BME 344-LA: Transport in Biological Systems Lab (Spring 2023)

Meeting Times: Thursday 2:00 – 4:50 pm
Classroom Location: McLean B11 (Basement)
Instructor: Professor Jinho Kim (McLean 302, jkim6@stevens.edu)
Contact Info: Office: McLean 302, Email: jkim6@stevens.edu, Phone: 201-216-5518
Office Hours: Thursday 12:00 pm – 2:00 pm (or by appointment)
Teaching Assistants: Mr. Erfan Sarhaadei (McLean 304, esarhaad@stevens.edu)

Lab Description and Class Schedule

This laboratory course consists of five sections, each of which contains a central experiment and writing focus. These experiments are designed to demonstrate principles discussed in the lectures as well as to help students familiarize with basic principles and methods used widely in biomedical engineering to study transport phenomena in the human body. The writing lab reports associated with each experiment will teach students how to write a specific component of a formal report. The five sections of this course include the experimental topic as shown in the table below:

	BME344 LA (Thursday 2:00 pm – 4:50 pm)	
Lab #	**Date**	**Topic**
Intro	01/19	Course introduction
1	02/02	Hydrostatics
2	02/16	Microfluidic devices
3	03/02	Computational Fluid Dynamics (CFD)
4	03/30	Surface tension
5	04/13	Diffusion

Although all submitted work must be completed on an individual basis, for the actual experimentation, students will be required to work in teams, as shown in the schedule below. ***Attendance is mandatory! Failure to attend (and participate) in the experiments will result in a failing grade***.

Students must alert the TA or the instructor of any scheduling conflicts as early as possible. Students may be required to submit proof of a scheduling conflict (e.g., note from coach or doctor) to the Office of Undergraduate Academics. ***In the event of a scheduling conflict after group placement has occurred, the student will be responsible for making the necessary arrangements to switch groups with another student*** or make up the experiment with the TA. If a student misses a class, regardless of whether or not they have an official excused absence, it is the student's responsibility to contact the TA ***within one week of the missed lab*** in order to make up the assignments. Failure to do so will result in a grade of 0 for all related assignments.

Experimental Objectives

1. Lab #1 (Hydrostatics): A simple experiment related to hydrostatics will be demonstrated. In particular, we will investigate depth-dependent hydrostatic pressures within a fluid. This experiment is primarily meant to complement information presented in the lecture portion of the course.

2. Lab #2 (Microfluidics): Students will learn how to produce polydimethylsiloxane (PDMS)-based microfluidic devices, which can be created on the microscale and used to mimic biofluid movements such as the blood flowing through the capillary. The objective of this experiment is to observe flow through macroscopic PDMS channels and learn how such channels can be created on the microscale.

3. Lab #3 (Computational Fluid Dynamics): This lab will focus on the basic principles and calculations behind Computational Fluid Dynamics (CFD) through a geometrically defined construct. Using COMSOL Multiphysics® software, students will observe differences in fluid flow (e.g., velocity, pressure, shear stress) under different conditions that represent biofluids, such as blood flow in the blood vessel and airflow in lung.

4. Lab #4 (Surface tension): The fourth experiment will focus on measurement of force generated by surface tension. We will study the Laplace pressure created by capillary action within narrow glass tubes or channels.

5. Lab #5 (Diffusion): The fifth experiment will focus on simulation and quantification of the rate of diffusion across a semipermeable membrane that recapitulate the cell membrane. After obtaining spectrophotometric data, students will perform a series of calculations in order to determine quantities such as particle accumulation and flux and, ultimately, determine whether steady state or non-steady state diffusion has occurred.

Expected Outcomes

General

- I can work in a team to complete experiments and share data.
- I understand the purposes of each section (Abstract, Introduction, Materials & Methods, Results, Discussion, and References) within a formal report.

Lab #1: Hydrostatics

- I understand the relationship between depth and hydrostatic pressure.
- I can calculate pressure at a specified depth within a fluid.

Lab #2: Microchannel fabrication and imaging

- I understand how PDMS devices can be fabricated.
- I understand how PDMS devices can be used to study fluid flow phenomena.

Lab #3: Computation of Fluid Dynamics using COMSOL Multiphysics®

- I can use COMSOL Multiphysics® software to simulate fluid flow through 2D microchannels.
- I can analyze results based on pressure, velocity, shear rate, and Reynolds number.

Lab #4: Surface tension

- I can measure the contact angle of the meniscus generated within the tube.
- I can calculate the theoretical height of a column of fluid based on the radius of tube.
- I can measure the contact angle of a droplet on the flat and tilted surface

Lab #5: Diffusion across a membrane

- I understand how spectrophotometry can be used in a diffusion experiment.
- I can calculate and graph accumulation and flux to analyze diffusion.

Grading Policy for Labs

All submitted work must be completed as a report prepared and submitted by a group of 3-4 students. All grades will be posted on Canvas. Please be proactive in checking your scores to ensure that your grades have been recorded correctly. The grade components and weights are as follows:

Protocol Quizzes	**25%**
Lab Report	**75%**

1. Protocol Quizzes (25%)

- It is expected that students familiarize themselves with the experiment protocol and applicable material safety data sheets (SDSs) prior to each corresponding lab session. This is to ensure a safe laboratory environment for everyone.
- The necessary study materials such as ***lab introduction & procedure documents will be posted by Monday of the week you will perform the experiment***.
- Quizzes on the protocol will be given ***at the start of each session***. Additionally, to ensure adequate comprehension of the experimental procedures and topics, quizzes may also be given ***immediately following the completion of each lab***.
- Grades for each quiz will be posted within a week after each lab.

2. Lab Report (75%)

- Each group (3 or 4 students) is required to submit one lab report for each lab as a team.
- ***Lab report is due exactly one week after your experiment, unless otherwise noted.*** *Submit your lab report electronically ***through Canvas by 5pm on the due date***.
- You can collect, organize, and start entering background information related to the lab into their reports prior to attending each class.
- In your report, include lab title, group members name, date, objective, hypothesis, full procedure, results, and discussions (see the table below).
- You can take photos during experiment and include them in your report, if you would like.
- Each group ***will receive grade on their report at least one week in advance of the date of the next experiment***.
- Each lab entry should contain and/or will be graded based on the following rubric:

Lab Report Grading Rubric	**/10**		
Experiment Background Info Title/topic of the lab; date the lab was performed; names of any students the lab was performed with	0	1	
Objective & Hypothesis Briefly, what we are doing in the experiment and why; *appropriate* hypothesis	0	1	
Procedure Correct (what we actually did); enough detail to be used to repeat experiment 6+ months later	0	1	2
Results *All* raw and subsequent data (e.g., tables, images); calculations explained fully with equations and any assumptions; all taped/pasted additions *initialed & dated transversing the page*	0	1	2
Discussion Points Summary of major findings of experiment; Sources of error; Future directions, etc.	0	1	
Timely Completion & Professionalism Lab title, signature, and date on every page; cross out and initial & date empty space	0	1	
Table of Contents & Page Numbers The Table of Contents (1st page in lab report) should direct the reader to at least the first page of every experiment; page numbers should be in the upper, outer corner of every page	0	1	
Neatness Single cross-outs for any mistakes (no obliterations); legible handwriting; adequate use of space	0	1	

Grading Scale

Letter grade	Final score
A	94-100%
A-	90-94%
B+	87-90%
B	84-87%
B-	80-84%
C+	77-80%
C	74-77%
C-	70-74%
D+	67-70%
D	64-67%
D-	61-64%
F	0-61%

Lab Safety

- As a laboratory course, safe lab practice is mandatory.
- Long hair and loose clothing must be confined.
- Footwear must be able to provide protection from chemical spills and dropped objects, a leather or canvas product is best.
- Sandals and footwear with perforations are not acceptable.
- Long pants and shirts must be worn to protect body parts.
- Horseplay in the lab will not be tolerated, and if you are kicked out, you will not be able to make up the lab.
- Students are expected to familiarize themselves with the experiment protocol and applicable material safety data sheets (SDSs) prior to attending class.