BIOE 420: Transport Phenomena in Bioengineering

Fall 2024

Instructor

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BRC 765

Teaching Assistants

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Office Hours

Weekly instructor office hours will be held on Fridays from 11:00am to 12:00pm over Zoom (link will be provided on Canvas). In addition, TA office hours will be held on an ad hoc basis around problem set due dates and exams. TAs will announce dates and times at least one week in advance so you may plan ahead. For best results, please arrive with specific questions.

Course Description

This course will cover transport phenomena as applied to bioengineering systems. Equations for conservation of momentum, mass, and energy will be derived and used to characterize transport of fluids, mass, and energy in biology, physiology, and in biomedical devices. This course synthesizes much of the content learned in BIOE 252 and 322, and applies knowledge from BIOE 372 and 391. This course is designed for senior bioengineering students.

Prerequisites: MATH 211, MATH 212, (BIOE 332 or CHBE 411), and BIOE 391

Course Objectives

By the end of the course, students will demonstrate the ability to:

1. Employ applied mathematical skills to solve complex engineering problems
2. Apply governing equations for momentum transport (Newton's law of viscosity, Navier-Stokes equations)
3. Apply governing equations for mass transport (Fick's law, diffusion and convection/diffusion)

Textbook

This course will use *Transport Phenomena in Biological Systems, 2nd Edition* by Truskey, Yuan, and Katz. A reference copy of the textbook will be made available to students in BRC 230, but *it must stay in the lab*. Removal of any reference copies will result in severe penalties.

Students may find it helpful to also consult the following optional supplemental textbooks: *Transport Phenomena, Revised 2nd Edition* by Bird, Stewart, and Lightfoot; *Problems for Biomedical Fluid Mechanics and Transport Phenomena* by Johnson and Ethier.

Attendance Policy

Students are required to attend all lectures to complete in-class problems and exams. Exceptions for illness (including days necessary for mental health), family emergencies, or other excusable absences may be granted with instructor approval on a case-by-case basis. Any make-ups for valid absences must be done at the convenience of the instructor.

Grading Policy

Category	Submissions	Total points	% Final grade
Problem sets, drop two lowest grades (x5)	Canvas	100	20%
Take home exams (x4)	Canvas	400	80%

Regrade policy: It is inevitable that errors in grading will occur. If you believe that an error was made in grading your assignments, you should directly email the instructor a short justification of your claim. The deadline for regrade requests is one week after the assignment was returned. I will review your claim and regrade your assignment if appropriate.

Late policy: Problem sets will be penalized 50% of the total assignment value per day.

Earned letter grade: There is no curve in this course – what you see is you get! The earned letter grades will follow conventional numerical standards based on the cumulative percentage of assignment scores:

- A+: ≥ 97, A: ≥ 93, A–: ≥ 90
- B+: ≥ 87, B: ≥ 83, B–: ≥ 80
- C+: ≥ 77, C: ≥ 73, C–: ≥ 70
- D+: ≥ 67, D: ≥ 63, D–: ≥ 60
- F: < 60

Honor Code Policy

Collaboration is accepted on problem sets and group exams. However, you may not consult the materials from previous years' BIOE 420 courses, including but not limited to: lecture notes, in-class problems and quizzes, problem sets, and exams. Additionally, while you may collaborate on problem sets, your submitted work must reflect your individual efforts. In other words, you cannot submit another student's work as your own. For group exams, you may only collaborate with your assigned group.

In simpler terms, only submit work that is your own or your group's, where appropriate. If you need clarification, please contact the instructor *prior to submission* to avoid an infraction. For a list of standard definitions as outlined by the Honor Council, please see this link.

Commitment to Equitable Learning

This class is committed to an equitable learning environment. Accommodations will be made for students with alternative needs, but it is critical that you alert the instructor in advance of any additional resources you need prior to assignment submission and the final exam. In particular, you must notify the instructor of any alternative testing needs *at least two weeks prior to an exam*. For additional resources and more information, please visit the Disability Resource Center and the Access and Opportunity portal.

Schedule

Please see the Rice University Academic Calendar for other important administrative dates.
Unit 1: Introduction to transport and basic flow
Unit 2: Navier-Stokes equations and momentum transport
Unit 3: Introduction to mass transport and diffusion
Unit 4: Advanced mass transport

Lecture/Date	Topic	Truskey chapter, pages	Assign. due
0 (08/26)	Intro to transport; cons. of mass & momentum	Ch. 1, 2: p. 1–11, 53–67	
1 (08/28)	Couette flow; Newton's Law of Viscosity	Ch. 2: p. 74–79, 82–88	
09/02	Labor Day: No class		
2 (09/04)	Couette flow cont.; gen. problem solving strategy		
3 (09/09)	P-driven flow thru narrow rect. channel	Ch. 2: p. 88–92	PS1
4 (09/11)	P-driven flow thru cyl. tube	Ch. 2: p. 92–97	
09/16	Extra lecture/practice problems for Exam 1		PS2
09/18-09/20	**Exam 1**		
5 (09/23)	Math review		
6 (09/25)	Gen. form of cons. of mass and momentum	Ch. 3: p. 120–131	Exam 1 corr.
7 (09/30)	Navier-Stokes equations	Ch. 3: p. 131–136	PS3
8 (10/02)	Fluid motion with more than one variable	Ch. 3: p. 136–145	
10/07	Extra lecture/practice problems for Exam 2		PS4
10/09-10/11	**Exam 2**		
10/14	Midterm recess: No class		
9 (10/16)	Intro to mass transport, Fick's laws	Ch. 6: 259–269	
10 (10/21)	1D steady-state diffusion	Ch. 6: p. 288–300	Exam 2 corr.
11 (10/23)	1D unsteady diffusion in semi-∞ medium	Ch. 6: p. 300–310	
12 (10/28)	1D unsteady diff. in semi-∞ med, cont.		PS5
13 (10/30)	1D unsteady diffusion in finite medium	Ch. 6: p. 310–316	
14 (11/04)	1D unsteady diffusion in finite medium, cont.		
11/06	Extra lecture/practice problems for Exam 3		PS6
11/08-11/11	**Exam 3**		
15 (11/13)	Gen. form of mass transport equations	Ch. 7: p. 346–355	
16 (11/18)	Diffusion and convection	Ch. 7: p. 370–376	Exam 3 corr.
17 (11/20)	Diffusion and convection, cont.		
11/25 and 11/27	Thanksgiving week: No class		
12/02	Extra lecture/practice problems for exam 4		PS7
12/04-12/06	**Exam 4**		
Finals			Exam 4 corr.