONCENTRATION ☐ REVISED UNIVERSITY CONCENTRATION (Attach copy of current APPROVED checksheet)
☐ DISCONTINUED UNIVERSITY CONCENTRATION (Attach Transition Plan)

☐ NEW CONCENTRATION ☐ REVISED CONCENTRATION (Attach copy of current APPROVED checksheet)
☐ DISCONTINUED CONCENTRATION (Attach Transition Plan)

☐ NEW GRADUATE CERTIFICATE ☐ REVISED GRADUATE CERTIFICATE

☒ NEW DEGREE ☐ REVISED DEGREE ☐ DISCONTINUED DEGREE
(Attach Transition Plan)

• EFFECTIVE DATE: GRADUATING CLASS OF 2020 (List Year Only)

• FOR ALL CHECKSHEETS, NEW AND REVISED: Attach Statement from Dean or Departmental Representative Outlining the Changes from the Currently APPROVED Checksheet and Method(s) of Communication to Students Impacted by these Changes.

• Attach Appropriate Letters of Support from Affected Departments and/or Colleges

• Revised checksheets with 20% or less revision can be forwarded directly to the Office of the University Registrar (0134) for Administrative Approval. Supporting documentation should be attached.

Revision Summary:

APPROVAL SIGNATURES

Department Representative

College Curriculum Committee Representative

College Dean

Date: 3/29/16

Date: 4/14/16

Date: 4/14/16

Rev. 04-20-2012
January 18, 2016

Memorandum

To: COE Undergraduate Curriculum Committee

From: Department of Biomedical Engineering and Mechanics

Subject: Support for new B.S. degree program in Biomedical Engineering

Please find the attached proposal for the development of a new B.S. in Biomedical Engineering. The BME Undergraduate Curriculum Committee has reviewed and approved the proposed curriculum described in the following proposal. In addition, all courses within the proposed check sheet have been approved by their departments to be included in the curriculum (Support letters are included). Required resources are also described within the document.

Sincerely,

Pamela VandeVord
BME Program Chair
Professor

Stefan Duma
BEAM Department Head
Harry C. Wyatt Professor
Bachelor of Science Degree in Biomedical Engineering
Presentation to the Board of Visitors,
Academic Affairs Committee
April 3, 2017

Pamela VandeVord, Professor and Interim Department Head, BEAM
What is Biomedical Engineering?

Applying engineering analysis and design to clinical applications in order to improve the quality of life
What is the Demand for Biomedical Engineers?

“27% job growth from 2012-2022. This is more than double the 11% outlook for all occupations”

“employment of biomedical engineers is expected to grow by 62% from 2010 to 2020, much quicker than the average for all engineering professions”

Data from the American Society for Engineering Education (ASEE), reveal that biomedical engineering is the 8th top major for undergraduate students in engineering colleges.

Forbes ranked BME as the #1 major that was worth student’s tuition, time, and effort.

“These aren’t majors that anyone could do. They’re hard, …there is high demand for them and a low supply of people with the skills, so it drives up the labor market price.”

Goudreau, J. (2012, May 15). The 15 Most Valuable College Majors

Schools.com projects the career outlook for biomedical engineers in Virginia at 95.9%
Bachelor of Science Degree in Biomedical Engineering

Careers

Recent Graduate

Engineers and scientists with diverse technical skills are needed to advance biomedical engineering technologies that improve patient care and contribute to our nation's healthcare and economic growth. We offer diverse technical challenges and opportunities for research, development, and applications.

Functional Areas

Depending on background:
- Biomedical
- Computer
- Electrical
- Materials
- Mechanical

Careers

We're looking for engineers who enjoy technology and individual challenges. We welcome all engineers to join us in our mission to improve patient care and save lives.

Candidates must have:
- Minimum
- A bachelor's degree in Science, 5 years of relevant experience

Support project teams.

Careers in:
government agencies, hospitals, pharmaceutical and medicine, device and drug design, medical equipment and supplies manufacturing

Patent Examiner (Biomedical Engineer)

Department Of Commerce 3.9 96 Reviews – Alexandria, VA

Job Description

About the Agency

Applications will also be accepted from students who expect to complete qualifying education within 9 months from the date of application. USPTO requires verification of successful completion before extending a final offer.

Come work for the USPTO, we have been ranked as one of the Best Places to Work in the Federal Government®!

The U.S. Patent and Trademark Office (USPTO) has been serving the economic interests of America for more than 200 years. We are responsible for granting US intellectual property rights for patents and trademarks. Our efforts have provided inventors exclusive rights over their discoveries. It's an effort that continues to contribute to a strong global economy. To encourage investment in innovation and to cultivate an entrepreneurial spirit for the 21st century. The USPTO is headquartered in Alexandria, Virginia, and has over 12,000 employees, including engineers, scientists, attorneys, analysts, IT specialists, etc. all dedicated to accomplishing the USPTO's mission, vision, strategic goals and guiding principles. For more information about the USPTO, please visit the USPTO Careers Website.

THIS VACANCY ANNOUNCEMENT IS FOR POSITIONS LOCATED IN ALEXANDRIA, VA ONLY. YOUR APPLICATION TO THIS VACANCY ANNOUNCEMENT WILL ONLY ALLOW CONSIDERATION FOR THIS ANNOUNCEMENT AND THIS DUTY STATION.

Please read this entire announcement before submitting application materials.
Bachelor's Degree in Biomedical Engineering

Department of Biomedical Engineering and Mechanics (BEAM)
Program Objectives

• **Educate and train the future biomedical engineers** for a complex, diverse and global workplace

• **Expose students to and provide opportunities for them to conduct state-of-the-art research** that embraces societal challenges

• **Capitalize on the department’s biomedical partnerships with**: VT Carilion School of Medicine and Research Institute, Institute for Critical Technology and Sciences, Virginia-Maryland College of Veterinary Medicine, VT Biocomplexity Institute, VT Transportation Institute, and Edward Via College of Osteopathic Medicine (VCOM)

• **Establish the BEAM as the national leader in biomedical engineering education!**
Bachelor of Science Degree in Biomedical Engineering

BME Curriculum Summary

- General Engineering Core 24%
- Math and Science courses 17%
- Entry-level Science courses 16%
- Pathways to General Education courses 17%
- Technical Electives 17%
- Upper-level BME courses 13%
- Capstone Senior Design courses 5%
Bachelor of Science Degree in Biomedical Engineering

Interdisciplinary Coursework

- Intro to BME
- Principles of Biology
- Physics
- Electrical Theory
- Computer Programming

- BCHM
- BIOL
- BMVS
- CHEM
- HNFE
- NEUR
- 8 Engineering Departments

- Multivariable Calculus
- Statics
- Dynamics
- Mechanics of Deformable Bodies
- Linear Algebra

- BME Cellular Lab
- Fluid Mechanics
- Bioinstrumentation
- Problem Solving in BME
- Medical Physiology
- Commercialization of BME Research

Biomedical Engineering Undergraduate Degree
Why VT?

- Limited opportunity in Virginia, as only 2 other universities in the State have a bachelor's-level research-based education program
- VT 2012-2018 Strategic Plan proposes major growth in the fields of "science, technology, engineering, mathematics, and health sciences (STEM-H)"
- President Sand’s emphasizes interdisciplinary programs and research opportunities
- Roanoke Health Sciences & Technology campus
Why VT?

- VT BME Minor Program currently has over 200 undergraduates students enrolled
- Key participants in Destination Areas (Brain Behavior and Data Analytics)
- Draws on strengths of engineering faculty with expertise in biomedical research
Bachelor of Science Degree in Biomedical Engineering

VT College of Engineering has expertise in key BME Research Areas

- Biomechanics
- Biomedical Devices
- Biomedical Imaging
- Cardiovascular Engineering
- Translational Cancer Research
- Neuroengineering
RECOMMENDATION:

That the above resolution recommending the establishment of the Bachelor of Science Degree in Biomedical Engineering be approved.

April 3, 2017