PURDUE UNIVERSITY | College of Engineering

Engineering Faculty Document
No.: 111-23
March 28, 2023

TO: The Engineering Faculty

FROM: The Faculty of the Weldon School of Biomedical Engineering

RE: New 500-level course – BME 54200 Cell & Tissue Mechanics

The Faculty of the Weldon School of Biomedical Engineering has approved the following new 500-level course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM:

BME 59500 Cell & Tissue Mechanics
Term offered: Spring or Fall
3 credit Lecture
Requisites, Restrictions, and Attributes: BME only
Previously offered in Spring 2018 (6 enrolled), Fall 2020 (5 enrolled), Spring 2022 (8 enrolled)

TO:

BME 54200 Cell & Tissue Mechanics
Term offered: Typically offered Fall of odd years
3 credit Lecture
Restriction: Graduate standing OR
Prerequisites: MA 26200 OR MA 26500 and MA 26600, AND BIOL 23000

DESCRIPTON:

This course develops and applies scaling approaches and simplified models to biomechanical phenomena at molecular, cellular, and tissue level. Topics include: Molecular forces; Viscous drag; Brownian motion; Diffusion; Polymer mechanics; Polymer dynamics; Molecular motors; Cytoskeleton; Viscoelasticity; Membrane; Cell migration; Cell adhesion; Mechanobiology; Mechanotransduction; Elastic, viscoelastic, and poroelastic behavior of tissues & Cell-matrix interaction.

RATIONALE:

Various areas in biomedical engineering are deeply involved with biological processes. Many of the physiological and pathophysiological phenomena studied in biomedical engineering areas originate from mechanical interactions between cells and extracellular environments. In this course, students will learn about the mechanical behaviors and properties of cells and tissue that are core to biomechanics and mechanobiology. It will help graduate students in BME conduct their research related to biomechanics and mechanobiology and also will serve as an advanced biomechanics course for senior undergraduate students who chose the BME

biomechanics/biomaterials pathway. In addition, this course will be taught every other year when the other cell and tissue mechanics course is not offered at the Indianapolis campus of BME so that students can take the course every year.

It has been offered at least 3 times previously with student evaluation scores ranging from 3.86-4.86. It is also being added in Fall 2023 as a core BME course for engineering professional students in the online BME concentration through Purdue Engineering Online.

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

Link to Curriculog entry:
https://purdue.curriculog.com/proposal:24253/form

Course Information

- **Course number and title:** BME 54200, Cell & Tissue Mechanics
- **Meeting day(s) and time(s)**: Fall 2023, TR 10:30-11:45am
- **Instructional Modality:** Face-to-Face for PWL students and Async-Online for the online section participants
- **Course credit hours:** 3
- **Prerequisites**: This course is recommended for undergraduate students who have taken introductory courses related to differential equations MA 26200 or (MA 26500 and MA 26600) AND molecular cell biology (BIOL 23000).

Instructor Contact Information

- **Name of the instructor:** Taeyoon Kim
- **Office Location:** MJIS 3031
- **Office Phone Number:** 4-4797
- **Purdue Email Address:** kimty@purdue.edu
- **Student consultation hours, times, and location**: By appointment

Course Description

This course develops and applies scaling approaches and simplified models to biomechanical phenomena at molecular, cellular, and tissue level. Topics include: Molecular forces; Viscous drag; Brownian motion; Diffusion; Polymer mechanics; Polymer dynamics; Molecular motors; Cytoskeleton; Viscoelasticity; Membrane; Cell migration; Cell adhesion; Mechanobiology; Mechanotransduction; Elastic, viscoelastic, and poroelastic behavior of tissues & Cell-matrix interaction.

Learning Resources, Technology & Texts

Recommended:

- C.R. Jacobs, H. Huang, R.Y. Kwon, Introduction to Cell Mechanics and Mechanobiology, 2012, ISBN: 9780429171277
- D. Boal, Mechanics of the Cell, 2001, ISBN: 9780511810954
- J.D. Humphrey and S.L. O'Rourke, An Introduction to Biomechanics, 2015, ISBN: 978-1-4939-2622-0

They may be freely accessed online at:

- https://www.taylorfrancis.com/books/mono/10.1201/9781135042653/introduction-cell-mechanics-mechanobiology-christopher-jacobs-ronald-kwon-hayden-huang
- https://www.cambridge.org/core/books/mechanics-of-the-cell/F9489BBA03A685F638DCDFFC54AA67FE
- https://link.springer.com/book/10.1007/978-1-4939-2623-7

Learning Outcomes

The student who successfully completes this course will be able to:

- analytically solve basic biomechanics problems or estimate their approximate solutions
- utilize gained knowledge to interpret experimental results related to biomechanics and characterize them in the form of equations
- develop computational models for biological systems or design experiments

Assignments

Your achievement of course learning outcomes will be assessed through a combination of participation, term project, homework, and midterm and final exams spread throughout the academic period. Details on these assignments and exams, including a schedule of due dates, rubrics to guide evaluation, and guidelines on discussion participation and evaluation will be posted on the course website.

Assignments	Due	Points
Participation	Throughout the semester	10
Homework	Throughout the semester	20
Term project	The end of the semester	20
Midterm exam	TBD	25
Final exam	Final week	25
		Total: 100

- Participation (10 points): During lectures, several questions will be asked via Hotseat and other mechanisms, which will be counted for participation score.
- Homework (20 points): This assignment relates to all course learning objectives, and students will i) solve given equations and find their solutions in either an analytical or approximated manner, ii) interpret given experimental data to derive mathematical equations for a constitutive relationship between quantities, and iii) write MATLAB scripts to describe simple biological systems as well as propose experimental designs to study biological problems.
- Term project (20 points): Students will choose either the single-paper critique (in which students choose and critically analyze one journal article) or the sub-field review (in which students choose 5 journal articles and review research areas). Students need to submit a short report at the end of a semester.
- Midterm and final exams (25 points per each): It will consist of a mix of short answer and long-answer questions. More details will be shared in the Brightspace.

Grading Scale

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

Attendance Policy

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.

Course Schedule

Week	Topic & Readings	Assignments
Week 1	Introduction of biomechanics Molecular forces	None
Week 2	Viscous drag Diffusion	Homework 1
Week 3	Polymer mechanics	None
Week 4	Polymer dynamics	None
Week 5	Molecular motor Experimental & computational techniques at molecular scales	Homework 2
Week 6	Cytoskeleton	None
Week 7	Viscoelasticity	None
Week 8	Membrane	Homework 3
Week 9	Application of scaling approaches	None
Week 10	Cell migration and adhesion	None
Week 11	Experimental & computational techniques at cell scale	Homework 4
Week 12	Mechanical behaviors and properties of tissues	None
Week 13	Mechanical behaviors and properties of tissues	None
Week 14	Cell-matrix interaction	Homework 5
Week 15	Mechanobiology Mechanotransduction	Report of the term project

* Schedule and assignments subject to change. Any changes will be posted in the learning management system.

Academic Integrity

Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or 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]

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 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.

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.

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.

Emergency Preparedness

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.