

San José State University College of Engineering
Department of Biomedical Engineering
BME 117, Biotransport Phenomena, Fall 2022

Course and Contact Information

Instructor:	Melinda Simon
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Office Hours:	Tuesday: 11:00 AM- 12:00 PM Friday: 12:30-1:30 PM
Class Days/Time:	Tuesday: 12:00 – 1:15 PM Thursday: 12:00 – 1:15 PM
Classroom:	ENG 329
Prerequisites:	BME 115, Math 123 or Math 133A, BME 130

Course Format

Technology Intensive, Hybrid, and Online Courses

The course adopts a “flipped” format. Links to pre-recorded lectures will be posted to Canvas, to be viewed before attending class. Class meeting times will be used to check comprehension of the material presented in the lectures and work through problems together. In addition to the regular class meeting times, a “recitation” session will be held on selected Thursdays (communicated through Canvas), where students will have the opportunity to work through additional practice problems together in groups, and then with the instructor. It is *encouraged, but not required*, that you attend these recitation sessions. In class, each student is required to have an internet-connected device (e.g. smartphone, tablet, laptop) to be used exclusively for learning-related activities, including the iClicker technology available at SJSU.

Faculty Web Page and MYSJSU Messaging

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on the Canvas learning management system course website. All communications relevant to the course will be sent out using the Canvas messaging system (Canvas email and announcement board). You are responsible for regularly checking with the messaging system through Canvas to learn of any updates.

All content-related questions can either be addressed in-person during office hours, or posted on the Canvas discussion board for the class. The instructor will *not* respond to content-based inquiries over email. Posting questions on the Canvas discussion board will allow the entire class to have access to clarifications and assistance with course material. Emails to the instructor are to be used exclusively for messages which contain personal or sensitive information (i.e. medical illness notification, question about course grade).

Course Description

Applications of fundamentals of thermodynamic and kinetic aspects of momentum and mass transport phenomena to biological systems. Development of quantitative description of transport processes beginning from the molecular level to entire organ systems. Prerequisite: BME 115, Math 123 or Math 133A, BME 130 all with C- or better.

BME 117 builds on the conservation principles developed in BME 115 and applies them to systems of increasing complexity. While BME 115 took a generalized approach, we will begin to consider systems at a finer level of detail and attempt to understand the dynamics of momentum and mass transport in biological systems. The course focuses more on quantitative analysis of physical, chemical, and biological systems. Along the way, we will build capability with numerical solution techniques via MATLAB/Octave and COMSOL.

Course Learning Outcomes

Upon successful completion of this course, students will be able to:

1. **identify** basic components of biological transport phenomena and their function;
2. **apply** engineering approaches and prescribed problem solving techniques to modeling momentum and mass transport in biological systems;
3. **analyze** the physical, chemical, and biological aspects of a system at multiple scales and multiple levels of complexity and detail;
4. **identify** the relationships and laws that govern the flow of biological fluids, as well as the variables of interest;
5. **select** the appropriate frame of reference for describing the flow of biological fluids;
6. **explain** the effect of fluid properties and constitutive behavior on fluid flow;
7. **describe** the unique aspects of blood rheology and cardiovascular flows;
8. **apply** Ohm's law for fluidics to relevant physiological situations;
9. **explain** the role of biotransport phenomena in the development of some major disease conditions;
10. **solve** simple biotransport problems analytically using MATLAB/Octave;
11. **work** in teams to complete specified course assignments (exams must be individual work);

Required Texts/Readings

Textbook

Ostadfar A., Biofluid Mechanics, Principles and Applications, 1st Edition, Academic Press (2016), electronic version (.pdf) *available free of charge to SJSU students* via the MLK library.

Other Readings (optional)

- Rubenstein D.A., Yin W., and Frame M.D. Biofluid Mechanics: An Introduction to Fluid Mechanics, Macrocirculation, and Microcirculation, Second Edition, Academic Press (2015) *1st edition available free of charge to SJSU students* via the MLK library.
- Truskey G.A., Yuan F., Katz D.F., Transport Phenomena in Biological Systems, Prentice Hall (2009).
- Humphrey J.D. and Delange S., An Introduction to Biomechanics: Solids and Fluids, Analysis and Design. Springer (2004).

Other technology requirements: iClicker

You will have several options available to participate in clicker sessions:

iClicker REEF app (iOS, Android, web app): Allows you to use your smartphone, tablet, or even laptop in class as a clicker to participate.

Clicker Remote: You can request to borrow a Clicker remote from eCampus (eCampus@sjsu.edu) for free. Remotes are to be returned to eCampus at the end of the semester.

How to set up an iClicker account and add a course

Follow the instructions available on the dedicated eCampus webpage (Student Resources section) at <http://www.sjsu.edu/ecampus/teaching-tools/reef/index.html>.

Library Liaison

Anamika Megwalu

Phone: (408) 808-2089

Email: anamika.megwalu@sjsu.edu

Course Requirements and Assignments

Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally three hours per unit per week) for instruction, preparation/studying, or course related activities, including but not limited to internships, labs, and clinical practice. Other course structures will have equivalent workload expectations as described in the syllabus. More details about student workload can be found in University Syllabus Policy S16-9 at <http://www.sjsu.edu/senate/docs/S16-9.pdf>.

Attainment of the learning objectives (as listed above) will be assessed via homework, in-class quizzes (iClicker), two mid-term examinations, the final examination, and the term project.

Homework

Homework assignments will include questions and problems related to the materials covered in the lectures, as well as assignments that require the use of MATLAB.

Students are expected and encouraged to work together on assignments. However, submitted homework should be individual work. **Late assignments** will be assessed 1.5%/hour off of the maximum possible score. The lowest homework grade will be dropped at the end of the semester.

Under no circumstances will assignments be accepted via email to the instructor. Homework assignments must be submitted via Canvas.

Canvas lecture video quizzes

Periodically, students will be assigned a quiz in Canvas, which will cover the content of the lecture videos provided for viewing before class. These quizzes are intended to promote viewing of the lecture videos before class, so that students obtain the most benefit possible from the synchronous class time.

In-class quiz (iClicker)

There will be regular in-class quizzes based on multiple-answer questions. iClicker will be used as a student response system in class. iClicker helps the instructor to understand what you know and gives everyone a chance to participate in class. iClicker will NOT be used to keep track of attendance. Refer to the Grading Policy and Student Technology Resources section for additional details on iClicker.

Term project

All students are required to complete a term project. The project will focus on the use of MATLAB/Octave to solve a set of biotransport problems analytically and numerically. To successfully complete the term project, students will need a good understanding of the laws governing biotransport phenomena, and be able to correctly formulate biotransport problems in MATLAB. Acquaintance with the software tools is essential, as well as a good understanding of the unique aspects and limitations of each of those environments.

The requirements for the project report and the evaluation criteria will be posted on Canvas. A final project report will be submitted by the students through Canvas, along with all the scripts created by the students.

You will have the opportunity to evaluate the contributions of each of your group members with submission of the final report. Students with no contribution will receive no credit for the term project.

Late submissions of the term project report are strongly discouraged. However, under exceptional circumstances and *pending instructor approval*, in case of late submission of the term project report, points will be deducted as follows:

- . One day late: -10%
- . Two days late: -25%
- . Three days late: -50%

No submission will be accepted later than three days after the deadline. Please note that this late submission policy only applies to the term project assignment.

NOTE that University policy F69-24 at <http://www.sjsu.edu/senate/docs/F69-24.pdf> states that “Students should attend all meetings of their classes, not only because they are responsible for material discussed therein, but because active participation is frequently essential to insure maximum benefit for all members of the class. Attendance per se shall not be used as a criterion for grading.”

Midterm examinations

There will be two mid-semester examinations. Each examination will cover the *entire* course material covered until the time of the examination (i.e. comprehensive). Examinations may include multiple-choice questions, open-ended questions, and problems. During the exam, students can have only a non-programmable scientific calculator. Internet-connected devices, books and notes are not allowed.

The tentative dates of the mid-semester examinations are indicated in the Lecture Schedule.

Final Examination

The final examination will be held on the date and time stipulated by SJSU’s Final Examination Schedule for the particular semester. The final examination will cover the *entire* course material covered during the semester. The final examination may include multiple-choice questions, open-ended questions, and problems. During the exam, students can have only a non-programmable scientific calculator. Internet-connected devices, books and notes are not allowed.

Grading Information

Letter Grades:

A+	> 97%
A	> 93% – 97%
A-	> 90% – 93%
B+	> 87% – 90%
B	> 83% – 87%
B-	> 80% – 83%
C+	> 77% – 80%
C	> 74% – 77%

C-	> 70% – 73%
D	> 60% – 70%
F	< 60%

Determination of Grades

Grades will be determined based on all the assignments and examinations, weighted as reported in the table below:

Homework	10%
Canvas lecture video quizzes	5%
iClicker quizzes	+ 2% (extra credit)
Midterm 1	20%
Midterm 2	20%
Final Exam	30%
Term Project	15%

Absence during examinations, without prior approval, will result in a zero. Prior approval will be given only under exceptional circumstances. Please contact the instructor as soon as possible if you have such a situation.

Note that “All students have the right, within a reasonable time, to know their academic scores, to review their grade-dependent work, and to be provided with explanations for the determination of their course grades.” See University Policy F13-1 at <http://www.sjsu.edu/senate/docs/F13-1.pdf> for more details.

Classroom Protocol

Attendance and arrival times

Students are expected to be set up for lecture by the time the class begins. Attendance in class is not mandatory and shall not be used per se as a criterion for grading. However, class attendance and participation are highly recommended.

Behavior

Students should remain respectful of each other at all times. Students will respect a diversity of opinions, ethnicities, cultures, and religious backgrounds. Interruptive or disruptive attitudes are discouraged. While in the classroom, the use of electronic devices (laptops, tablets, smartphones) **MUST** be limited to activities closely related to the learning objectives. While in the classroom, electronic devices should not be used for personal communication, including messaging and use of social media. All cell phones must be silenced prior to entering the classroom.

Safety

Students should familiarize themselves with all emergency exits and evacuation plans. In particular, if the class meeting ends in the evening, students should be aware of their surroundings when exiting the building, and are encouraged to carry a cell phone for emergency communications.

University Policies

Per University Policy S16-9, university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate Programs’ Syllabus Information web page at <http://www.sjsu.edu/gup/syllabusinfo/>. Make sure to review these policies and resources.

BME 117, Biotransport Phenomena, Fall 2022 Course Schedule

(subject to change with fair notice)

Week	Date	Lecture topics, Workshops, Examinations	Reading (Ostadfar)
1	Aug 23	Introduction to Biotransport phenomena. The syllabus	
	Aug 25	Introduction to Fluid Mechanics. Kinematic quantities (acceleration)	1.1.2 - 1.1.4
2	Aug 30	Kinematics. Frames of reference. (ang. velocity, vorticity)	
	Sept 1	MATLAB workshop 1 – introduction to MATLAB, plotting	1.2.1, 1.2.2, 1.2.8
3	Sept. 6	Kinematics. Frames of reference.	1.2.2, 1.2.7, 1.2.8
	Sept. 8	Kinetics. Stress and Pressure. Constitutive behaviors	1.2.3, 6.1, 6.3, 7.2, 7.4
4	Sept. 13	Blood rheology. Hemocompatibility. Blood cell damage	
	Sept. 15	Fluid statics. Manometers.	
	Sept. 20	Midterm 1 review	
6	Sept. 22	Midterm 1 exam	
	Sept. 27	Reynolds Transport Theorem. Conservation principles	
7	Sept. 29	Navier-Stokes equations	1.2.10, 1.2.11, 1.2.12
	Oct. 4	Navier-Stokes equations	1.2.4, 1.2.5, 1.2.6, 1.2.13, 1.2.16
8	Oct. 6	Steady flows. Exact solutions - Poiseuille flow	1.2.14, 1.2.15, 1.2.17
	Oct. 11	Laminar and turbulent flows. MATLAB workshop 2 - Plotting N-S exact solutions	1.2 sections 4,5, 6, 13,16
9	Oct. 13	Blood flow in the capillaries - Hagen-Poiseuille equation and Ohm's law for fluidics	8.3-8.5
	Oct. 18	Inviscid flow. Bernoulli equation.	
10	Oct. 20	COMSOL workshop 1 - Poiseuille and Couette flow	
	Oct. 25	Midterm 2 review	
11	Oct. 27	Midterm 2	
	Nov. 1	Mass transport in the human body. Fick's laws of diffusion	
12	Nov. 3	Steady-state diffusion in one dimension	
	Nov. 8	Transport through Porous Media	1.2.16, 1.2.17, 2.3-2.5, 3.6
13	Nov. 10	COMSOL workshop 2 – Diffusion	
	Nov. 15	Mass transport in the lungs. Blood oxygenation. Part I	3.8 (short section)
14	Nov. 17	Mass transport in the lungs. Blood oxygenation. Part II	
	Nov. 22	Mass transport into tissue. Krogh cylinder model.	4.2.4 - 4.2.6

15	Nov. 24	Thanksgiving break – no class	4.2.4 - 4.2.6
	Nov. 29	Mass transport in capillaries. Osmotic pressure, Starling equation.	
16	Dec. 1	Mass transport in the kidneys. Blood filtration.	3.3
	Dec. 6	Mass transport in the kidneys. Blood filtration.	4.3
		FINAL EXAM	