Engineering Faculty Document No. 26-22

November 2, 2021

TO: The Faculty of the College of Engineering

FROM: The Faculty of the Weldon School of Biomedical Engineering

RE: Changes to Undergraduate Course, BME 45600, Mathematical Models and Methods in Physiology

The Faculty of the School of Biomedical Engineering has approved the following course-level and description changes to an undergraduate course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM: BME 45600: Mathematical Models and Methods in Physiology
Term Offered: Fall, Lecture 3, Cr. 3
Prerequisite: BME 25600

Description: Teaches principles of mathematical modeling applied to the excitable tissues, including peripheral nerves, brain, muscle, and heart. Using small group, problem-based learning, students solve challenging problems involving coupled differential equations, finite element analysis, simulated annealing, and other numerical methods in order to model consequences of assumptions about how excitable tissues work or interact with implanted devices. Creation of custom computer code is required. Written problem descriptions provided by the instructor are extensive and detailed, serving as a "guide on the side" to student groups, while requiring key discoveries to be made by students themselves. Background information for each problem is presented in lectures. Problems are related to topics such as the function of the cochlea, the genesis of the electrocardiogram, and deep brain stimulation for the treatment of Parkinson's disease.

TO: BME 35600: Mathematical Models and Methods in Physiology
Term Offered: Fall, Lecture 3, Cr. 3
Prerequisite: BME 25600

Description: This course uses real-world engineering problems to introduce advanced analytical tools and concepts relevant to biomedical engineering design. Each topic is briefly introduced, and students work in small teams to investigate physical mechanisms involving human anatomy and physiology using mathematical models and methods. Group work is done during scheduled class periods and other times by arrangement. Topics include brain concussions and protective helmets, origin of the electrocardiogram and bi-ventricular pacing, and deep brain stimulation for Parkinson's disease. Mathematical methods include coupled linear and nonlinear differential equations, finite element analysis, and simulated annealing. Creation of custom computer code is required. Students prepare extensive and detailed written technical reports. A midterm and a final examination encourage individual accountability and understanding.

Reason: The BME Undergraduate Curriculum Committee has reviewed this course in the context of the revised curriculum structure and determined that, since the only prerequisite was a 200-level course, and because it aligned with the new pathway courses, this course should be renumbered at the 300-level. This course has been taught very successfully for 3 years as BME 456 with enrollments of 22 in Fall 2019, 28 in Fall 2020 & 32 in Fall 2021. It will be a required course for students in the new Computational Biomedicine pathway.

David M. Umulis
Dane A. Miller Head and Professor
Weldon School of Biomedical Engineering

BME 356 Mathematical Models and Methods in Physiology
Fall 2022

Class time: Mondays 3:30-5:20
Location: MJIS 1097

Course Instructor:
Dr. Charles F. Babbs (babbs@purdue.edu)

Prerequisite:
BME 25600

Course Description: This course uses real-world engineering problems to introduce advanced analytical tools and concepts relevant to biomedical engineering design. Each topic is briefly introduced, and students work in small teams to investigate physical mechanisms involving human anatomy and physiology using mathematical models and methods. Group work is done during scheduled class periods and other times by arrangement. Topics include brain concussions and protective helmets, origin of the electrocardiogram and bi-ventricular pacing, and deep brain stimulation for Parkinson's disease. Mathematical methods include coupled linear and nonlinear differential equations, finite element analysis, and simulated annealing. Creation of custom computer code is required. Students prepare extensive and detailed written technical reports. A midterm and a final examination encourage individual accountability and understanding.

Learning outcomes: Students will learn and practice the following engineering skills: Reviewing anatomy of a selected body organ or system, conducting research on a disease process using the Internet, pronouncing medical terms correctly, creating a biomechanical model of a body organ or tissue, describing the function of a body organ system in terms of algebra, calculus, and/or governing differential equations, evaluating constants in mathematical models on the basis standard normal physiology and routine medical observations, solving second order, linear differential equations by the method of undetermined coefficients, programming in Visual Basic, MATLAB or a suitable computational engine including the use of arrays and subroutines; debugging computer code; testing the validity of numerical methods such as Newton-Raphson, validating mathematical models by comparison with known analytical solutions, solving systems of coupled linear or nonlinear differential equations using numerical methods such as simple Euler or Runge-Kutta, solving systems of simultaneous equations using tools such as simulated annealing, Gauss-Seidel, Gauss-Jordan, creating graphs and charts of results, reconciling theoretical calculations with experimental observations, discussing the strengths and limitations of a particular mathematical model, preparing a bibliography for a technical report, writing, revising, an proofreading detailed technical reports, working in teams in both face-to-face and online environments to enhance productivity and eliminate errors.

Class Attendance: Attendance is required for introductory sessions. Attendance is required also at work sessions during regular class time (3:30 to 5 p.m. Mondays), during which spontaneous oral progress reports may be requested by the staff. Some additional team meetings and work sessions will likely be needed as "homework", and can be scheduled by arrangement within each group. Online collaboration using Google documents is recommended (see docs.google.com), but do not convert Word files into Google document format; it causes trouble with equations.

Course Format: Class sessions are designed to be interactive and task oriented with a minimal number of formal lectures. Groups are required to meet and work on assignments during class time when there is no lecture. To investigate topics students will use the first floor laboratories, small group study rooms, Internet access, and electronic document support. Groups are required to keep current research progress. Faculty and staff may request spontaneous oral progress reports at any time during scheduled class sessions. Faculty and staff will be available to address questions and give encouragement. The written problem statements provided to students on Blackboard are exceedingly detailed and supplied with adequate hints so that students can do challenging, advanced work while avoiding false starts and blind alleys. These written problem statements include instruction and guidance on relevant mathematical methods.

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- All hazards warning (examples of hazards: tornado (severe weather)/hazardous materials release/civil unrest/directed by police personnel) – When you hear the all hazards alarm immediately seek shelter. Continue to a safe location (typically the lowest level of the building in an area without windows).
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- If we hear a fire alarm during class we will immediately suspend class, evacuate the building, and proceed outdoors. Do not use the elevator.
- If we are notified during class of a Shelter in Place requirement for a tornado warning, we will suspend class and shelter in the basement.
- If we are notified during class of a Shelter in Place requirement for a hazardous materials release, or a civil disturbance, including a shooting or other use of weapons, we will suspend class and shelter in the classroom, shutting the door and turning off the lights.
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Students with Disabilities: Any student who feels s/he may need an accommodation based on the impact of a disability should contact the instructor privately to discuss specific needs. Please contact the Disability Resource Center in room 830 Young Hall for more information on reasonable accommodations for students with documented disabilities.

Academic Conduct: Students are expected to behave in a professional and ethical manner in all aspects of this course. Plagiarism, cheating, or other acts of academic dishonesty will not be tolerated. Any infractions whatsoever will result in immediate expulsion from the course and a failing grade for the semester. Instances of plagiarism or cheating will also be reported to the Dean of Students Office to be recorded on your permanent academic record. If an individual behaves in any other manner that is unprofessional or unethical during the semester, the course instructor(s) reserves the right to fail the student for that as well. For more information, see the Purdue University Student Conduct Code at: http://www.purdue.edu/odos/adminstration/codeconduct.htm.

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Strength of Diversity: In this course, each voice in the classroom has something of value to contribute. Please take care to respect the different experiences, beliefs and values expressed by students and staff involved in this course. We support Purdue's commitment to diversity, and welcome individuals of all ages, backgrounds, citizenships, disabilities, education, ethnicities, family statuses, genders, gender identities, geographical locations, languages, military experience, political views, races, religions, sexual orientations, socioeconomic statuses, and work experiences.

Course Assessment

Grade Composition and Grading Scale (subject to change with notice):

- 2 group-based, written technical reports, 60% (grade penalties for lateness)
- 1 individual midterm exam, 15%
- Comprehensive individual final exam, 25%

90-100%	A
80-89%	B
70-79%	C
60-69%	D
00-59%	F

Make-up exams: Given at the discretion of the instructor; format may be different from regular exams. Advance notice, when possible, is highly recommended. Students must adhere to Purdue policy as outlined: http://www.purdue.edu/usp/acad_policies/attendance.shtml

Problem work groups:

- Modified random assignment of group members (see attached list)
- Practice "teaming", including face-to-face and online collaboration
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- Individual grades on technical reports determined from overall report grade and individual grade correction factors based on peer evaluations (see below)

Group dynamics

Teamwork is essential in biomedical engineering. All members of each report writing group are expected to contribute evenly. Rotate roles to enhance the learning experience (lead author, code writer, Power Point maestro, etc.) Encourage quieter members to speak up. Encourage more dominant personalities to listen. Work through minor personal and interpersonal issues with respectful, open communication. If major personal or interpersonal problems arise, contact the instructors and/or counseling staff early-on.

Peer evaluation

To minimize problems with loafing or freeloading by individual members and to mimic the real-world situation in which a person's reputation at work matters, a peer evaluation system will be used in this course. Educational research has shown that having multiple peer evaluations reduces social loafing and increases students' satisfaction with group members' contribution and also the perceived fairness of the project grades (Aggarwal, 2008). The simple, survey-based system that we will use in this course is the most effective and fair yet devised (Zhang and Ohland, 2009). After each technical report is turned in, group members will receive and E-mail with a link to a short survey in which they rate the contributions of all group members, including themselves to the overall success of the project. Individual grades, G_i, will be calculated from the group grade, G_g, as

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TBA	**Final Exam**

Style guide for technical reports

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- Results section including validation of methods, numerical results, presented in Figures and legends as well as Tables in line with the text, positioned for easy reading and accompanied by brief prose descriptions of the results, which never "speak for themselves"
- Discussion including major general principles discovered, limitations of the models and methods, reasons why the limitations can be discounted in this case (otherwise it would have been stupid to proceed)
- Conclusions regarding the biological or medical significance of the results
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Fall 2022

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Dr. Charles F. Babbs (babbs@purdue.edu)

Teaching Assistant:
Position open

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