BMED 2400 – Introduction to Bioengineering Statistics (3 credits)

1 Course overview

1.1 Instructional Team

Prof. Todd Fernandez (Todd) ***Email:*** Todd.Fernandez@bme.gatech.edu ***Weeks 1-5***	**Prof. Essy Behravesh (Essy)** ***Email:*** Essy@Gatech.edu **Weeks 6-10**

1.2 In Class Schedule

Day	Time	Location
Tuesday	12:00pm-2:00pm	TBD
Thursday	12:00pm-2:00pm	TBD

1.3 Office hours

TBD but will likely occur on Wednesdays to maximize availability and align with the course

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 Tuesday and a reading for Thursday. 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 Wikipedia 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. Closer to 2250 than to whatever flavor of calculus you took.

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

Data, data types, and descriptive statistics
Distributions as models for observations
Normal and other distributions
Estimation and testing statistical hypothesis
One- and Two-way ANOVA.
Some non-parametric procedures
Tables and Chi-Square Theory
Linear and Logistic correlation and regression
Statistics in scientific journalism and the media

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 explicitly 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 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, we will not be taking formal attendance. **That being said, we will use multiple factors, including feedback from your teammates and our observations, to assess whether people are participating in their groups**. Failure to participate in your group 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.

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

2.4 Diversity, inclusion, and equity

We want our classroom to be a place where you, and everyone else, are treated with respect. Our class will welcome individuals of all backgrounds, beliefs, and identities both visible and invisible. All members of this class are expected to cooperate in the creation of a respectful, welcoming, and inclusive environment for every other member of the course. If there are things the teaching team or others have done to degrade that environment we encourage you to bring them to my attention and we will work to correct them.

2.5 Preferred name / pronouns

We will gladly use an alternate name or gender pronoun of your choice. Please advise a member of the teaching team of this preference as early as possible so that we may make appropriate changes to our records. At your preference, we will do so privately and/or publicly.

2.6 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.

2.7 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.

2.8 Safe Zone

We (Todd & Essy) are a member of a SafeZone Ally community network and available to listen and support you in a safe and confidential manner. As a SafeZone Ally, we can help you connect with resources to address problems you may face that interfere with your ability to engage in academic and social pursuits on campus as it relates to issues of sexual orientation, gender identity, and other elements of your identity and life experience. Our goal is to help maintain a safe and equitable campus. If we or someone else can help you, our door is open.

3 Course structure

3.1 Synopsis:

- Generally, Tuesday is more 'lecture-like', i.e., demonstration and worked problems
- Generally, Thursday 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 in class tests and NO required homework outside of class.
- Course assessment will based on demonstrations of mastery of course content[2].
    - All assessments are pass fail and most can be resubmitted/redone
    - Core content learning objectives will be assessed through individual mastery tests that can be taken outside of class at any time.
    - Complimentary content learning objectives will be assessed through group assignments that are completed in and out of class.
    - Your final grade is based on the number of core and complimentary assignments that you pass.

3.2 Week by week schedule

Wk	Content
1	Course Introduction, Data Collection, Types of Data, Population vs. Sample, excel.
2	Probability, Distributions, Descriptive Statistics, Random Variables, Sampling
3	Bayes theorem, Bayes formula, sensitivity, specificity, and implications
4	Revisiting distributions, data visualization, excel skills development, research questions
5	fundamentals of hypothesis testing, degrees of freedom, t-tests and variations
6	ANOVA's and Z-tests
7	goodness of fits and non-parametric
8	Correlation, regression, multiple regression, logistic regression
9	sample size, effect size, power, confidence and prediction intervals
10	Putting it all together, data management, wrap-up

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 a single problem, typically multi part, assessment of whether an individual student has mastered one (or one set) of the core concepts of the course. You will know the topic in advance and will have the ability to take these tests at any time of your choosing using Canvas. You have the opportunity to take each test up to 3 times (no it is not the same test each time). 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. If you do not get a passing grade, you will get

[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.

feedback from us on what went wrong. You can take the tests in any order. You do NOT have to complete all of the tests to pass the class, nor do you have to complete all of the tests for an A.

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

3.3.2 Complimentary learning objectives and Group assessments

We will assess the complimentary learning objectives using group work. There will be a total of 8 submitted group assignments. Typically, most of the assignments will be completed in class. All group assignments will be due one week after they are assigned. There are two types of group assignments. Data assignments will involve the collection, analysis, and reporting of biomedical engineering work. Case studies will involve you being given a biomedical engineering research report of some form and asked to analyze, interpret, and critically analyze of that report. The content you will be working on in each group assessment will align with the content we are covering in class that week, see schedule above.

3.4 Grading

Each assignment will be graded based on a pass fail standard. That is, you will either get a grade of pass or a grade of fail on any given assignment. Passing does not require perfection, but it does require solid good work (typically B+). In each assignment, we will detail what the specifications are for a passing grade and will solely use those transparent and pre-identified criteria for grading. Typically, specifications will be based on three components of a problem:

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 number of assignments you passed for each of the two types of assignments. 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.

For a given grade, you must meet both criteria.

Grade	Mastery tests	Group assignments
A	13	6
B	11	5
C	9	4
D	7	4

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

A few last notes about grading…

- Please understand that the teaching team are human and sometimes make mistakes. If something isn't right, we ask that you let us know and give us a chance to fix it. It will help us all work together in class if we all assume everyone else, teammates, classmates, instructors, students, everyone is acting in good faith and in support of each others' learning.
- If we make a mistake when grading, please ask us to regrade an assignment. All regrades must be submitted via a written email no later than one week after feedback on that assignment is returned to you and include a reason you would like a regrade. Please identify specific specifications.