San José State University
College of Engineering
Biomedical Engineering Department
BME 147, Quantitative and Statistical Methods for Biomedical Engineers, Fall 2020

Course and Contact Information

Instructor:	Alessandro Bellofiore
Email:	alessandro.bellofiore@sjsu.edu
Office Hours: (via Zoom)	Tuesday: 11:00AM - 12:00PM (*one-on-one meetings*, drop in) Thursday: 11:00AM - 11:30AM (*one-on-one meetings*, drop in) Thursday, 11:30AM - 12:00PM (*open forum*, drop in)
Class Days/Time: (via Zoom)	Tuesday, 3:00 – 4:15PM Thursday, 3:00 – 4:15PM
Prerequisites:	**Math 32, BME 115, BME 177 all with C- or better.**

Course Format

The course adopts a blended approach, combining asynchronous sessions (recorded video lectures) and synchronous session (Zoom). The recorded video lectures will generally focus on introducing the core concepts and methodologies, as well as examples of solved problems and software tutorials. The live Zoom sessions will be generally organized around interactive review and practice of the concepts and methodologies introduced in the videos. The live sessions will include, for instance, collaborative problem-solving activities, discussions, workshops and iClicker quizzes. Computer-based learning activities will be integral to the learning outcomes of this course.

Course materials and activities are organized into Modules, available in Canvas. Each module is tied to general Course Learning Goals (listed below) and specific Course Learning Outcomes (available in Canvas).

Communications

Course materials such as syllabus, handouts, notes, slides, videos, assignment instructions, etc. can be found on Canvas Learning Management System course login website at http://sjsu.instructure.com. Recordings of the live Zoom sessions will be shared with the students via Canvas and will be considered an essential component of the course materials.

All communications relevant to the course will be shared with the students using at least one of the following channels: (1) the live Zoom sessions, (2) the Canvas announcement board, and (3) Canvas email. You are responsible for regularly checking all of those channels through Canvas to learn of any updates.

Discussion board

Students will have multiple avenues to communicate with the instructor and ask questions about any aspect of the course. First, students are highly encouraged to engage in open discussions and ask questions during the live Zoom sessions. Second, an online discussion board will be available for students to discuss any topics or questions, as long as they do not include any personal or confidential information, as well as partial or complete solutions to course assignments. The instructor will check the discussion board regularly and provide answers and suggestions as appropriate.

Office hours

Office hours will be offered twice a week, according to the tentative calendar specified elsewhere in this syllabus. 75% of the office hours will be available for one-on-one meetings, whereas the remaining 25% will be organized as an open forum that all students can attend for questions about course mechanics (e.g. objectives, schedule, grading, resources).

Course Description

Principles of experimental design; types of data and variables; descriptive statistics; elements of probability; probability distributions; sampling distributions and the Central Limit Theorem; hypothesis testing: ANOVA, one-sample and two-sample t-test, multiple comparisons, confidence intervals; power analysis; linear regression; statistical approach to medical device design; statistical process control.

Statistics is present in all aspects of our lives and affects many decisions that we make, whether we make them consciously or unconsciously. In engineering, medicine and science, decisions are often based on data obtained from experimental measurements, which are prone to errors, variability and uncertainty. This class will focus on the application of statistical methods to biomedical engineering problems. After a brief introduction of the fundamentals of data collections and design of experiments, the student will be guided through the basic methodologies used to summarize data (descriptive statistics), assume a probability model, formulate and test hypothesis, compare means and variances of two or more populations, perform a linear regression. Particular emphasis will be placed on topics that have been traditionally challenging to engineering students with little or no prior experience with statistical analysis, such as when and how to use t-tests instead of the more general analysis of variance (ANOVA), the meaning of the p-value, the importance of sample size on the power of a statistical test, the importance to verify the assumption of a normal distribution, how to choose a statistical test appropriate for the sample data and the question to be addressed. The course will include one or more of the following special topics of particular interest to biomedical engineers: statistical quality control for medical device manufacturing, validation of a new test methodology against a clinical standard, and a brief primer on biostatistical methods.

Course Learning Goals

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

1. **Understand** the role of statistics in mediating our understanding of real-world quantitative phenomena
2. **Understand** the basic concepts of probability and random variables
3. **Formulate** a problem (questions, hypotheses, design of experiment) that can leverage statistical analysis to gain quantitative knowledge about real-world phenomena
4. **Design** an appropriate experimental approach to collect meaningful quantitative data
5. **Analyze** and **interpret** quantitative data
6. **Apply** tools of inferential statistics, including confidence intervals and hypothesis testing
7. **Apply** linear regression analysis for building empirical models of engineering and scientific data
8. **Apply** tools of inferential statistics to nominal and categorical data
9. **Understand** the basic principles of statistical quality control
10. **Utilize** appropriate software tools for statistical data analysis
11. **Communicate** quantitative information and mathematical and statistical concepts using language appropriate to the context and intended audience

Required Texts/Readings

Textbook

Stanton Glantz, Primer of Biostatistics, 7th Edition, McGraw-Hill Medical (2012).

Other Readings

Kristina Ropella, Introduction to Statistics for Biomedical Engineers, 1st Edition, Morgan & Claypool (2007).

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.

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/iclicker/index.html.

Other technology requirements

Students are required to have an electronic device (laptop, desktop or tablet) with a camera and built-in microphone. SJSU has a free equipment loan program available for students.

Students are responsible for ensuring that they have access to reliable Wi-Fi during tests. If students are unable to have reliable Wi-Fi, they must inform the instructor, as soon as possible or at the latest one week before the test date to determine an alternative.

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), personal essays, two midterm 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 statistical analysis software (e.g. JASP, G*Power).

Students are expected and encouraged to work together on assignments. However, submitted homework should be individual work. Homework must be turned 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.

Personal essays

Every other week, students choose an article (either news or scientific) that is related to COVID-19 and contains a statistical component (e.g. experimental design, descriptive statistics, hypothesis testing, linear regression), and write a personal essay about it. The essays will be posted to Canvas on a discussion thread called the "Sandbox." The class will be divided into small groups (4 or 5 students, depending on total enrollment) and students in each group can comment on one another's sandbox essays – not to criticize but to be encouraging.

Students will be given credit for completeness of the following items: a summary of the article (max 50 words); an explanation of one statistical component of the article (max 100 words); a reflection on impact on perception and/or action plan (max 150 words); a reflection on a specific topic proposed by the instructor (max 100 words). In addition, students will be given credit for posting meaningful comments (i.e. not just "well done") on at least 3 essays in their group. One option to make their comments meaningful is to articulate them around a "gold star sentence" highlighted in each essay.

A detailed schedule with the deadline for submitting essays and comments will be available in Canvas.

Term project

The term project is a brief statistical study to answer a question of interest about the students in the Biomedical Engineering program. In this project, students will formulate a research question (and statistical hypotheses), collect data, perform relevant analyses to answer the question, and produce a document that details their findings.

All students are required to complete a term project. Students will work in teams of no more than three.

Student teams should develop a question of interest that will require them to collect data about at least one variable on individuals sampled from at least two groups such that their question may be answered with one of the "two-or-more samples" hypothesis tests that are covered in this class.

Students will complete the term project in 3 parts, with 2 deliverables.

Part 1 of the project (*graded*) will revolve around formulating a **study proposal**. The instructor will review and approve the proposals within the context of correctness and efficiency, as well as to avoid potential ethical issues. Teams may be required to submit a corrected proposal.

Part 2 of the project (*ungraded*) is data collection. For the sake of efficiency, the instructor will aggregate the questions by all teams into **one anonymous survey** to be sent out to all the students in the BME department. The survey will be open for up to two weeks. Once the survey is closed, the raw anonymous data will be shared with the class.

In **Part 3** of the project (*graded*), teams will use statistical software (e.g. JASP) to perform the statistical analysis of the data, which should include both descriptive and inferential statistics. To complete their project, each team will submit a **final report**, which should include the proposal, the raw dataset in tabular form, a brief description of the experimental and statistical methodologies used, a description of the results (text, tables, plots), and a discussion of major findings, recommendations and decisions based on the analysis, along with a discussion of the limitations of

the analysis. **Final reports cannot exceed 7 pages**, not including Cover page, Acknowledgments, Statement of academic integrity and Appendix. The final project report is submitted through Canvas. 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.

A detailed description of the term project, including tentative timeline and grading rubric, will be available in Canvas.

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 and Final examinations

There will be two midterm exams and one final exam. Each exam will include a timed quiz and a "*Design-and-Solve a Problem*" component. The tentative dates of the exams are indicated in the Course Schedule at the end of this document.

Timed quiz

Students will have to answer a bank of multiple-answer questions and true/false statements during a timed session. Questions and statements will cover the entire course material covered since the previous midterm. Questions and statements will be randomly assigned to each student.

Design-and-Solve a Problem (DSP) component

This portion of the exam will be completed over a period of 3 days. Students will work in pairs (assigned randomly).

Day 1: each student is assigned a topic. They will have to create a problem from scratch, different from the other homework and textbook problems covered in this course. The problem must be an original creation (i.e. not lifted from textbooks or online resources). By the end of Day 1, each student submits the text of the problem, and a worked solution. Credit is awarded individually for correctness, completeness, clarity and difficulty of the problem, as well as for the correctness of the solution.

Day 2: each student will be assigned a team member (randomly) and will be given the problem created by their team member. The two students work together on verifying that the problem is correctly formulated, and in case they fix any issue and the solution. By the end of Day 2, the students will submit a revised version of the text of the problem. Credit will be given for correctness, completeness and clarity of the problem formulation. This portion of the exam will be scored as a team (i.e. credit shared between the two team members).

Day 3: each student creates a short video where they demonstrate the complete solution to the problem created by their team member, using for instance Canvas Studio. Credit is awarded individually for correctness of the solution, clarity of the explanation, and quality of the video. Alternatively, students who cannot record a video can submit a complete script of the video. This alternative arrange must be discussed with the instructor and approved by the instructor for each individual student **at the beginning of the semester**.

Credit is also awarded for correct and complete use of units, as well as timeliness of every submission. A detailed grading rubric will be provided for each exam.

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%
Personal essays = 10%
Midterm 1 = 20%
Midterm 2 = 20%
Final Exam = 20%
Term Project = 20%
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 at http://www.sjsu.edu/senate/docs/F13-1.pdf for more details.

Classroom Protocol

Attendance: live Zoom sessions

Students are expected to log into the live Zoom session by the time the class begins, and use their real names. 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.

Recording Zoom Classes

The live Zoom sessions of this course will be recorded for instructional or educational purposes. The recordings will only be shared with students enrolled in the class through Canvas. The recordings will be deleted at the end of the semester. If, however, you would prefer to remain anonymous during these recordings, then please speak with the instructor about possible accommodations (e.g., temporarily turning off identifying information from the Zoom session, including student name and picture, prior to recording).

Students are not allowed to record without instructor permission. Students are prohibited from recording class activities (including class lectures, office hours, advising sessions, etc.), distributing class recordings, or posting class recordings. Materials created by the instructor for the course (syllabi, lectures and lecture notes, presentations, etc.) are copyrighted by the instructor. University policy S12-7 (https://www.sjsu.edu/senate/docs/S12-7.pdf) is in place to protect the privacy of students in the course, as well as to maintain academic integrity through reducing the instances of cheating. Students who record, distribute, or post these materials will be referred to the Student Conduct and Ethical Development office. Unauthorized recording may violate university and state law. It is the responsibility of students that require special accommodations or assistive technology due to a disability to notify the instructor.

Zoom Classroom Etiquette

Mute Your Microphone: to help keep background noise to a minimum, make sure you mute your microphone when you are not speaking.

Be Mindful of Background Noise and Distractions: find a quiet place to "attend" class, to the greatest extent possible:

- Avoid video setups where people may be walking behind you, people talking/making noise, etc.
- Avoid activities that could create additional noise, such as shuffling papers, listening to music in the background, etc.

Limit Your Distractions/Avoid Multitasking: you can make it easier to focus on the meeting by turning off notifications, closing or minimizing running apps, and putting your smartphone away (unless you are using it to access Zoom).

Use Appropriate Virtual Backgrounds: if using a virtual background, it should be appropriate and professional and should NOT suggest or include content that is objectively offensive or demeaning.

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 a live Zoom session, the use of electronic devices (laptops, tablets, smartphones) MUST be limited to activities closely related to the learning objectives. Electronic devices should not be used for personal communication, included messaging and use of social media. All cell phones must be silenced prior to logging into the live Zoom session.

Academic Dishonesty

Students who are suspected of cheating during an exam will be referred to the Student Conduct and Ethical Development office and depending on the severity of the conduct, will receive a zero on the assignment or a grade of F in the course. Grade Forgiveness does not apply to courses for which the original grade was the result of a finding of academic dishonesty.

University Policies

Per University Policy S16-9 (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 at http://www.sjsu.edu/gup/syllabusinfo/". Make sure to visit this page, review and be familiar with these university policies and resources.

BME 147, Quantitative and Statistical Methods for Biomedical Engineers, Fall 2020

Course Schedule

(subject to change with fair notice)

Module	Start Date	Topics, Readings, Assignments, Deadlines
1	August 20	Introduction: why learn statistics? Example-based overview of basic concepts
2	August 25	Software tools: JASP
3	August 28	Collecting Data: population, sample, variables, bias, experimental design
4	September 8	Summarizing Data: descriptive statistics
5	September 15	Elements of Probability: sample space, random variables, normal distribution
6	September 22	Sampling distributions, Central Limit Theorem
	September 28	**Midterm exam 1 (time quiz starts at 15:00)**
7	October 6	Probability distributions, z-scores, degrees of freedom
8	October 13	Hypothesis testing: general framework, ANOVA
9	October 20	One-sample and two-sample t-Test. Post-hoc tests
10	October 27	Confidence intervals
	November 3	**Midterm exam 2 (time quiz starts at 15:00)**
11	November 10	Power analysis. Software tools: G*Power
12	November 17	Hypothesis testing for nominal variables
13	November 24	Linear regression
14	December 1	Statistical process control
	December 11	**FINAL EXAM (time quiz starts at 14:45)**