AME 416
Mechanics and Transport in Medicine and Biology
Units: 4 (MW 4-5:50 PM)

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Teaching Assistant: TBD
Office: TBD
Office Hours: TBD
Contact Info: TBD

Course Description

This course provides an analytical and theoretical introduction to the mechanics and transport phenomena of biological systems. Topics include scaling in biology, modeling physiological and biological systems (dimensional analysis), biological forces in fluids and solids, Fick's law, Darcy's law, surface tension, viscosity, pressure, Bernoulli equation, Poiseuille flow, stress, strain, viscoelasticity, mechanics of living organs, transports in living organs, bio-inspired design, and special topics. No prior background in physiology or biology is needed.

Learning Objectives and Academic Rationale

After taking this course, the students will be able to analyze the mechanics of living organs, cells, and other biological systems from a mechanical viewpoint. They will learn how to tackle unsolved problems in biology and how to address the unmet clinical need in medicine using basic principles of fluid mechanics, solid mechanics, and transport phenomena. Overall, students will be able to use laws of mechanics to link mechanical insights back to physiological and biological functions. While this course is designed mainly to prepare mechanical engineering students for careers in the biotech industry and research in medical and bio-related fields, it can also serve other engineering, biology, and medical students who are interested in understanding the mechanics and transport phenomena of biological systems.

Prerequisite(s): N/A

Co-Requisite(s): None
Concurrent Enrollment: None
Recommended Preparation: Fundamental physics and the understanding of static forces at the level of AME 201 and differential equations at the level of MATH 245 are recommended.

Course Notes
Letter grade. Copies of lecture slides and other class information will be provided.

Technological Proficiency and Hardware/Software Required
None
Grading Breakdown

<table>
<thead>
<tr>
<th>Assessment Tool (assignments)</th>
<th>Points</th>
<th>% of Grade</th>
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<tbody>
<tr>
<td>Homeworks</td>
<td>600 (100(hw))</td>
<td>20%</td>
</tr>
<tr>
<td>Midterm exam</td>
<td>100</td>
<td>30%</td>
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<tr>
<td>Final Exam</td>
<td>100</td>
<td>30%</td>
</tr>
<tr>
<td>Final Project</td>
<td>100</td>
<td>20%</td>
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<tr>
<td>TOTAL</td>
<td>900</td>
<td>100%</td>
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Grading Scale
Course final grades will be determined using the following scale
A 93-100
A- 87-92
B+ 80-86
B 73-79
B- 67-72
C+ 60-66
C 53-59
C- 47-52
D+ 40-46
D 33-39
D- 27-26
F 26 and below

Textbook:
Required textbook:

The following textbooks are suggested as supplements to the required text book, lecture notes, and handouts:

Description and Assessment of Assignments
Problem sets and final project: Collaboration is allowed for problem sets. Details about the final project and Homework assignments are provided below.

Homework assignments: HWs are usually assigned on Mondays and due dates will be two weeks from the assigned dates. The typical hours for each HW assignment is eight hours. Collaborations are allowed for HWs. Equations and formulas that have been derived in the class can be directly used in HW problems.
**Final project:** The final project can be one of the following: 1- Comprehensive review of an application of mechanical engineering or transport phenomena in biology or medicine (e.g. fluid dynamics of Glaucoma), 2- Computational modeling of a physiological system (e.g. deformation of red blood cells), 3-analytical modeling of a physiological or biological system (e.g. hip modeled as a ball and socket joint), and 4- experimental investigation of the mechanics of a biological or physiological system (pressure wave reflection in coronary network). Working as a group is allowed if the workload of the project can be justified. Maximum number of people allowed in each group is two.

**Final project timeline:**
- Week 11: Final project proposal due (team member, topics, and milestone)
- Week 15: Project presentation
- Last day of final exams: Final project report due

**Final project report component:** It must include an abstract, introduction/background, methods (not required for comprehensive review projects), result/discussion, and future direction.

**Final project report format:** It must be at least 12 pages for comprehensive reviews (without references) and 8 pages for numerical simulation, analytical, and experimental projects (without references), typed, single-spaced, and maximum margin of 1” on each side. It must include an introduction, conclusion, and references.

**Sample project:** “The Effects of Space Flight on Human Body Biofluid Mechanics”. The student will review seminal and recent articles and suggest improvements in design based on what they learned in class.

**Grading breakdown of the final project:**
- Proposal: 10%
- Presentation: 30%
- Final report: 60%

**Assignment Submission Policy**
Problem sets must be submitted as a hard copy (printout) in the class. No assignments will be accepted past the due date. In cases you cannot make it to campus, it is your responsibility to email a good-quality scan of HW to a classmate who can submit a printout on your behalf. The final project proposal and report can be submitted as hard copy, pdf, or MS word.

**Additional Policies**
- Final grade will depend entirely on the performance on the above components, and be independent of the financial support requirements (e.g., minimum grade requirement for tuition reimbursement).
- Work-related travel must be scheduled during time periods outside of the mid-term and final exams. Accommodation to take exams on different dates will be made for only family emergencies and documented illness or health-related emergencies. Other exceptions will be considered on a case-by-case basis.
- Curved grading will be applied

**Course Schedule: A Weekly Breakdown**

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Topics/Daily Activities</th>
<th>Readings and Homework</th>
<th>Deliverable/ Due Dates</th>
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<tbody>
<tr>
<td></td>
<td>Scaling and Modeling in Biology and Medicine</td>
<td>Pages 53-69.</td>
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<tr>
<td>Week 2</td>
<td>Diffusion, Fick’s law, Surface Tension, Osmotic Effects</td>
<td>Pages 119-129, Homework 1</td>
<td>HW1 assigned</td>
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<tr>
<td>Week 3</td>
<td>Viscosity, Flow regimes, Pressure, Drag and Lift</td>
<td>Pages 129-142, Homework 1</td>
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<tr>
<td>Week 4</td>
<td>Conservation laws, Poiseuille flow, Streamlines</td>
<td>Pages 143-163, Homework 2</td>
<td>HW2 assigned/HW1 due</td>
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<tr>
<td>Week 5</td>
<td>Bernoulli equation and its application in biology &amp; medicine</td>
<td>Pages 419-427, Homework 2</td>
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<td>Week 6</td>
<td>Bio-solid mechanics I: Material properties, Stress, Strain</td>
<td>Pages 428-443, Homework 3</td>
<td>HW3 assigned/HW2 due</td>
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<td>Week 7</td>
<td>Bio-solid mechanics II: Structures, Buckling</td>
<td>Pages 164-178, Homework 3</td>
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<td>Week 8</td>
<td>Viscoelasticity</td>
<td>HW4 assigned/ HW3 due</td>
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<td>Midterm exam</td>
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<td>Week 9</td>
<td>Hemodynamics, Dynamics of Microcirculation</td>
<td>Pages 179-239, Homework 4</td>
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<td>Week 10</td>
<td>Mechanics of a Living Organ: Cardiovascular System</td>
<td>Pages 240-249, Homework 5</td>
<td>HW5 assigned/ HW4 due</td>
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<tr>
<td>Week 12</td>
<td>Mechanics of a Living Organ: Respiratory System</td>
<td>Pages 332-378, Homework 6</td>
<td>HW6 assigned/ HW5 due</td>
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<tr>
<td>Week 13</td>
<td>Mechanics of a Living Organ: Skeletal System</td>
<td>Pages, 379-439, Final project proposal</td>
<td>Project report/at final exam date</td>
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<tr>
<td>Week 14</td>
<td>Special Topics</td>
<td>HW6 due</td>
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<tr>
<td>Week 15</td>
<td>Special Topics</td>
<td></td>
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<tr>
<td>Final Exam</td>
<td></td>
<td>Date: For the date and time of the final exam for this class, consult the USC Schedule of Classes at classes.usc.edu.</td>
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Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” https://policy.usc.edu/scampus-part-b/. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
https://studenthealth.usc.edu/counseling/
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 - 24/7 on call
http://www.suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press "0" after hours - 24/7 on call
https://studenthealth.usc.edu/sexual-assault/
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086/Title IX - (213) 821-8298
https://equity.usc.edu/, http://titleix.usc.edu/
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
https://usc-advocate.symplicity.com/care_report/
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776
http://dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Campus Support and Intervention - (213) 821-4710
https://uscsa.usc.edu/
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
https://diversity.usc.edu/
Information on events, programs and training, the Provost’s Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

**USC Emergency - UPC:** (213) 740-4321, **HSC:** (323) 442-1000 – 24/7 on call
http://dps.usc.edu/ , http://emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

**USC Department of Public Safety - UPC:** (213) 740-6000, **HSC:** (323) 442-1200 – 24/7 on call
http://dps.usc.edu
Non-emergency assistance or information.