San José State University
College of Engineering
Department of Biomedical Engineering
BME 117, Biotransport Phenomena, Spring 2019

Course and Contact Information

Instructor:	Melinda Simon
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Office Hours:	Thursday: 12:00-1:00 PM Tuesday: 5:00-6:00 PM
Class Days/Time:	Tuesday: 1:30 – 2:45 PM Thursday: 1:30 – 2:45 PM
Classroom:	CL 222
Prerequisites:	**BME 115, Math 123 or Math 133A, BME 130**

Course Format

Technology Intensive, Hybrid, and Online Courses

The course adopts traditional lecturing as a primary teaching method, combined with in-class problem solving 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.

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 (formerly REEF Polling)

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, formerly REEF Polling), 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/Octave.
Students are expected and encouraged to work together on assignments. However, submitted homework should be individual work. Homework must be turned in at the **beginning of class** on the due date. **Late assignments** will be assessed 10%/day off of the maximum possible score. Homework not submitted in class will be subject to a late penalty.

In-class quiz (iClicker, formerly REEF Polling)

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/Octave. Acquaintance with the software tools is essential, as well as a good understanding of the unique aspects and limitation of each of those environments.
The requirements for the term paper 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. The report must include an Acknowledgments section indicating the specific contributions of each student. 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. 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+	> 67% – 70%
D	> 64% – 67%
D-	> 60% – 63%
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%
Midterm 1	20%
Midterm 2	20%
Final Exam	35%
Term Project	15%
Extra-credit (iClicker)	2%

Participation with iClicker will be the **only** extra credit assignment. *Participating* in at least 75% of the iClicker quizzes over the semester is necessary to obtain the extra credit.

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, included 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.

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Course Schedule

(subject to change with fair notice)

Week	Date	Lecture topics, Workshops, Examinations	Reading (Ostadfar)
1	Jan 24	Introduction to Biotransport phenomena. The syllabus	
2	Jan 29	Introduction to Fluid Mechanics. Kinematic quantities	1.1.2 - 1.1.4
2	Jan 31	***MATLAB workshop 1 – introduction to MATLAB, plotting***	
3	Feb 5	Kinematics. Frames of reference.	1.2.1, 1.2.2, 1.2.8
3	Feb 7	Kinetics. Stress and Pressure. Constitutive behaviors	1.2.2, 1.2.7, 1.2.8
4	Feb 12	Blood rheology. Hemocompatibility. Blood cell damage	1.2.3, 6.1, 6.3, 7.2, 7.4
4	Feb 14	***MATLAB workshop 2 – Integration, writing a function***	
5	Feb 19	Fluid statics. Manometers.	
5	Feb 21	**Midterm 1 review**	
6	Feb 26	**Midterm 1 exam**	
6	Feb 28	Reynolds Transport Theorem. Conservation principles	
7	March 5	Navier-Stokes equations	1.2.10, 1.2.11, 1.2.12
7	March 7	Steady flows. Exact solutions. Laminar and turbulent flows	1.2.4, 1.2.5, 1.2.6,
8	March 12	Hagen-Poiseuille equation and Ohm's law for fluidics	1.2.14, 1.2.15
8	March 14	Unsteady flow. Womersley solution.	1.2 sections 4,5, 6, 13,16
9	March 19	***MATLAB workshop 3 –problems with time steps, Bessel***	
9	March 21	**Midterm 2 review**	
10	March 26	**Midterm 2 exam**	
10	March 28	Inviscid flow. Bernoulli equation.	
11	April 2	**Spring Recess – no class**	
11	April 4	**Spring Recess – no class**	1.2.13
12	April 9	Flow rate measurement – flow rate, blood pressure, respiration	8.3-8.5
12	April 11	Flow in compliant arteries. Optimal arterial design. Murray's	1.2.16, 1.2.17, 2.3-2.5
13	April 16	*Guest Lecture: Echo-Doppler and PC-MRI (in vivo)*	
13	April 18	In-vitro biofluid mechanics: PIV. In silico modeling: CFD	15.1
14	April 23	Mass transport in the human body. Fick's laws of diffusion	3.6
14	April 25	Mass transport in the lungs. Blood oxygenation. Part I	4.2.4 - 4.2.6
15	April 30	Mass transport in the lungs. Blood oxygenation. Part II	4.2.4 - 4.2.6
15	May 2	Mass transport into tissue. Krogh cylinder model.	
16	May 7	Mass transport in capillaries. Osmotic pressure, Starling	3.3
16	May 9	Mass transport in the kidneys. Blood filtration.	4.3
	May 17	**FINAL EXAM (12:15 - 14:30)**	