BioE 104: Biotransport

Instructor: Anand Subramaniam, PhD

Catalog Description: Introduces methods for deriving and solving differential equations that govern the transport of momentum, mass, and energy. Applications include quantitative modeling of transport in biological and biomedical systems.

Course Objectives: This course presents, through bi-weekly lectures and one section, an opportunity for students to explore a variety of techniques for applying conservation equations of mass and momentum to living and non-living systems. The course uses advanced mathematical techniques for solving problems. As such, this course addresses certain ABET outcome criteria at a variety of levels.

Specific Outcomes: By the end of the course, students should be able to:

1. Understand conservation of mass, momentum, and energy as applied to the flow of mass and fluids.
2. Use control-volume analysis to formulate governing equations for simple flow and mass transport geometries.
3. Analyze complex fluid flows via approximate analytical tools.
4. Derive appropriate conservation equations, select boundary conditions, and apply analytical and computational techniques to solve flow and mass transfer problems in biological and medical systems.
5. Estimate fluid behavior in compliant structures and u20teady flows.
6. Specify characteristics of fluid and mass transport components in bio/medical systems.

Outcomes Addressed by this Course:

A. An ability to apply knowledge of mathematics, science, and engineering.

E. An ability to identify, formulate, and solve engineering problems.

L. An understanding of biology and physiology.

M. The capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology.

Prerequisites:

1. BIO 002: Introduction to Molecular Biology
2. MATH 024: Linear Algebra and Differential Equations
3. PHYS 009: Introductory Physics II for Physical Sciences or PHYS 009H: Honors Introductory Physics II for Physical Sciences or PHYS 019: Introductory Physics II for Biological Sciences

Course Policies:

Academic Dishonesty Statement:

a. Each student in this course is expected to abide by the University of California, Merced's Academic Honesty Policy. Any work submitted by a student in this course for academic credit will be the student's own work.
b. You will gain the most from this class if you come prepared. Please do the readings prior to class and participate actively in class discussions.
c. You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of an e mail, an e mail attachment file, a diskette, or a hard copy. Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Policy can also be extended to include failure of the course and University disciplinary action.
d. During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

Disability Statement:

Accommodations for Students with Disabilities: The University of California Merced is committed to ensuring equal academic opportunities and inclusion for students with disabilities based on the principles of independent living, accessible universal design and diversity. I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances. Students are encouraged to register with Disability Services Center to verify their eligibility for appropriate accommodations.

Textbooks:

Transport Phenomena in Biological Systems (2nd Edition)**,** George A. Truskey, Fan Yuan, David F. Katz. Pearson

Topics:

	Day		**Chapter from Truskey**	**HW**
Week 1	August 22	Introduction		

Week 2	August 27	Fluid Kinematics: Control Volume, Velocity Field, Flow Rate	2.2, 2.2.2	PS 1 Assigned
	August 29	Acceleration	2.2.4	
Week 3	September 3	Labor Day		
	September 5	Forces: The stress tensor	2.3.3	
Week 4	September 10	Newton' s Law of Viscosity, Non-Newtonian Rheology	2.5.1, 2.5.2	
	September 12	Conservation of Mass, Momentum, Boundary Conditions, Flow-Induced by a Sliding Plate	2.3.1, 2.3.2, 2.3.4, 2.7.1	PS 1 due, PS 2 assigned
Week 5	September 17	Pressure-Driven Flow through a Narrow Rectangular Channel	2.7.2	
	September 19	Pressure-Driven Flow through a Cylindrical Tube; Flow of a Power Law Fluid through a Cylindrical Tube	2.7.3, 2.7.4	
Week 6	September 24	Laminar and Turbulent Flow, Surface Tension, Membrane and Cortical Tension	2.4.2, 2.4.3, 2.6	
	September 26	Differential Form of the Equation of Conservation of Mass in Three Dimensions	3.2.1, 3.2.2	PS 2 due
Week 7	October 1	**Midterm 1**		
	October 3	Differential Form of the Conservation of Linear Momentum	3.3.1	PS 3
Week 8	October 8	Differential Form of the Conservation of Linear Momentum and Navier-Stokes, Pressure-Driven Flow through a Cylindrical Tube	3.3.2	
	October 10	Flow-Between Rotating Cylinders		
Week 9	October 15	Fluid Statics and Gravity-Driven Flow		

	October 17	Fluid Motion with More than One Dependent Variable	3.41	
Week 10	October 22	Time to Establish Steady Flow in a Channel	3.4.2	
	October 24	Dimensional Analysis and Dimensional Groups	3.5.1	PS 3 Due
Week 11	October 29	**Midterm 2**		
	October 31	Conservation Relations, Boundary Conditions. Fick's Law of Diffusion	6.3.1. 6.3.2,6.4.1	Self-Study (6.1-6.2)
Week 12	Nov 5	Steady-state Diffusion	6.7.1, 6.7.2, 6.7.3	
	Nov 7	Unsteady Diffusion: Point Source Infinite Domain	6.8.2	PS 4 assigned
Week 13	Nov 12	Veteran's Day		
	Nov 14	Quasi-Steady Transport Across Membranes: 1D Finite Domain	6.8.4	
Week 14	Nov 19	Fick's Law of Diffusion and Solute Flux, Conservation of Mass of Dilute Solutions	7.1	
	Nov 21	Non-Instructional Day		
Week 15	Nov 26	Fick's Law of Diffusion and Solute Flux, Conservation of Mass of Dilute Solutions		
	Nov 28	Dimensional Analysis	7.4	
Week 16	December 3	Electrolyte Transport	7.5	
	December 5	Diffusion and Convection	7.6	PS 4 due, Self-Study (7.7, 7.8)
	December 8	Final Exam		

Class Schedule: Monday, Wednesday, 10:30-11:45 am. Kollig 217

Assessment/Grading Policy:

- 20% Section Participation and Problem Sets
- 20% Midterm#1 (in-class 90 minute exam)
- 20% Midterm#2 (in-class 90 minute exam)
- 30% Final Exam (in-class 90 minute exam)

- 10% Attendance, in-class participation, in class quizzes (Attendance percentage will be multiplied with the average of in class quizzes. The two lowest quiz grades will be dropped). Additional points may be added as described in class.

  All exams are closed book. No makeup midterm exams will be given. Final exam grade may be substituted for one midterm if your final grade is higher.

Homework: Problem sets are due in class at the end of class of the due date.

1. Begin each question on a new sheet of paper
2. Write your name at the top of every page
3. Write the names of collaborating students at the top of the first page for each problem. Collaboration and group work is encouraged to enhance learning.
4. Show all work/calculations (i.e. numerical answers that do not show which formulas and/or calculations were used will not receive full credit, even if the answer is correct)
5. If you use Excel, MATLAB, etc. to answer a question print out your excel sheet/MATLAB code/etc.

Homework Collaboration Policy:

1. List all students that worked together at the top of each problem.
2. Each student must write up his or her own solutions.
3. Failure to do this may result in the assignment being discounted, and possibly more serious consequences.

Late Homework Policy:

Homework handed in after the end of class will be considered late.

Lateness	**Total taken off HW score**
Same day (After HW is collected in class	20 %
2nd Day	40 %
3rd Day (Last day to hand in HW)	60 %

Grading Scheme

A+	98-100
A	90-98
A-	87-89

B+	84-86
B	79-83
B-	74-78
C+	70-74
C	65-70
C-	60-65
D	57-60
F	<57

Teaching Fellow: Vaishnavi Girish

Contact Information:

Anand Subramaniam

Office: SE2- 291

Email: asubramaniam@ucmerced.edu

Office Hours:

By appointment