UNIVERSITY FACULTY SENATE FORMS

Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

Submitted by: Takashi Buma and Robert Rogers  Phone: 831-8447 and 831-8517

Department: Electrical & Computer Engineering  Email: buma@ece.udel.edu and rrogers@ece.udel.edu

Action: Add minor in bioelectrical engineering
(Example: add major/minor/concentration, delete major/minor/concentration, revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc.)

Effective term: 08F
(use format 04F, 05W)

Current degree: None
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed change leads to the degree of: Minor in Bioelectrical Engineering
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed name: Minor in Bioelectrical Engineering
Proposed new name for revised or new major/minor/concentration/academic unit
(if applicable)

Revising or Deleting: None

Undergraduate major/Concentration:
(Example: Applied Music–Instrumental degree BMAS)

Undergraduate minor:
(Example: African Studies, Business Administration, English, Leadership, etc.)

Graduate Program Policy statement change:
(Must attach your Graduate Program Policy Statement)

Graduate Program of Study:
(Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)

Graduate minor/concentration:

Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.
List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations?
(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter “None”)

Two new courses are electives for the proposed minor.

ELEG 479 Introduction to Medical Imaging Systems - This course has been offered twice and is currently in the process of obtaining a permanent course number. Medical imaging systems encompass a wide range of electrical engineering concepts including device technology, signal processing, and computer hardware. This course provides engineering students with an important biomedical application of material covered in their previous coursework. Non-engineering students benefit from gaining a more quantitative understanding of the operating principles behind medical imaging technology. The Minor in Bioelectrical Engineering is strongly supported by the device physics, instrumentation, and signal and image processing covered in this course.

ELEG 680 Immunology for Engineers - This course has been offered once and is currently in the process of obtaining a permanent course number. Mathematical biology applies computational modeling to yield important and surprising insights to complex biological systems. This course emphasizes mathematical immunology to study the development and suppression of disease. Engineering students will benefit from the opportunity to apply their previous coursework to a medically significant problem. Non-engineering students benefit from learning how biological systems can be described in a mathematical framework. The Minor in Bioelectrical Engineering is strongly supported by the cell biology, mathematics, and computational modeling covered in this course.

Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education: http://www.ugs.udel.edu/gened/

2. Learn to think critically to solve problems.
   The coursework challenges both non-engineering and engineering students to “think differently” about problems. Non-engineering students will apply more mathematics in problem solving. Engineering students will learn how to apply engineering concepts to less familiar biological scenarios.

5. Understand the diverse ways of thinking that underlie the search for knowledge in the arts, humanities, sciences and social sciences.
   A deeper understanding of how signals are measured, processed, and displayed provides non-engineering students with a powerful tool for careers in academia or industry. Engineering students will gain more perspective by understanding the connection between their calculations with complex biological systems.

6. Develop the intellectual curiosity, confidence, and engagement that will lead to lifelong learning.
   The proposed minor provides non-engineering students with the technical background necessary to communicate effectively with engineers. Likewise, engineering students will be able to relate with biologists, chemists, and even clinicians. These enhanced communication skills will foster not only teamwork but also curiosity and the ability to pursue creative ideas.

Identify other units affected by the proposed changes:
(Attach permission from the affected units. If no other unit is affected, enter “None”)

See attached support letters from the following departments:

Department of Biological Sciences – BISC 207 is required for the proposed minor. BISC 208 cannot be substituted for BISC 207.

Department of Human Movement and Exercise – HESC 688 is an elective course of the proposed minor that is open to any senior in the university who has completed the four required courses (see attachment).
Department of Mathematical Sciences – MATH 242 is required for the proposed minor.

Department of Physics – PHYS 202 or 208 are required for the proposed minor. It is understood that PHYS 201 or 207 are taken before PHYS 202 or 208.

**Describe the rationale for the proposed program change(s):**
(Explain your reasons for creating, revising, or deleting the curriculum or program.)

Biomedical engineering is a rapidly growing field that is highly interdisciplinary. The lack of a dedicated biomedical engineering department at the University of Delaware forces biomedical engineering education to be distributed among existing departments. An undergraduate minor offers students the opportunity to merge biological sciences with a specific engineering discipline. Redundancy is avoided by ensuring the minor emphasizes the strengths of the particular engineering department while maintaining accessibility to any undergraduate student. For example, the Department of Mechanical Engineering offers a Biomedical Engineering Minor that emphasizes various aspects of biomechanics. The Department of Chemical Engineering offers a Biochemical Engineering Minor that emphasizes engineering approaches to pharmaceutical and biotechnology problems. Therefore, it is reasonable for the Department of Electrical and Computer Engineering to offer a minor in Bioelectrical Engineering. Instead of focusing on electronic instrumentation, the proposed minor takes a more general approach by emphasizing the acquisition, processing, and visualization of signals containing information regarding biological systems. In this manner we seek to create a formal minor in Bioelectrical Engineering that will serve the educational goals of the university at large. As a result, we expect that students who complete the minor will have an advantage when seeking either employment or advanced educational opportunities in this area.

**Program Requirements:**
(Show the new or revised curriculum as it should appear in the Course Catalog. If this is a revision, be sure to indicate the changes being made to the current curriculum and include a side-by-side comparison of the credit distribution before and after the proposed change.)

Please see attached document for the proposed coursework.

**Rationale for the proposed coursework:**

The required courses are intended to provide students with sufficient background in both biology and engineering. BISC 207 covers the fundamentals of cell biology as well as laboratory techniques. MATH 242 further develops integration techniques and provides an introduction to computational work in symbolic, numerical, and graphical analysis. PHYS 202 and 208 cover the fundamentals of electricity and magnetism. ELEG 471 is an introduction to human physiology from an engineering perspective, while BISC 306 covers human physiology with a life sciences viewpoint. Undergraduates majoring in the life sciences benefit from taking courses with more mathematical content, which also prepares them for the technical electives. A comprehensive biology course challenges engineering students to extend beyond the boundaries of a “conventional” engineering curriculum.

The technical electives are open to any student who has completed successfully the required coursework. In the past, many of these courses have been taken by non-engineers as well as non-ELEG engineers. This strongly suggests that the technical electives are well within the capabilities of undergraduates who have not gone through the standard curriculum of the Electrical & Computer Engineering Department.
<table>
<thead>
<tr>
<th>Role</th>
<th>Date</th>
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<tbody>
<tr>
<td>Department Chairperson</td>
<td>10/25/07</td>
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<tr>
<td>Dean of College</td>
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<tr>
<td>Chairperson, College Curriculum Committee</td>
<td></td>
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<td>Chairperson, Senate Com. on UG or GR Studies</td>
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<td>Chairperson, Senate Coordinating Com.</td>
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<td>Secretary, Faculty Senate</td>
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<td>Date of Senate Resolution</td>
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<td>Registrar</td>
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<td>Vice Provost for Academic Programs &amp; Planning</td>
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<td>Board of Trustee Notification</td>
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<td>Revised 5/02/06 /Ahs</td>
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Attachment for Proposed Minor in Bioelectrical Engineering

MINOR IN BIOELECTRICAL ENGINEERING

A minor in Bioelectrical Engineering may be earned by a student in any University bachelor's degree program. This degree provides students with an opportunity to integrate physiology and biological sciences with engineering aspects in signal measurement and processing. To qualify for a Minor in Bioelectrical Engineering, students must complete a minimum of 21 credits as described below with a minimum grade of C- in each course.

CURRICULUM

Course requirements

(1) All students must take the following three courses:

BISC 207(a) Introductory Biology I ................................................................. 4
MATH 242 Analytic Geometry and Calculus B ..................................................... 4
PHYS 202(b) Introductory Physics II ................................................................. 4
or
PHYS 208(b) Introductory Physics II ................................................................. 4

(2) And one of the following courses:

BISC 306 General Physiology ................................................................. 3
ELEG 471 Introduction to Biomedical Engineering ............................................. 3

(3) And two of the following courses(c):

ELEG 470 Biophysics of Excitable Membranes .................................................. 3
ELEG 473 Signal Processing in Neural Systems .................................................. 3
ELEG 475 Image Processing with Biomedical Applications .................................. 3
ELEG 478 Introduction to Nano and Biophotonics ............................................. 3
ELEG 479 Introduction to Medical Imaging Systems ......................................... 3
ELEG 676 Bioinformatics and Biosystems Analysis I ....................................... 3
ELEG 680 Immunology for Engineers .......................................................... 3
BISC 627 Neuroscience II ............................................................... 3
HESC 688 Electromyographic Kinesiology .................................................... 3

TOTAL CREDITS = 21

(a) BISC 208 cannot be substituted for BISC 207.
(b) It is understood that PHYS 201/207 is taken before PHYS 202/208.
(c) The listed 400 and 600-level courses are open to any student who has completed requirements (1) and (2) and the necessary prerequisites (or obtained permission of instructor).

Further inquiries about the Bioelectrical Engineering Minor can be made to Prof. Takashi Buma at 831-8447 (buma@ece.udel.edu).
# Proposed Coursework and Comparison to Related Engineering Minors

## Bioelectrical Engineering Minor in ECE (21 credits)

<table>
<thead>
<tr>
<th>Required courses (four)</th>
<th>Elective courses (two)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BISC 207</strong> Introductory Biology I</td>
<td><strong>ELEG 470</strong> Biophysics of Excitable Membranes</td>
</tr>
<tr>
<td><strong>MATH 242</strong> Calculus B</td>
<td><strong>ELEG 473</strong> Signal Processing in Neural Systems</td>
</tr>
<tr>
<td><strong>PHYS 202 or 208</strong> Physics II</td>
<td><strong>ELEG 475</strong> Image Processing with Biomedical Applications</td>
</tr>
<tr>
<td>Choose ONE from:</td>
<td>ELEG 478 Intro to Nano and Biophotonics</td>
</tr>
<tr>
<td><strong>BISC 306</strong> General Physiology</td>
<td>ELEG 479 Intro to Medical Imaging Systems</td>
</tr>
<tr>
<td><strong>ELEG 471</strong> Intro to Biomedical Engineering</td>
<td>ELEG 676 Bioinformatics and Biosystems Analysis I</td>
</tr>
<tr>
<td><strong>ELEG 478</strong> Intro to Nano and Biophotonics</td>
<td><strong>ELEG 680</strong> Immunology for Engineers</td>
</tr>
<tr>
<td><strong>BISC 605</strong></td>
<td><strong>HESC 627</strong> Neuroscience II</td>
</tr>
<tr>
<td><strong>ELEG 627</strong></td>
<td><strong>HESC 688</strong> Electromyographic Kinesiology</td>
</tr>
</tbody>
</table>

## Biomedical Engineering Minor in MEEG (21 credits)

<table>
<thead>
<tr>
<th>Required courses (four)</th>
<th>Elective courses (two)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BISC 207 or 208</strong> Introductory Biology I or II</td>
<td><strong>MEEG 482</strong> Clinical Biomechanics</td>
</tr>
<tr>
<td><strong>MATH 243</strong> Analytic Geometry and Calc C</td>
<td><strong>MEEG 483</strong> Orthopaedic Biomechanics</td>
</tr>
<tr>
<td><strong>PHYS 201 or 207</strong> Physics I</td>
<td><strong>MEEG 484</strong> Biomaterials and Tissue Engineering</td>
</tr>
<tr>
<td>Choose ONE from:</td>
<td><strong>MEEG 485</strong> Control of Human Movement</td>
</tr>
<tr>
<td><strong>BISC 306</strong> General Physiology</td>
<td><strong>MEEG 486</strong> Cell and Tissue Transport</td>
</tr>
<tr>
<td><strong>BISC 401</strong> Mol. Biology of the Cell</td>
<td><strong>MEEG 612</strong> Biomechanics of Human Movement</td>
</tr>
<tr>
<td><strong>HESC 220</strong> Anatomy and Physiology</td>
<td><strong>ELEG 471</strong> Introduction to Biomedical Engineering</td>
</tr>
</tbody>
</table>

## Biochemical Engineering Minor in CHEG (19 credits)

<table>
<thead>
<tr>
<th>Required courses (four)</th>
<th>Elective courses (two)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BISC 207</strong> Introductory Biology I</td>
<td><strong>CHEG 621</strong> Metabolic Engineering</td>
</tr>
<tr>
<td><strong>BISC 401</strong> Mol. Biology of the Cell</td>
<td><strong>CHEG 650</strong> Biomedical Engineering</td>
</tr>
<tr>
<td><strong>CHEM 527</strong> Intro to Biochemistry</td>
<td><strong>CHEM 643</strong> Intermediary Metabolism</td>
</tr>
<tr>
<td><strong>CHEG 620</strong> Biochemical Engineering</td>
<td><strong>CHEM 644</strong> Mechanisms of Enzyme Catalysis</td>
</tr>
<tr>
<td><strong>CHEM 645</strong> Protein Structure and Function</td>
<td><strong>CHEM 646</strong> DNA-Protein Interactions</td>
</tr>
<tr>
<td><strong>CHEM 648</strong> Membrane Biochemistry</td>
<td><strong>CHEM 649</strong> Molecular Biophysics</td>
</tr>
</tbody>
</table>
### B.S. Biochemistry

**Required for Major**
- BISC 207, BISC 208, MATH 241, MATH 242 (very strongly recommended)
- PHYS 201, PHYS 202

**Typical technical elective for Major**
- BISC 306

**Additional load for Bioelectrical Engineering Minor**
- Two elective courses

### B.S. Chemistry

**Required for Major**
- MATH 241, MATH 242
- PHYS 201, PHYS 202

**Typical technical elective for Major**
- BISC 306

**Additional load for Bioelectrical Engineering Minor**
- BISC 207
- ELEG 471 or BISC 306
- Two elective courses

### B.S. Biology (Cell & Molecular Biology and Genetics)

**Required for Major**
- BISC 207, BISC 208
- MATH 241
- PHYS 201, PHYS 202

**Typical technical elective for Major**
- BISC 306

**Additional load for Bioelectrical Engineering Minor**
- MATH 242
- Two elective courses

### B.S. Biology (Biotechnology)

**Required for Major**
- BISC 207, BISC 208
- MATH 241
- PHYS 201, PHYS 202

**Typical technical elective for Major**
- BISC 306

**Additional load for Bioelectrical Engineering Minor**
- MATH 242
- Two elective courses

### B.S. Quantitative Biology

**Required for Major**
- BISC 207, BISC 208
- MATH 241, MATH 242, MATH 243
- PHYS 207, PHYS 208

**Typical technical elective for Major**
- BISC 306

**Additional load for Bioelectrical Engineering Minor**
- Two elective courses

### B.S. Physics

**Required for Major**
- BISC 207
- MATH 241, MATH 242, MATH 243
- PHYS 207, PHYS 208

**Typical technical elective for Major**
- BISC 306

**Additional load for Bioelectrical Engineering Minor**
- ELEG 471 or BISC 306
- Two elective courses

### B.S. Computer Science

**Required for Major**
- MATH 241, MATH 242
- PHYS 207/208 or BISC 207/208

**Additional load for Bioelectrical Engineering Minor**
- PHYS 208 or BISC 207
- ELEG 471 or BISC 306
- Two elective courses

### B.S. in Exercise Science

**Required**
- MATH 242, PHYS 208
- BISC 207, BISC 276 or 306

**Additional load for Bioelectrical Engineering Minor**
- Two elective courses
October 24, 2007

Robert F. Rogers, Ph.D.
Assistant Professor
Dept. of Electrical & Computer Engineering
310 DuPont Hall
University of Delaware
Newark, DE 19716

Dear Professor Rogers:

Thank you for sharing your proposal for a minor in bioelectrical engineering. My department is in support of interdisciplinary programs in general, and this minor in particular, and we do not anticipate any problems associated with the inclusion of HESC688 as an elective course.

Regards,

Susan J. Hall, Ph.D.
Professor and Chair
MEMORANDUM

TO: Robert F. Rogers, Ph.D.

FROM: Dan Carson

SUBJECT: Bioelectrical Engineering Minor

I and my Associate Chair, Dave Usher, have had a chance to review your proposed Bioelectrical Engineering Minor and support the concept of this interdisciplinary program. We don't anticipate any problems associated with the required or elective courses as they impact Biological Sciences.
Thursday, October 18, 2007

Professor Takashi Buma  
Electrical and Computer Engineering  
University of Delaware  
Newark DE 19716

Dear Professor Buma:

I am writing to you to express the Department of Mathematical Sciences' support for your proposed undergraduate minor in Bioelectrical Engineering. You propose to add MATH242 as a required course, and we agree that this is highly desirable. We do not expect to need any more teaching resources to handle students in the Bioelectrical Engineering minor since most students in physical sciences already take MATH242.

We think that the minor will be of considerable interest to our Bachelor of Science students because of the great importance of applications in biology. We will certainly bring your minor to the attention of all our undergraduates.

Best wishes,

Peter Monk  
Chair
October 24, 2007

MEMORANDUM

TO: Prof. Takashi Buma, ECE

FROM: Norbert Mulders
       Director Undergraduate Programs, DPA

SUBJECT: Bioelectrical Engineering Minor

The Department of Physics and Astronomy supports the introduction of a Minor in Bioelectrical Engineering. The physics courses proposed as part of the minor will not measurably increase the teaching load of the department.

We would hope that physics majors have access to this minor. Our only concern is that the proposed ELEG courses for this minor all have the restriction “only for seniors”. It would be helpful if a statement could be made that this means that all seniors can register for these courses (provided they meet possible other prerequisites for the course), not just ECE majors.
November 2, 2007

Norbert Mulders, Ph.D.
Director of Undergraduate Affairs
Department of Physics and Astronomy
262 Sharp Laboratory
University of Delaware
Newark, DE 19716

Dear Professor Mulders,

Thank you for your support of the proposed minor in Bioelectrical Engineering. We appreciate your concern about the accessibility of ELEG elective courses to undergraduates outside the ECE department. Yes, ELEG courses listed as “only for seniors” are indeed open to any senior, not just ECE majors, who has satisfied the necessary prerequisites or obtained permission of the instructor.

Thank you again for your support, and we look forward to collaborating with you in making the proposed minor in Bioelectrical Engineering a success.

Regards,

Takashi Buma
Assistant Professor
Department of Electrical & Computer Engineering