

The University Senate of Michigan Technological University

Proposal 14-15

(Voting Units: Academic)

“CONCENTRATION IN BIOMEDICAL APPLICATIONS within the degree BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING”

Contact: Daniel R. Fuhrmann, Dave House Professor and Chair
Department of Electrical and Computer Engineering

1. General description and characteristics of the program

The Department of Electrical and Computer Engineering at Michigan Technological University proposes a new Concentration in Biomedical Applications within the degree Bachelor of Science in Electrical Engineering. The rationale for creating this Concentration includes: 1) helping current and prospective students to be aware of the many applications of electrical engineering in today's marketplace, and the opportunities available to electrical engineers with interests in healthcare, and 2) attracting more women into the field of electrical engineering and to Michigan Tech. The concentration include 6 credits in biology subjects to taken from approved and select approved electives, 13 credits in biomedical engineering topics to be taken as EE core and elective courses, and one change to the EE core curriculum, substitution of the course BE 2400, Cellular and Molecular Biology, for the course EE 3120, Introduction to Energy Systems. The concentration is based entirely on existing courses at Michigan Tech and therefore no new resources are required. This proposal is supported by the Department of Biomedical Engineering.

2. Rationale

Electrical engineering and affiliated fields such as computer engineering and computer science are among the technical disciplines which are experiencing the highest demand currently among prospective employers. This is particularly true at Michigan Tech, where our educational approach emphasizing a firm grounding in the fundamentals, individual skills, team-based projects, and hands-on experiences produces graduates which are highly recruited in industry. For example, at the Fall 2014 Career Fair, there were representatives from 341 companies and organizations on campus; 196 were seeking electrical engineers and 103 were seeking computer engineers for co-ops, internships, and full-time positions. Self-reported data from the Michigan Tech EE and CpE graduates in the Class of 2013 indicates a 96% placement rate and an average starting salary in excess of \$60,000.

A trend observed in recent years among recruiters at Michigan Tech is the breadth of industrial sectors seeking electrical engineers. In past years, there have always been opportunities in defense and aerospace, communications, computer systems, and (especially for Michigan Tech) utility power, but more recently we see demand in such diverse areas as automotive, healthcare, manufacturing, environmental, transportation, infrastructure, metals, mining, and even the financial and insurance sectors. There has been particular strong interest in control engineering, which spans most if not all of these fields. The reason behind this renewed interest in electrical engineers from such a diverse set of areas is the current technological push toward control and automation across all areas of our society. This is what some are calling the "4th Industrial Revolution": a convergence of computing, control, and communication, that brings together homes, buildings, factories, cars and just about every engineered product or system in one vast interconnected network.

One challenge we face as educators in electrical engineering is raising awareness of the breadth of opportunities to our own current and prospective students. Many come into the field, if they come at all, with vague and ill-informed notions of what electrical engineering is, and what an electrical engineering can be. We need to help students make good choices about the fields or sub-fields that they may enter, and then provide them with the tools they need to be competitive in the job market that they choose to enter. With that as our primary motivation, we introduce here a proposal to establish a Concentration in Biomedical Applications within the degree Bachelor of Science in Electrical Engineering. The target audience is that group of students with the interest and aptitude for electrical engineering but with a strong desire to apply their skills in the field of healthcare. We seek to raise awareness of the opportunities in healthcare, biomedical instrumentation, medical imaging, and related fields, for EEs, and then provide them with a path through our curriculum that prepares to make their contributions in those areas.

A secondary motivation for the establishment of this concentration is to attract and retain more women into the field of electrical engineering. This motivation is consistent with University's 2035 Portrait, which includes a female undergraduate population which is 40% of the total, the College of Engineering's former strategic goal of being among the 10 largest engineering programs in the nation for women, and the ECE Department's strategic goal of having undergraduate women make up 20% of our enrollment by 2020. At the current time we are falling short of these goals by a large margin: Michigan Tech's engineering program is 34th in the nation in the number of degrees granted to women, and the percentage of women graduating from our EE and CpE programs has averaged 10% for the past five years and fell below that mark in the past two years. At Michigan Tech we are not even keeping pace with national averages: in 2013 the national average for women graduates from EE programs was 12.3%, or 1311 out of 10,662 degrees granted.

In contrast, the Department of Biomedical Engineering, and biomedical engineering as a field nationwide, is far more successful in attracting women to their profession. Of the 4709 undergraduate degrees in biomedical engineering nationwide, 1832, or 39%, went to women. Of the 297 declared majors in Biomedical Engineering at Michigan Tech in Fall 2014, 131, or 44%, are women.

In addition to showing the strong interest among women in health-related fields, the data above indicate that there is a significant number of women entering the field of electrical engineering, just not as large a number in proportion to men as in biomedical engineering. Hence, we feel that there is an underserved market here: undergraduate students with an inclination toward electrical engineering and who want to practice their trade to make advances in healthcare and related fields. Obviously this applies to all students but we believe this may include a significant number of women. The proposed concentration is designed specifically to meet this need.

3. Discussion of related programs within the institution and at other institutions

3.1. Michigan Technological University

Our College of Engineering is home to the Department of Electrical and Computer Engineering and the Department of Biomedical Engineering, each with its own successful undergraduate programs. The proposed concentration is in no way a duplication of, or in competition with, the program leading to the degree Bachelor of Science in Biomedical Engineering. We have chosen the name of the concentration, Biomedical Applications, carefully to underscore the distinction. The field of biomedical engineering is focused on the *organism*: its form and function and the systems-level engineering required to improve upon or remediate some defect in that form and function. Electrical engineering students in this concentration will still focus on *electrical engineering* – circuits, signal processing, instrumentation, control, etc. – and will be seeking ways to apply those skills toward applications in healthcare. External advisors in the ECE and BME Departments have pointed out that there are roles for each type of engineer in the rapidly growing field of biomedical instrumentation: biomedical engineers who understand the organism, and have a professional familiarity with instrumentation, and *vice versa* the electrical engineers whose expertise is in the circuits and systems and have a professional familiarity in the appropriate biology. Recognizing that there is this distinction, and in a spirit of cooperation and collaboration, the Department of Biomedical Engineering has reviewed and endorsed the proposed concentration. A letter of support from the Chair, Prof. Sean Kirkpatrick, is attached as an addendum.

3.2. Michigan Research Universities

The University of Michigan has departments of Electrical Engineering and Computer Science (EECS) and Biomedical Engineering (BME). There does not appear to much curricular overlap between their respective undergraduate programs. There is a minor in electrical engineering, but no minor in biomedical engineering. There is some teaching and research in biomedical topics within EECS; they list two upper-level technical electives with EECS course numbers in the “biomedical” category.

Michigan State University has no department of biomedical engineering. Teaching and research in biomedical engineering topics is found in many of the other departments in the College of Engineering, including Electrical and Computer Engineering. Six of the undergraduate engineering majors include optional concentrations in biomedical-related areas; ECE has an optional Concentration in Biomedical Engineering.

Wayne State University has departments of Electrical and Computer Engineering and Biomedical Engineering. There are no minors, concentrations, or other curricular overlap between the two programs.

3.3. Other Michigan Universities

Grand Valley State University has an MS program but no BS program in biomedical engineering. Four of the engineering majors, including electrical engineering and computer engineering, may elect a Minor in Biomedical Engineering.

Lawrence Technological University has separate departments of Biomedical Engineering and Electrical and Computer Engineering, although until quite recently these disciplines were under one department. The BSEE program has an optional Concentration in Biomedical Instrumentation, for “students interested in healthcare technology and the design of innovative medical products.”

3.4 Peer Institutions

Colorado School of Mines has a Department of Chemical and Biological Engineering (CBEN) but no undergraduate degree in biomedical engineering. The university offers a multidisciplinary Minor in Biomedical Engineering, with many of the courses taught in CBEN.

Missouri University of Science and Technology has no department of biomedical engineering and little emphasis on biomedical topics within engineering. The university offers an undergraduate Minor in Bioinformatics.

4. Curriculum design

The curriculum for the proposed Concentration in Biomedical Applications is consistent with the requirements of University Senate Proposal 15-11. In particular:

“Concentrations (also referred to as options) within a major degree program will be granted to students who have completed the requirements established by the program's home academic unit at Michigan Technological University. Concentrations will be noted on official transcripts and diplomas. The purpose of a concentration is to give recognition that the student has actively and consciously engaged the intellectual issues central to the concentration.”

“A concentration does not have any specific credit limitations, except that the total number of credits required by the degree and the major concentration combined may not exceed 128 credits (or 131 credits if 3 credits of free elective are included in the degree requirements). The academic unit offering the concentration determines specific courses fulfilling the requirement. The minimum grade-point average required for the concentration is that of the major degree program.”

The current Michigan Tech BSEE curriculum is summarized in Table 4.1.

General Education Required Courses	12 Credits
Humanities, Arts, and Social Sciences Distribution Courses	12 Credits
Math, Physics, and Engineering Fundamentals Required Courses	30 Credits
Electrical Engineering Core Curriculum	46 Credits
Capstone Design	6 Credits
Electrical Engineering Electives	15 Credits
Approved Electives	3 Credits
Select Approved Electives	3 Credits
Free Electives	1 Credits
Total	128 Credits

Table 4.1. Summary of Michigan Tech BSEE Curriculum

In the BSEE curriculum, “approved electives” are chosen from a broad menu of courses in science, technology, engineering, and mathematics offered across all of Michigan Tech. “Selected approved electives” are chosen from a restricted menu of courses offered primarily in the College of Engineering, effectively creating an engineering distribution requirement.

The curriculum for the Concentration in Biomedical Applications, within the Bachelor of Science in Electrical Engineering, comprises 19 credits of required and elective courses, offered by the Department of Biological Sciences and the Department of Biomedical Engineering, as described in Table 4.2.

To comply with the requirement that the total number of credits for the BSEE degree with the Concentration not exceed 128, the courses required for the Concentration will be used toward BSEE core and elective credit, as summarized in Table 4.3. This requires the following modification to the BSEE degree requirements, which will be allowed only for those students electing the concentration:

- BL 2010 and BL 2020 will be added to the list of approved and select approved electives
- EE 3120, Introduction to Energy Systems, will be removed from the BSEE core requirements, and replaced with BE 2400, Cell and Molecular Biology
- All other BE courses in Table 4.2 will be added to the list of EE electives

Required Courses	13 Credits
BL 2010 Anatomy and Physiology I	
BL 2020 Anatomy and Physiology II	
BE 2400 Cellular and Molecular Biology	
BE 3700 Biomedical Instrumentation	
BE 3701 Biomedical Instrumentation Laboratory (1 credit)	
Focus Area: Choose 1	3 Credits
BE 2800 Biomaterials I: Fundamentals of Matls Science and Engineering	
BE 3300 Biomechanics I: Statics and Dynamics	
Electives: Choose 1	3 Credits
BE 2800 Biomaterials I (not chosen as Focus Area above)	
BE 3300 Biomechanics I (not chosen as Focus Area above)	
BE 3350 Biomechanics II: Soft Tissue and Bio-Fluid Mechanics	
BE 3800 Biomaterials II: Properties and Biological Interactions	
BE 4250 Biomedical Optics	
BE 4610 Biological Microscopy for Engineers	
BE 4770 Biomedical Microcontrollers	
BE 4700 Biosensors: Fabrication and Applications	
BE 4755 Medical Devices	
Total	19 Credits

Table 4.2. Curriculum for Concentration in Biomedical Applications

Free, Approved, and Select Approved Electives	6 Credits
BL 2010 Anatomy and Physiology I	
BL 2020 Anatomy and Physiology II	
EE Core Curriculum	3 Credits
BE 2400 (replaces EE 3120)	
EE Electives	10 Credits
All other BE courses in Table 4.2	
Total	19 Credits

Table 4.3. Application of Concentration Requirements to BSEE Requirements

5. New course descriptions

No new courses are required as part of this concentration.

6. Additional resources required

No additional resources are required, beyond the student and/or teaching support that may be required for the additional undergraduate enrollment that this concentration may bring to Michigan Tech.

7. Accreditation requirements

Students electing the Concentration in Biomedical Applications will see minor changes in the requirements for the Bachelor of Science in Electrical Engineering, as described in Section 4 above. These changes will only be allowed for students electing and completing all the requirements for the Concentration. The Department of Electrical and Computer Engineering will need to document and justify these changes to the degree requirements in the next accreditation cycle (Fall 2017) for their BSEE program accreditation with the Accreditation Board for Engineering and Technology (ABET). The Department has done this previously with the Concentration in Photonics and has not experienced any difficulty.

8. Planned implementation date

Fall 2015.

February 10, 2014

Dan Fuhrmann, Ph.D.
Professor & Chair
Department of Electrical & Computer Engineering
Michigan Technological University

Re: Support for ECE Biomedical Applications Concentration

Dear Dan,

I am writing to express my support for your newly proposed concentration in Biomedical Applications. Cross-disciplinary education at both the undergraduate and graduate levels is the path to the future and one that we must embrace.

The Department of Biomedical Engineering does not see this proposed concentration as a competitive program, nor as a program that is in anyway harmful to the future development of BME at Michigan Tech. In fact, we see it as precisely the opposite. This proposed program will offer new opportunities to students in both disciplines as they prepare themselves to be productive and highly employable engineers.

The medical device industry is one of the key economic drivers in the upper midwestern section of the United States. This concentration within the ECE Department will help to fill the outstanding need for engineers who are classically trained in electrical and computer engineering, while still having a firm introduction to the reality of engineering practice in and around the human body.

In summary this proposed concentration has my highest support and I look forward to working with you and your students as the program matures.

Sincerely,



Sean J. Kirkpatrick, Ph.D.
Professor & Chair
Department of Biomedical Engineering