BMED 2400 – Introduction to Bioengineering Statistics (3 credits)

1 Course overview

1.1 Instructional Team

Prof. Mason Borzin Nezafati
Email: Maysam@gatech.edu

Grading teaching assistants:

TBD Email: TBD

TBD Email: TBD

1.2 In Class Schedule

Day	Time	Location
MTWTH	10:05 – 12:00	ENG 3035

1.3 Office hours

Will be scheduled based on request.

1.4 Course Resources

Course webpage: We will use Canvas® for communication and posting information. Please check Canvas regularly, we will post EVERYTHING course related there.

Primary text:
We will post various online resources as reading for each class. Typically, there will be a reading for each topic. It is critical that you do the readings to get the most out of the class.

Secondary text:
Title: Engineering Biostatistics: An Introduction using MATLAB and WinBUGS
Author: Dr. Brani Vidakovic
ISBN: 978-1-119-16896-6
URL for a FREE PDF copy: http://statbook.gatech.edu/statb4.pdf (also posted on canvas)

Notes about the readings in this class:

- Ready for a curveball? Because of some of our secondary goals in the course, explained in the learning objectives a little more deeply, you will see some Online readings for this class. You will also see other internet sources.
- We reserve the right to ask you to find appropriate readings introducing each topic.
- We also STRONGLY suggest you retain a copy of the textbook as a personal resource after this course. That is why we suggest it. It is a wonderful technical resource. You should learn how to read this type of textbook as an engineer, that skill will benefit you forever.
- We will also assign problems out of the textbook as suggested homework. These are our primary source of practice problems so we suggest you do them. Yes, the language is a little dense and sometimes subtly different from what we use in class. Yes, that is intentional.

- One of our goals in the course, noted in the learning objectives, is teaching you how to (1) find, (2) digest, and (3) apply things you find through your own searching as you learn about a new topic.

1.5 Course description

This course is a biomedical engineering specific introduction to statistics, probability, and inference. It is *also* an introduction to the related skills that are needed to employ statistics, probability, and inference in biomedical engineering contexts. It is primarily concerned with the use of statistical tools for modeling, analysis, and (MOST IMPORTANTLY) making sense of data in biomedical engineering research. The primary focus is practical and applied rather than theoretical, but will be theoretical when such understanding is necessary to properly understand the methods covered. Basically, it is an engineering course.

Software Support

The course will require the use of Microsoft Excel or another spreadsheet tool that allows iterative solutions (PRIMARY) and MATLAB (SECONDARY).

General topics list

1. Types of data and Sampling
2. Probability and distributions
3. Descriptive statistics
4. Bayes theorem and formula
5. Sensitivity, specificity, and test optimization
6. Fundamentals of hypothesis testing and degrees of freedom
7. Z-tests
8. T-tests
9. ANOVAs
10. Non-parametric tests
11. Goodness of fit tests
12. Correlation and Regression
13. multi regression and Logistic regression
14. Sample size, effect sizes, and power
15. Confidence and prediction intervals

1.6 Course learning objectives

Core

- Translate real life inferential problems to proper statistical models.

- Use Bayes theorem in the context of medical testing: sensitivity, specificity, positive predicted value, and ROC curves.
- Identify and employ basic probability tools to assess frequencies or likelihood of occurrence of independent and dependent events.
- Perform the following statistical test: T-test, ANOVA, Z-Test, Regression, Correlation, Multiple Regression, Non-parametric tests, Chi-square tests
- Formulate, formally state, and identify appropriate tests to serve research goals
- Summarize and describe data, identify parameters and calculate their point and interval estimates.
- Make meaning from statistical tests

Complementary

In addition to the core learning objectives, we have a set of 'complimentary' learning objectives that round out the core learning objectives to ensure comprehensive preparedness of young engineering-statisticians. These include:

- Read, interpret, and validate statistical analysis in BME papers and media
- Prepare professionally appropriate reports on data analysis
- Make and execute data collection and analysis plans
- Work effectively in teams

2 Policies and expectations for our learning environment

This section details the overarching policies, expectations, and guidelines we ask all members of the course community to participate in. They apply equally to the every member of the instructional team and all of the students.

2.1 Collaboration and group work policy

Each assignment in this course is explicitly indicated as either collaborative or individual work. If you are unclear about the definitions or boundaries of academic misconduct in regards to individual or academic work, it is <u>explicitly</u> your responsibility to seek clarification in advance.

Individual assignments should be your own work and only your own work. What that means is that the intellectual output should be yours and yours alone, in your words, completed by you and you alone. You may not work with anyone else in class on those assignments.

For collaborative assignments, we expect all group members to participate in the intellectual labor of assignments. Students choosing not to effectively and meaningfully collaborate on such assignments should not expect to receive credit for the work of their teammates.

2.2 Attendance Policy

Attendance and participation in class is expected. While we will post slides, they will not include any work on the board or the performance of any examples in class. Further, your presence in class not only supports your own learning and growth, it supports the learning and growth of your course peers and instructor as well. Every study that we are aware of[1] shows a strong correlation between course attendance and final grade. You will learn in this course that

[1] If you ask, we can provide probably **dozens** of articles on this topic.

correlation is not causation, but it does point a flashing red arrow towards what may be the cause. Finally, this course DOES involve in class work with a team that contributes to your grade.

However, we also believe in treating you as professionals – because you are. Therefore, your presence solely will not be evaluated but your class participation will be evaluated. This section of your grade is called **professionalism**. This includes participation in group problem solving sessions, participation in point solutions short questioners, … Failure to participate in your class and group assignments will affect your individual grade on those assignments. Part of your role in the course is helping your peers learn – both as a part of our community and because it helps you learn as well. That necessitates active engagement.

2.3 Academic integrity

Academic misconduct, including plagiarism and completing others' work for them, hurt you and your classmates and will not be tolerated in this course. Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards and Tech's Academic Honor Code (http://www.catalog.gatech.edu/policies/honor-code/).

As a member of the Georgia Tech community, we assume that you have read and understood the Academic Honor Code. By rule, we am required to report any student suspected of cheating or plagiarizing on a quiz, exam, or assignment to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations. Specifically, we will submit any cases where there is ***significant evidence*** of academic misconduct and am then constrained to the results of that process.

2.4 Basic needs statement

Any student who has difficulty affording or accessing sufficient food to eat every day or who lacks a safe and stable place to live, and believes this may affect their performance in the course, is urged to contact the Dean of Students for support and direction to available resources. Furthermore, if you are comfortable doing so, please talk to me. This will enable me to direct you towards any resources that we are aware of or that are within my control. While we strongly believe in the importance of education, we also believe that your success in this course is contingent on having your basic personal safety and needs met. Research has shown that addressing these issues are necessary precursors to effective learning. They are also personally important to me because we are all human beings first.

2.5 Disability and accommodations

We all need some accommodations in education because we each learn differently. If you are a person with circumstances that you believe may affect your learning experience (e.g., visual, hearing, learning disabilities) please let me know as soon as possible so that we can collaborate on appropriate accommodations. You should also contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your needs and to obtain an accommodation letter.

This syllabus and all other course documents are also available in the Dyslexie font upon request. The font is designed to ease reading for those with certain learning disabilities.

3 Course structure

3.1 Synopsis:

- Generally, first hour of class is more 'lecture-like', i.e., demonstration and worked problems
- Generally, second hour is more 'PSS-like' with group work and discussions. These will include working with data to do data analysis and statistics as well as taking case studies or research papers and extracting or interpreting statistics.
- Each week will cover a set of select topics that integrate to build a major area of understanding in statistics. This course heavily builds from week to week, both so you understand the basis
- In an effort to support flexibility for students during study abroad, there are NO required homework outside of class.
- Course assessment will based on demonstrations of mastery of course content[2].
    - There are 4 assessments in this class. Each covers specific topics mentioned in the table here.
    - All assessments are open book, open note, and your lecture notes can be used. They will be online and an online proctoring system will be used for them.
    - Core content learning objectives will be assessed through individual mastery tests that will be taken at the beginning of each Thursday class.
    - Complimentary content learning objectives will be assessed through group project that are completed in and out of class.
    - We do believe the key to effective learning is to give/receive feedback and improving the work through iterations. So, you will have the opportunity to retake the assessments. Within one week of grade publishing.
    - Each student receives 4 vouchers, the vouchers can be used for retaking an assessment or rescheduling of an assessment.
    - Each assessment cannot have more than 3 attempts (in short, you cannot retake an assessment more than two times).
    - The final grade for each assessment would be sum of grades in each attempt divided by number of attempts. In short, arithmetic mean of attempts of each assessment.
    - Note 1: each unused can be used as + 0.5 bonus point toward your final course grade.
    - Note 2: through the semester I will share some opportunities with you to obtain extra vouchers.

[2] This all probably requires a little more out of class work for students, but it is designed to enormously increase flexibility and the amount of active engagement with the content in the classroom. From our prior experiences teaching this course, this course is more about mindset and perspective and process than content. We think this will work better than a more traditional lecture.

- You also will have a group project based on your industry visits. I will share with you the instructions for this project at the beginning of your class. So you can plan everything accordingly.

3.2 Week by week schedule

		Topic #	Topic
Monday	5/18/25	1	Types of data & sampling
Tuesday	5/19/25	2 & 3	Probability & Descriptive statistics
Wednesday	5/20/25	2 & 3	PSS (Probability & Descriptive statistics)
Thursday	5/21/25	4	Bayes formula, theorem, and implications
Monday	5/25/25	5	Sensitivity and Specificity
Tuesday	5/26/25	6	Statistical distributions, Hypothesis testing, degrees of freedom
Wednesday	5/27/25	7	Z-tests
Thursday	5/28/25		Assessment 1 from topics (1-4)
Friday	5/29/25	8	The t-Test, research questions, variations
Tuesday	6/2/25	9	ANOVA
Wednesday	6/3/25	10	Non-parametric tests
Thursday	6/4/25		Assessment 2 from topics (5-7)
Monday	6/8/25	11	Goodness of fit tests
Tuesday	6/9/25	12	Correlation and Regression
Wednesday	6/10/25	13	Logistic and/or multiple regression
Thursday	6/11/25		Assessment 3 from topics (8-10)
Monday	6/15/25	14	Sample Size, effect size, and Power
Tuesday	6/16/25	15	Confidence and prediction intervals
Wednesday	6/17/25	-	Presentation in person
Thursday	6/18/25		Assessment 4 from topics (11-15)

3.3 Assessments in this course

3.3.1 Core learning objectives and Mastery tests

We assess the core learning objectives using what we call 'mastery tests.' Mastery tests are assessment of whether an individual student has mastered one (or one set) of the core concepts of the course. You have the opportunity to take each test up to 2 times (no it is not the same test each time). The second attempt will have 50% of the weight the first attempt. The seconf attempt can be made within 1 week from the grading of the first attempt. The total grade of each assessment will be the weighted average of the attempts. Each test will contain clear

guidelines and a rubric for what is passing and what is not (see grading for more details). You will have one hour to do the test.

3.3.2 Complimentary learning objectives and Group Assessment

The group assignment is a project that you work on a case study and use your statistics knowledge to create value for all the stakeholders. In this project you are going to find a case study about that and analyze the data that was used in it. The due date for group assignment's report is Friday June 20th at 8 pm (the presentation will be in person on Wednesday 6/18th) .

3.4 Grading

Each assignment will be graded out of 100%. We evaluate three components of a problem, when grading it:

Setup – The first part of any statistical work is preparing yourself to do the math. In my experience, this is the area where most mistakes are made. During the setup you need to figure out precisely what question you are asking, what data you have or need, what analyses you need to run, what your dependent and independent variables are, and what assumptions you are making implicitly and explicitly.

Calculation – With the setup complete, you need to run your analyses. That includes identifying correct variables, plugging things in correctly, selecting the right options for any formulas, calculating the results, and reporting the results. It includes things like arithmetic but also includes things like reporting the correct number of significant digits.

Interpretation - With the setup and the calculation in hand, you need to make sense of what you have found out. That includes synthesizing the results and communicating them to whoever is reading your assignment. Just getting the calculation right isn't the end of the problem, ***you have to articulate what the answer means***. Most importantly, you must draw the conclusions from your calculations and your setup.

3.4.1 Final Grade Scale

The final grading scale is based purely on the points you receive for each assignment. Grades are individual and based on mastery – rather than relative or a 'bell curve'. In plain English, that means that there are no limits on how many people can earn a specific grade. Theoretically, and hopefully, everyone can get an A in the course.

Assignment	Weight (%)	Details
Assessment 1-4	Each 20 (totally 80)	Covers topics in class, see table above.
Project Report	7.5	IEEE report of project
Project Presentation	7.5	10-minute presentation for a totally professional audience (guests from industry might be invited to the session)

Professionalism	5	Class participation, contribution to PSS activity, response to class clicker questions, engage in learning activities, and punctuality

For a given grade, you must meet both criteria to receive the letter grade you are aiming for.

Grade	Mastery tests
A	90.00
B	80.00
C	70.00
D	60.00

Note: the cutoffs are firm and we do not round the final grades. So, if your final grade is 90.00 and above it means your grade is an A. But 89.99 would be counted as B.

3.4.2 Grading detritus: Late assignments, re-grading, etc.

A few last notes about grading

- Please understand that the teaching team used a precise rubric to grade your work, verbal communication about grade disputes is not accepted. If you think that there is a discrepancy about your grade and rubric, you must submit a re-grade request within one week of receiving the test materials. We will not grantee any grade improvement, and you must know that if you get a lower grade in the re-grade that will be replace your original grade.