Degrees Offered

Bachelor of Science in Bioengineering

The Bachelor of Science degree in Bioengineering is offered by the University of the Pacific School of Engineering and Computer Science. Within a few years of graduation, graduates of the Bioengineering program are expected to be able to:

- Apply engineering solutions to biomedical, human health, or biological problems
- Engage in life-long learning and pursue advanced level studies
- Demonstrate leadership, collaboration, and communication skills in their profession

Bioengineering is an extremely exciting field. By integrating information, methods and tools of engineering with knowledge found in the sciences and mathematics, it promises challenging careers in a broad range of fields, including medical research and the design of medical instruments, to name just a few.

Student Outcomes

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Bachelor of Science in Bioengineering

Students must complete a minimum of 120 units of academic work in order to earn the bachelor of science in bioengineering. Students must also adhere to the University's graduation requirements for bachelor degrees. Traditional Career Path requires a minimum of 32 units of Cooperative Education. Cooperative Education for the Biomedical Career Path is optional.

I. General Education Requirements

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACS 001</td>
<td>What is a Good Society</td>
<td>4</td>
</tr>
<tr>
<td>PACS 002</td>
<td>Topical Seminar on a Good Society</td>
<td>4</td>
</tr>
<tr>
<td>PACS 003</td>
<td>What is an Ethical Life?</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: 1) Pacific Seminars cannot be taken for Pass/No Credit. 2) Transfer students with 28 or more transfer units complete 2 additional General Education elective courses from below in place of taking PACS 001 and PACS 002.

One course from each subdivision below:

Social and Behavioral Sciences

Two courses from the following:

- IA. Individual and Interpersonal Behavior (ECON 053 or PSYC 031 recommended)
- IB. U.S. Studies (BUSI 053 or ECON 055 recommended)
- IC. Global Studies

Arts and Humanities

- IIB. ENGR 030

One course from the following categories:

- IIA. Language and Literature (COMM 027 recommended)
- IIC. Visual and Performing Arts

Note: 1) Only one course can come from each subcategory (A, B, or C) within each category. 2) No more than 2 courses from a single department may be applied to meet the breadth program requirements, with the exception of certain 1-unit GE IIC courses.

II. Diversity Requirement

Students must complete one diversity course (3-4 units)

- ENGR 030 Engineering and Computing Ethics in Society 3

Note: 1) Transfer students with 28 units or more transfer units prior to fall 2011 are encouraged but not required to complete a designated diversity course prior to graduation. 2) Courses may be used also to meet general education and/or major/minor requirements.

III. Fundamental Skills

Students must demonstrate competence in:

- Writing
- Quantitative analysis

Note: 1) Fundamental skills must be satisfied prior to enrolling in upper division courses.

IV. Major Requirements

Mathematics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>MATH 051</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 053</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 055</td>
<td>Calculus III</td>
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<tr>
<td>MATH 057</td>
<td>Applied Differential Equations I: ODEs</td>
<td>4</td>
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Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 037</td>
<td>Introduction to Statistics and Probability</td>
<td>4</td>
</tr>
<tr>
<td>MATH 039</td>
<td>Probability with Applications to Statistics</td>
<td>4</td>
</tr>
</tbody>
</table>
### Basic Science

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>BIOL 051</td>
<td>Principles of Biology</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 061</td>
<td>Principles of Biology</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 025</td>
<td>General Chemistry</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 027</td>
<td>General Chemistry</td>
<td>5</td>
</tr>
<tr>
<td>PHYS 053</td>
<td>Principles of Physics I</td>
<td>5</td>
</tr>
<tr>
<td>PHYS 055</td>
<td>Principles of Physics II</td>
<td>5</td>
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### General Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>ENGR 010</td>
<td>Dean's Seminar</td>
<td>1</td>
</tr>
<tr>
<td>ENGR 020</td>
<td>Engineering Mechanics I (Statics)</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 025</td>
<td>Professional Practice Seminar</td>
<td>1</td>
</tr>
<tr>
<td>ENGR 110</td>
<td>Instrumentation and Experimental Methods</td>
<td>2</td>
</tr>
<tr>
<td>MECH 015</td>
<td>Mechanical Engineering Graphics</td>
<td>3</td>
</tr>
</tbody>
</table>

Select one of the following: 3-4

- **COMP 051** Introduction to Computer Science
- **COMP 061** Introduction to Programming for Data Science
- **ENGR 019** Computer Applications in Engineering

### Bioengineering Core

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>BENG 005</td>
<td>Introduction to Bioengineering</td>
<td>2</td>
</tr>
<tr>
<td>BENG 103</td>
<td>Biomaterials</td>
<td>4</td>
</tr>
<tr>
<td>BENG 104</td>
<td>Biomedical Imaging</td>
<td>4</td>
</tr>
<tr>
<td>BENG 108</td>
<td>Engineering Physiology</td>
<td>5</td>
</tr>
<tr>
<td>BENG 124</td>
<td>Biomechanics</td>
<td>4</td>
</tr>
<tr>
<td>BENG 130</td>
<td>Biotransport</td>
<td>4</td>
</tr>
<tr>
<td>BENG 194</td>
<td>Bioengineering Project Proposal</td>
<td>3</td>
</tr>
<tr>
<td>BENG 195</td>
<td>Senior Project</td>
<td>3</td>
</tr>
<tr>
<td>ECPE 041</td>
<td>Circuits</td>
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<tr>
<td>ECPE 041L</td>
<td>Circuits Laboratory</td>
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</tr>
</tbody>
</table>

### Career Path Electives

Select one career path below: 6-10

#### Biomedical Career Path *

- **CHEM 121** Organic Chemistry
- **CHEM 123** Organic Chemistry

Select one of the following:

- **BENG 140** Introduction to Tissue Engineering
- **BENG 154** Introduction to Magnetic Resonance Imaging

#### Traditional Career Path

Select three of the following: **

- **BIOL 101** Genetics
- **BIOL 145** Microbiology
- **BIOL 153** Cell Biology
- **BIOL 146** Industrial Microbiology
- **BENG 140** Introduction to Tissue Engineering
- **BENG 154** Introduction to Magnetic Resonance Imaging
- **CHEM 121** Organic Chemistry
- **CHEM 123** Organic Chemistry
- **CHEM 141** Analytical Chemistry
- **CHEM 159** Biophysical Chemistry
- **COMP 129** Software Engineering
- **COMP 135** Human-Computer Interface Design
- **COMP 151** Artificial Intelligence
- **COMP 153** Computer Graphics
- **COMP 155** Computer Simulation
- **COMP 157** Design and Analysis of Algorithms

### Bioengineering Courses

**BENG 005. Introduction to Bioengineering. 2 Units.**

This course introduces students to the various sub-disciplines (medical, chemical, electrical, mechanical, and computation) of bioengineering.

**BENG 053. General Biology with Applications for Engineers I. 3 Units.**

This is the first of a two semester general biology course for engineering students. This course focuses primarily on evolution, plant and animal diversity and ecology. Laboratory activities are integrated into the lecture and are used to reinforce course content with experiential activities and the application of biological principles to an engineering context.

**BENG 056. General Biology with Applications for Engineers II. 4 Units.**

This is the second of a two semester general biology course for engineering students. This course focuses primarily on metabolism, genetics, and organ systems physiology. A separate laboratory section is used to reinforce course content with experiential activities and the application of engineering techniques used for analysis or control of biological systems.

**BENG 103. Biomaterials. 4 Units.**

This course discusses biomaterials and lays the groundwork for topics such as mechanical, chemical, and thermal properties of replacement materials and tissues. Implantation of materials in the body are studies from the biological point of view. Prerequisites: Completion of all Fundamental Skills; MATH 053; CHEM 025 or CHEM 027; BIOL 061 or BENG 063 with a "C-" or better.

**BENG 104. Biomedical Imaging. 4 Units.**

This course discusses major medical imaging modalities in radiology, including X-ray, CT, nuclear medicine, ultrasound, and MRI. Specific contents include physical principles of each imaging modality, instrumentation and data acquisition/image reconstruction strategy, clinical applications and imaging techniques. Prerequisites: MATH 055, PHYS 055, COMP 051 or ENGR 019.
BENG 108. Engineering Physiology. 5 Units.
This course is a lecture and lab-based study of the major organ systems in the human body. Lectures cover basic anatomy and detailed function and regulation of the nervous, endocrine, sensory, muscular, cardiovascular, lymphatic, respiratory, excretory, digestive, and reproductive systems, with the underlying theme of maintaining homeostasis while responding to physiological disturbances. Lectures also compare systems to abiotic models using principles of physics, math, and chemistry. Lab exercises demonstrate physiological processes and emphasize principles of instrument-based data acquisition and data presentation. Students also create virtual instruments (VIs) using the program LabVIEW and apply their VIs to a final independent lab project. Prerequisites: Completion of all Fundamental Skills; BIOL 051 or BENG 053; BIOL 061 or BENG 063; CHEM 025 all with a "C-" or better or permission of instructor.

BENG 124. Biomechanics. 4 Units.
This course discusses concepts of engineering mechanics including stress, strain, deformation, and analysis of structures with application to biomechanical phenomena over a range of biological length scales. Engineering mechanics concepts are used to evaluate forces and moments acting on human joints, forces in musculoskeletal tissue, material properties of biological tissues, and disease state conditions. Prerequisites: Completion of all Fundamental Skills; ENGR 020 with a "C-" or better. Prerequisite may be taken concurrently: MATH 057 with a "C-" or better.

BENG 130. Biotransport. 4 Units.
This course focuses on momentum transport (viscous flow) and mass transport (diffusion and convection) in living systems. The fundamental principles of momentum and mass transfer are explored and the laws of conservation applied to develop mathematical descriptions of physiological and engineering systems across a range of length scales. Students develop technical writing skills and learn to use computational fluid dynamics simulation tools. Prerequisites: Completion of all Fundamental Skills; MATH 057; PHYS 053 with a "C-" or better.

BENG 140. Introduction to Tissue Engineering. 4 Units.
Tissue engineering is a multidisciplinary and collaborative field that applies the principles of engineering and biology toward the development of biological substitutes that restore, maintain, and improve tissue function. In this course, there will be an overview of tissue engineering, including discussion of cell sources, cell-material interactions, and assessment of engineering outcome through destructive and nondestructive means with case studies of specific types of tissue engineering including skin, bone, cartilage, bladder, and liver. Finally, ethical standards for different techniques in tissue engineering will be discussed. Prerequisites: Completion of all Fundamental Skills; BIOL 061; BENG 103 all with a "C-" or better or permission of instructor.

BENG 154. Introduction to Magnetic Resonance Imaging. 4 Units.
Introduction to the physics, techniques, and applications of magnetic resonance imaging (MRI) in basic sciences and the clinic. Basics of nuclear magnetic resonance physics, and Fourier transform, MRI hardware, and MR imaging principles including signal generation, detection, and spatial localization techniques. Applications of MRI including tissue relaxometry measurement and diffusion weighted imaging of biological tissues, imaging of anatomy, and function. Prerequisites: Completion of all Fundamental Skills; BENG 104 with a "C-" or better of permission of instructor.

BENG 171. Bioelectricity. 4 Units.
This course provides the student with an understanding of the origins, function, and measurement of electrical potentials and currents within biological tissues, such as nerve, muscle, and heart. Topics include: the bioelectrical properties of ion channels, neurons, the synapse and neuromuscular junction, adaptation and learning in small networks of neurons, the functional organization of bioelectrical systems, and bioelectrical measurement and stimulation of tissues such as the heart and brain. Prerequisites: Completion of all Fundamental Skills; ECPE 041/ECPE 041L; Prerequisite may be taken concurrently: MATH 057 with a "C-" or better.

BENG 191. Independent Study. 1-4 Units.
Special individual projects are undertaken under the direction of one or more faculty members who are knowledgeable in the particular field of study. Permission of department chairperson and faculty members involved.

BENG 194. Bioengineering Project Proposal. 3 Units.
This course provides an introduction to the engineering design process. Students apply basic sciences, mathematics, and engineering topics to meet a stated objective. Students will write a proposal for a comprehensive design project, in which they establish design objectives and criteria, analyze solution alternatives, and synthesize a problem. Consideration for engineering standards, realistic constraints, ethics, and safety is included. Prerequisite: Completion of all Fundamental Skills, Junior or Senior standing. BENG 124 and BENG 103, may be taken concurrently, with a "C-" or better or permission of instructor.

BENG 195. Senior Project. 3 Units.
In this course, students will complete the engineering design process. Students will design and evaluate an engineering solution to an existing problem. Students apply basic sciences, mathematics and engineering topics to implement a solution that meets stated design objectives and criteria. Students will also test prototypes to evaluate design performance. Design documentation and demonstration are required. Includes both written and oral reports and presentations. Prerequisite may be taken concurrently: BENG 194 with a "C-" or better or permission of instructor.

BENG 197. Undergraduate Research. 1-4 Units.
This course is applied or basic research in bioengineering under faculty supervision. Permission of faculty supervisor and department chair. Students must be in good academic standing.

BENG 197D. Undergraduate Research. 1-4 Units.