

TO: The Engineering Faculty

FROM: The Faculty of the Weldon School of Biomedical Engineering

RE: New 600-level course – BME 65500: Multiscale modeling in Biomedical Engineering

The Faculty of the Weldon School of Biomedical Engineering has approved the following new 600-level course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM:

BME 69500: Multiscale modeling in Biomedical Engineering

Alternate Fall (Even)

3 credit Lecture

This course has been offered in 2019 (6 students), 2020 (6 students), 2022 (19 students) and 2024 (24 students).

TO:

BME 65500: Multiscale modeling in Biomedical Engineering

Alternate Fall (Even)

3 credit Lecture

Course description:

This is a 600-level course that will focus on current frontiers in modeling multiscale phenomena. The course is intended for graduate students interested in advanced computational modeling. Traditional modeling approaches focus on one scale, e.g. macroscale continuum models or microscale molecular dynamics models, population scale epidemiology, whole host biology, or single cell signaling dynamics. These models are remarkably successful in engineering applications where the smaller scales can be modeled by relatively simple constitutive relations or in analyses of microscopic behavior where it can be assumed that the process is homogeneous at larger scales. This one-scale approach, however, is not well suited for problems with complex hierarchy of spatial and time scales or with population heterogeneity, such as those common in biomedical engineering. For example, there are disparate time scales in the progression of an atherosclerotic plaque or a range of spatial scales affecting the functions and treatment of biological tissues and organs. The course will introduce state-of-the-art modeling techniques, address their limitations and review emergent papers that attempt to address multiscale modeling. Examples of biomedical problems involving disparate scales in time and space will be discussed. The course will discuss the following topics specifically for multi-scale models: multiscale model

construction, coupling solutions at disparate scales, data integration, sensitivity and uncertainty analyses, and model verification.

RATIONALE:

This course provides robust and hands-on training in multi-scale mechanistic modeling across a wide array of biomedical applications. It brings multi-scale perspectives to key foundational concepts like data integration, sensitivity analysis, data transfer, verification/validation, translation. By keeping these discussions general, while using real world applications as touch-stones, the course allows students to apply new concepts to their own research areas. BME 65500 also contributes to the BME PhD and Master's degree requirements and can be counted as the 600-level credits, BME credits, or quantitative/analytical credits in their plan of study. It is complementary to other courses on modeling and analysis, such as Continuum Models in Biomedical Engineering, Quantitative Systems Biology, Dynamical Systems Optimization, Numerical Methods in Biomedical Engineering and is especially valuable (in combination with BME 695 Quantitative Systems Biology) to students in the Computational Biomedicine research area. Additionally, we have had successful students from Mechanical Engineering, the PULSe program and Biological Sciences enrolled.

This course has been offered very successfully under a temporary number 4 times (in Spring 2019, and Fall in 2020, 2022 and 2024) with growing enrollment (6, 6, 19 and 24, respectively) and with student evaluation scores averaging in the 4.6 to 4.9 range.

 11/20/2024

Head of the Weldon School of Biomedical Engineering

Link to Curriculog entry: <https://purdue.curriculog.com/proposal:30721/form>



Course Information

- **Course number and title:** BME695 Multiscale modeling in Biomedical Engineering
- **CRN:** 23023
- **Meeting day(s) and time(s):** Tuesday/Thursday 9:00 – 10:15 AM
- **Instructional Modality:** Face-to-face
- **Course credit hours:** 3
- **Prerequisites (if any):** Students taking the course are expected to be familiar with traditional computational modeling techniques.

Instructor(s) Contact Information

- **Name of the instructor(s):** Dr. Elsje Pienaar
- **Office Location:** MJIS 3074
- **Office Phone Number:** 765-494-4682
- **Purdue Email Address:** epienaar@purdue.edu
- **Student consultation hours, times, and location:** You are welcome and encouraged to meet with me outside regular class times to discuss course content and group project progress. Please email me to schedule an appointment.

I will respond to emails between 9am and 5pm on weekdays. Please be mindful of my time constraints as assignment deadlines approach. Please begin your email subject with BME695.

Course Description

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While each topic will be introduced in overview lectures, the students are expected to work with literature in order to discuss the state-of-the-art and relevant examples. The class will be subdivided in groups, each assigned a journal paper to be presented and discussed with the rest of the class. In order to facilitate learning through implementation of a multiscale approach, the course will have a project where students will propose and develop a multi-scale model for a biomedical problem involving multiple scales. Students are welcome to work on their thesis-related model or on any multiscale problem of their choice. The project will be discussed throughout the semester, including two midterm progress reports and the final presentation and written report summarizing the project results. In addition to the course project, presentations of the reviewed papers and participation in class discussions will be considered for the grade assessment.

Learning Resources, Technology & Texts

We will use Brightspace to assign and submit assignments, for online discussions, and for sharing course materials. Any course updates will be posted to Brightspace announcements, so please make sure your alerts are activated if you don't check Brightspace regularly.

The use of **artificial intelligence (AI) or Large Language Models (LLM)** in this course is allowed in the project assignments. HOWEVER, this usage MUST be explicitly acknowledged at the start of the reports and presentations. This acknowledgement should include a clear description of which parts of the report/presentation contain AI-supported or AI-generated content, as well as how the AI tools were used in these sections.

The use of AI and LLM are NOT allowed for the discussion board posts. These are meant to be an online version of our classroom group discussions, so they need to be your own thoughts and your own words.

Please be very careful in how you use these resources, to ensure that you don't undermine your own learning of the fundamental concepts and skills.

Learning Outcomes

- Identify and articulate multi-scale phenomena in biomedical systems
- Critically analyze and discuss a variety of multi-scale modeling techniques
- Identify and implement appropriate multi-scale techniques for a defined biomedical system
- Quantitatively evaluate multi-scale model results (uncertainty quantification, sensitivity analysis, verification and validation)

Assignments

Your final grade will be calculated based on the following assessments:

- Literature reviews and discussion: 30%
- Milestone 1 project presentation/report 1: 20%
- Milestone 2 project presentation/report 2: 20%
- Final project presentation: 15%
- Final project written report: 15%

Rubrics will be provided for the presentations and reports.

Late Submission Policy

If an assignment is submitted after the deadline, we will still grade the submission if we receive it within 12 hours of the original deadline. Beyond 12 hours, we will still grade the submission, but we will subtract 50% from what your original grade would have been.

Attendance Policy

This course is designed in a hybrid model, with some face-to-face interactions and other interactions completed remotely via discussion boards. University policy states that students are expected to be present for every meeting of the classes in which they are enrolled. For the purposes of this course, being "present" means attending all face-to-face meetings unless you are ill or need to be absent for reasons excused by University regulations: grief/bereavement, military service, jury duty, parenting leave or certain medically excused absences (go to the [Office of the Dean of Students \(ODOS\) website](#) for details on how to submit those requests).

Being "present" also means participating remotely and completing work assigned for days when we do not meet face-to-face. This work is required to help you meet the course learning outcomes. These times count toward the course contact hours and your course grade.

Academic Guidance in the Event a Student is Quarantined/Isolated

If you must miss class at any point in time during the semester, please reach out to me via Purdue email so that we can communicate about how you can maintain your academic progress. If you find yourself too sick to progress in the course, notify your adviser and notify me via email. We will make arrangements based on your particular situation.

Course Schedule

Week 1 – Aug 19	<i>Introduction to multi-scale models</i>	<i>Moderating: Dr. Pienaar</i>
Week 2 – Aug 26	<i>Introduction to multi-scale models</i>	<i>Moderating: Team #2</i>
Week 3 - Sep 2	<i>The Hierarchy of Physical and Biomedical Models</i>	<i>Moderating: Team #8</i>
Week 4 – Sep 9	<i>Milestone 1 presentations: Course project proposal for a multiscale model in BME</i>	
Week 5 – Sep 16	<i>Problems with disparate time scales</i>	<i>Moderating: Team #9</i>
Week 6 – Sep 23	<i>Model coupling and data transfer across scales</i>	<i>Moderating: Team #6</i>
Week 7 – Sep 30	<i>Biomedical Digital Twins – Virtual conference attendance during Tuesday class time.</i>	<i>Moderating: Team #3 Dr. Pienaar</i>
Week 8 – Oct 7	<i>Tues - October break Thurs – Office hours for project discussions (please email if you intend to attend)</i>	
Week 9 – Oct 14	<i>Milestone 2 presentation: Course project preliminary data and progress report</i>	
Week 10 – Oct 21	<i>Uncertainty quantification and sensitivity analysis</i>	<i>Moderating: Team #7</i>
Week 11 – Oct 28	<i>Data integration</i>	<i>Moderating: Team #3 + #4</i>
Week 12 – Nov 4	<i>Validation and verification</i>	<i>Moderating: Team #5</i>
Week 13 – Nov 11	<i>Student selected papers</i>	<i>Moderating: Team #1</i>
Week 14 – Nov 18	<i>Final course project presentations</i>	
Week 15 – Nov 25	<i>Tues – Office hours for final project discussions (please email if you intend to attend) Thurs – Thanksgiving break</i>	
Week 16 – Dec 2	<i>Final report due – Friday 5pm</i>	

This schedule is subject to change. Changes will be announced and posted on Brightspace.

Equity and Inclusion

In our discussions, structured and unstructured, we will explore a variety of challenging issues, which can help us enhance our understanding of different experiences and perspectives. This can be challenging, but in overcoming these challenges we find the greatest rewards. While we will design guidelines as a group, everyone should remember the following points:

- We are all in the process of learning about others and their experiences. Please speak with me, anonymously if needed, if something has made you uncomfortable.
- Intention and impact are not always aligned, and we should respect the impact something may have on someone even if it was not the speaker's intention.
- We all come to the class with a variety of experiences and a range of expertise, we should respect these in others while critically examining them in ourselves.

Netiquette

Your instructor and fellow students wish to foster a safe online learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to comment, question, or critique an idea, but you are not to attack an individual. Our differences, some of which are outlined in the University's nondiscrimination statement below, will add richness to this learning experience. Please consider that sarcasm and humor can be misconstrued in online interactions and generate unintended disruptions. Working as a community of learners, we can build a polite and respectful course ambience.

Please read the Netiquette rules for this course:

- Do not dominate any discussion. Give other students the opportunity to join in the discussion.
- Do not use offensive language. Present ideas appropriately.
- Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.
- Avoid using vernacular and/or slang language. This could possibly lead to misinterpretation.
- Keep an "open-mind" and be willing to express even your minority opinion.
- Think and edit before you push the "Send" button.
- Do not hesitate to ask for feedback.

A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

Nondiscrimination Statement

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 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. A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

Accessibility

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. More details are available on our course Brightspace under Accessibility Information.

Classroom Guidance Regarding Protect Purdue

Any student who has substantial reason to believe that another person is threatening the safety of others by not complying with Protect Purdue protocols is encouraged to report the behavior to and discuss the next steps with their instructor. Students also have the option of reporting the behavior to the [Office of the Student Rights and Responsibilities](#). See also [Purdue University Bill of Student Rights](#) and the Violent Behavior Policy under University Resources in Brightspace.

Academic Integrity and Conduct

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-

8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace under University Policies.

You are expected to behave in a professional and ethical manner in all aspects of this course. Plagiarism or cheating will result in a zero for that particular assignment. Instances of unethical behavior will be reported to the Dean of Students Office and will result in a grade reduction of at least one letter grade. If an individual behaves unprofessionally or unethically during the semester, the instructor reserves the right to fail the student. For more information, see Purdue University Student Conduct Code at: http://www.purdue.edu/usp/acad_policies/student_code.shtml. This conduct includes online exchanges.

Re-grade Policy

Students have the right to contest any grade throughout the semester. In the event that a student feels an assignment has been inappropriately graded, the student must submit a one page, typed document indicating the source of the problem and an explanation for the re-grade submission. The original assignment must be returned with the protest explanation.

Mental Health/Wellness Statement

If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try [WellTrack](#). Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the [Office of the Dean of Students](#). Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc., sign up for free one-on-one virtual or in-person sessions with a [Purdue Wellness Coach at RecWell](#). Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is free and can be done on BoilerConnect.

If you're struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact [Counseling and Psychological Services \(CAPS\)](#) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office on the second floor of the Purdue University Student Health Center (PUSH) during business hours. The [CAPS website](#) also offers resources specific to situations such as COVID-19.

Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it relates to COVID-19, students may submit requests for emergency assistance from the [Critical Need Fund](#)

Emergency Preparation

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.