

**San José State University**  
**College of Engineering**  
**Department of Biomedical Engineering**  
**BME 117, Biotransport Phenomena, Spring 2020**

**Course and Contact Information**

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<b>Office Hours:</b>	Tuesday: 12:30 - 1:30 PM Thursday: 12:30 - 1:30 PM
<b>Class Days/Time:</b>	Tuesday: 1:30 – 2:45 PM Thursday: 1:30 – 2:45 PM
<b>Classroom:</b>	E 331
<b>Prerequisites:</b>	<b>BME 115, Math 123 or Math 133A, BME 130</b>

**Course Format**

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 [Canvas Learning Management System course login website](http://sjsu.instructure.com) at <http://sjsu.instructure.com>. 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.

**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. **evaluate** the interaction between flow and blood vessels using simple analytical approaches;
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, 1<sup>st</sup> Edition, Academic Press (2016), electronic version (.pdf) *available free of charge to SJSU students* via the MLK library.

### Other Readings

- Rubenstein D.A., Yin W., and Frame M.D. Biofluid Mechanics: An Introduction to Fluid Mechanics, Macrocirculation, and Microcirculation, Second Edition, Academic Press (2015)
- 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](mailto: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](http://www.sjsu.edu/ecampus/teaching-tools/iclicker/index.html) (Student Resources section) at <http://www.sjsu.edu/ecampus/teaching-tools/iclicker/index.html>.

## Library Liaison

Anamika Megwalu

Phone: (408) 808-2089

Email: [anamika.megwalu@sjsu.edu](mailto: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](http://www.sjsu.edu/senate/docs/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.

### 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/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. Students will work in teams of two. 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 paper.

**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.

## 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.

NOTE that [University policy F69-24](http://www.sjsu.edu/senate/docs/F69-24.pdf) 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."

## Grading Information

### Letter Grades

*A plus* = 97 to 100%  
*A* = 93% to 97%  
*A minus* = 90% to 93%  
*B plus* = 87% to 90%  
*B* = 83% to 87%  
*B minus* = 80% to 83%  
*C plus* = 77% to 80%  
*C* = 74% to 77%  
*C minus* = 70% to 73%  
*D plus* = 67% to 70%  
*D* = 64% to 67%  
*D minus* = 60% to 63%  
*F* = 60% or lower

### 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) = 1%

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](http://www.sjsu.edu/senate/docs/F13-1.pdf) 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](http://www.sjsu.edu/senate/docs/S16-9.pdf) (<http://www.sjsu.edu/senate/docs/S16-9.pdf>), relevant information to all courses, such as academic integrity, accommodations, dropping and adding, consent for recording of class, etc. is available on Office of Graduate and Undergraduate Programs' [Syllabus Information web page](http://www.sjsu.edu/gup/syllabusinfo/) at <http://www.sjsu.edu/gup/syllabusinfo/>. Make sure to visit this page, review and be familiar with these university policies and resources.

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## Course Schedule

(subject to change with fair notice)

Week	Date	Lecture topics, Workshops, Examinations
1	January 23	Introduction to Biotransport phenomena. The syllabus
2	January 28	Introduction to Biofluid Mechanics
2	January 30	<b>MATLAB workshop 1</b>
3	February 4	Kinematics. Lagrangian vs Eulerian frame of reference.
3	February 6	Kinematics. Fluid rotation. Fluid deformation.
4	February 11	Kinetics. Stress and Pressure. Hydrostatic pressure
4	February 13	Constitutive behavior of fluids: Newtonian and non-Newtonian fluids.
5	February 18	Blood rheology. Hemocompatibility. Blood cell damage.
5	February 20	Fluid statics. Manometers.
6	February 25	<b>MATLAB workshop 2</b>
6	February 27	<b>Midterm 1 review</b>
7	March 3	<b>Midterm 1 exam</b>
7	March 5	<b>Midterm 1 solution.</b> Reynolds Transport Theorem.
8	March 10	Conservation principles for fluids in motion. Conservation of mass.
8	March 12	Conservation principles for fluids in motion. Conservation of momentum.
9	March 17	Navier-Stokes equations. Steady flows.
9	March 19	Navier-Stokes equations. Some exact solutions
10	March 24	Laminar vs turbulent flows. <b>MATLAB workshop 3</b>
10	March 26	Inviscid flow. Bernoulli equation.
11	March 31	<b>Spring Break – NO CLASS</b>
11	April 2	<b>Spring Break – NO CLASS</b>
12	April 7	<b>Midterm 2 review</b>
12	April 9	<b>Midterm 2 exam</b>
13	April 14	<b>Midterm 2 solution. MATLAB workshop 4</b>
13	April 16	<b>Guest Lecture: TBD</b>
14	April 21	Optimal arterial design. Murray's law. Arterial bifurcations.
14	April 23	Mass transport in the human body. Fick's laws of diffusion
15	April 28	Mass transport in the lungs. Blood oxygenation. Part I
15	April 30	Mass transport in the lungs. Blood oxygenation. Part II
16	May 5	Mass transport in tissue. Krogh cylinder model
16	May 7	<b>Final exam review</b>
	<b>May 19</b>	<b>FINAL EXAM (12:15 - 14:30)</b>