Engineering Faculty Document No. 48-18

March 21, 2018

TO: The Faculty of the College of Engineering

FROM: The Faculty of the School of Biomedical Engineering

RE: New Undergraduate Course, BME 44000, Computational Mechanics in Biomedical Engineering

The Faculty of the School of Biomedical Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

BME 44000 Computational Mechanics in Biomedical Engineering
Term offered: Fall, Spring, Lecture 3, Cr. 3
Prerequisites: MA 26100 and MA 26200

Description: Teaches modeling methods for biomedical engineering problems with focus on fluid/solid mechanics. Students are introduced to the most common numerical techniques in biomedical engineering and will learn the applications of these techniques to biomechanical problems at various length scales, such as cardiac contraction and blood flow. The first half of this course focuses on modeling based on ordinary differential equation (ODE) and partial differential equation (PDE) as well as on how we integrate these equations analytically or numerically using software packages such as MATLAB. The other half focuses on fundamentals of fluid/solid mechanics and also on the application of COMSOL or similar software to solving relevant biomechanical problems.

Reason: The importance of modeling for investigating biomedical engineering problems has been growing rapidly. This course, teaching modeling methods for various biomechanical problems, is critical to the preparation of biomedical engineers for careers in industry and further research in graduate programs. This course, which is an extension of contents learned in the core course, BME 306, Fundamentals of Biomedical Transport Phenomena, addresses a significant deficit of fluid/solid mechanics within the current BME curriculum. Although there are other courses at Purdue that cover individual modeling methods, this course is unique in that it covers diverse modeling methods focused on the application of the methods specific to biomechanical problems in biomedical fields.

The course has been taught one time previously in Fall 2017, and the student evaluation of this course was very positive.

George R. Wodicka

George R. Wodicka
Dane A. Miller Head and Professor
Weldon School of Biomedical Engineering

BME 44000: Computational Mechanics in Biomedical Engineering

Taeyoon Kim
Office: MJIS 3031
Phone: 4-4797
Email: kimty@purdue.edu
Office Hours: TBD

Course Information
Fall, 2017
MWF 11:30-12:20
MJIS 1083
3 credits

Course Description

This course is intended for senior-level undergraduate students interested in mathematical & computational modeling of biomedical processes and systems. This course focuses mainly on modeling based on ODE/PDE and modeling based on solid mechanics and fluid mechanics, which is the extension of BME 306. The students will be introduced to the most common numerical techniques and will learn the applications of these techniques to biomedical problems at various length scales, using MATLAB and COMSOL.

Prerequisites

This course is recommended for undergraduate students who have taken basic calculus courses and who have taken the biomedical transport fundamentals (BME 304). A minimum experience on writing MATLAB scripts is required.

Learning Outcomes

At the end of the course, students will be able i) to solve physical situations of real biomedical problems by formulating ordinary and partial differential equations and solving the equations via MATLAB, ii) to investigate complicated fluid flows observed in biomedical systems by applying knowledge in fluid mechanics and using COMSOL, and iii) to analyze stress and strain of biomedical materials by applying continuum mechanics and using COMSOL.

Required Texts

Required: Modelling Organs, Tissues, Cells and Devices: Using MATLAB and COMSOL Multiphysics, 1st edition. S. Dokos. Springer. 2017. (ISBN: 3642548008)

Grading

The following grading scale is just for your reference. Based on ensemble class performance, final grades will be curved up by the instructor if appropriate.

> 90%	A
80-90%	B
70-80%	C
60-70%	D
< 60%	F

Participation - 10%
For participation score, class attendance (5%) and student involvements (5%) will be counted. Students are expected to attend all the classes unless they have permission for absence in advance. In addition, students will obtain extra credits by actively participating in classes (asking critical questions or answering questions from the instructor).

Homework - 20%
Problem sets will be assigned in order to check how well students are progressing in learning course materials. Unless specified, all homework problems are due at the beginning of a lecture in one week.

Term project – 20%
In a term project, each student will delve deeply into one topic relevant to the course. The project can be devoted to a design or analysis effort related to biomedical problems. Students will write a 5-page concise report in scientific format consisting of introduction, methods, preliminary results, conclusions, and future work. Additional information regarding the term project will be provided later.

Midterm & final examinations - 25% per each
There will be two exams. These exams are designed to assess the extent of students' understanding about course materials.

Policies

Academic Dishonesty
Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, and knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section III-B-2-a, Student Regulations] Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972]

Use of Copyrighted Materials
Students are expected, within the context of the Regulations Governing Student Conduct and other applicable University policies, to act responsibly and ethically by applying the appropriate exception under the Copyright Act to the use of copyrighted works in their

activities and studies. The University does not assume legal responsibility for violations of copyright law by students who are not employees of the University.

A Copyrightable Work created by any person subject to this policy primarily to express and preserve scholarship as evidence of academic advancement or academic accomplishment. Such works may include, but are not limited to, scholarly publications, journal articles, research bulletins, monographs, books, plays, poems, musical compositions and other works of artistic imagination, and works of students created in the course of their education, such as exams, projects, theses or dissertations, papers and articles.

Attendance
Students are expected to be present for every meeting of the classes in which they are enrolled. Only the instructor can excuse a student from a course requirement or responsibility. When conflicts or absences can be anticipated, such as for many University sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency absences when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email, or by contacting the main office that offers the course. When the student is unable to make direct contact with the instructor and is unable to leave word with the instructor's department because of circumstances beyond the student's control, and in cases of bereavement, the student or the student's representative should contact the Office of the Dean of Students.

Missed or Late Work
Late homework or late lab assignments will be accepted only in a next day after the due date with 50% penalty.

Grief Absence Policy for Students
Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for misses assignments or assessments in the event of the death of a member of the student's family.

Violent Behavior Policy
Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity.

Emergencies
In the event of a major campus emergency, course requirements, deadlines, and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

Accessibility and Accommodations
Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Nondiscrimination
Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit www.purdue.edu/report-hate to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.

Disclaimer
This syllabus is subject to change.

Class Schedule

Week	Topic
1	Introduction of a course and mathematical/computational modeling
2	Lumped parameter modeling with ordinary differential equations (ODEs)
3	Numerical integration of ODEs
4-5	Distributed systems modeling with partial differential equations (PDEs)
6	Fundamentals of the finite element method
7	Solid mechanics principles

8	Linear elasticity Example: Detecting tension in a respirator strap
9	Linear viscoelasticity Example: Micropipette aspiration of a cell
10	Hyperelastic material Example: myocardial shear
11-12	Fluid mechanics principles Example: laminar flow through a circular tube
13	Navier-Stokes equation and non-laminar flow Example: drug delivery in a coronary stent
14	Electric circuit analogues for blood flow Example: Aortic blood flow Blood as a non-Newtonian fluid Example: axial streaming of a blood cell
15	Term project presentation

Learning Outcomes

At the end of the course, students will be able

i) to solve physical situations of real biomedical problems by formulating ordinary and partial differential equations and solving the equations via MATLAB,

ii) to investigate complicated fluid flows observed in biomedical systems by applying knowledge in fluid mechanics and using COMSOL,

iii) to analyze stress and strain of biomedical materials by applying continuum mechanics and using COMSOL.