

ISE 111: Engineering Probability

Syllabus: Fall Semester 2018

Course Description

This course is an introductory course to the field of Probability designed for engineering students. This course focuses primarily on the study of Probability Theory. We may also cover some Statistics toward the end. Probability Theory is also of great use in and of itself in all branches of Engineering for understanding and modeling phenomena that exhibit random behavior. Probability Theory also provides the theoretical and mathematical basis for statistics, and thus must be studied first before one can truly understand statistics (which comes later in ISE 121).

The field of Statistics pertains to the presentation, analysis and interpretation of *data*. Engineers will be faced with the need to analyze data on a daily basis in the real world, and thus a good grounding in the basics of statistics is invaluable. Statistics is inherently *inductive* since inference is made about a whole population on the basis of information/data obtained from a *sample* from the population.

Unlike Statistics, Probability theory is inherently *deductive*, and has nothing to do with sample data. Rather it is a field of mathematics from which results and conclusions are derived from propositions and assumptions. A typical easy problem that one could solve using probability theory is "given that the probability of a coin flip coming up heads is 0.5, what is the probability that I will get exactly 5 heads if I flip the coin 10 times?" Note the absence of any sample data in this problem. Given an assumption (probability of a head is 0.5) one deduces the conclusion (the probability of exactly 5 heads is 0.2461).

Statistics is probably more useful for most engineers than probability. However, the theory that underlies statistics is probability, which makes its study necessary as well. The study of Probability Theory can be fun and interesting, but also difficult, confusing and frustrating. In particular, the use of counting methods to compute probabilities, which comes early in the class, is likely the most confusing and frustrating part of the course (in addition to hopefully being fun). Who would have thought that counting is hard?!

Course Objectives

Upon completion of this course, students will:

- Learn the basic tools of probability theory
 - Know the basic axioms and set theory upon which probability theory is based including sample spaces and events, mutual exclusivity, conditional probability, independence, and Bayes theorem.

- Be able to solve problems in counting and probability using techniques including permutations, combinations, permutation of like objects, “multi-choose”, and probability trees.
 - Understand the concept of random variables and probability mass functions, densities, and distributions.
 - Understand the concept of expectation and be able to apply it in decision making
 - Understand the mean and variance of a random variable.
 - Understand Chebyshev's inequality.
 - Know various well-known distributions and how they are used in practice.
 - Understand Poisson processes and what they are used for in practice
 - Understand joint, marginal, and conditional distributions
 - Understand covariance and correlation
 - Be able to apply the theory of expectation to solve decision problems involving the maximization of expected return
- Learn the mindset necessary to successfully apply probability theory in solving real engineering problems, namely:
 - Develop curiosity and a healthy skepticism about the assumptions inherent in probability models, and how to use sensitivity analysis to investigate
 - Be able to identify necessary components of a probability model and discover sources of data necessary to build the components to solve an engineering problem
 - Create value by understanding how to apply measures of value and risk to engineering decision problems.

Prerequisites

Math 22 (Calculus II) is a pre-requisite. You should be taking Math 23 (Calculus III) this semester, or have taken it already, since we will use some material from it (double integrals, in particular) later in our course. If you have not taken Math 22, or are retaking it this semester due to poor grades, you should drop this course now; we will offer it again next semester. In past years we sometimes let students who didn't have the prerequisite into ISE 111, only to see them struggle all semester long and end with *very* unsatisfactory grades.

Contact Information

Professor

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Office Hours: MWF 10:00 – 11:30 Mohler 477
 M 1:45-2:30 Mohler 477

W 2:30-4:00 Rauch Business Center 271
Or by appointment.

Grader

Haidong Gu hag218@lehigh.edu
354 Mohler Lab
Office Hours TBD

Textbook (required)

"Applied Statistics and Probability for Engineers": Latest Edition, Douglas C. Montgomery and George C. Runger, published by John Wiley and Sons and the associated "Student Workbook with Solutions", by Heecheon You.

We will be covering the following chapters in the following order: 2, 3, 4, 5. There will be 3 midterm (50-minute) exams, and a final exam. The final will be cumulative, but with extra emphasis material at the end of the course. In truth, we do not use the textbook much at all. However it is a valuable resource. Also, you will almost surely use the same textbook when you take ISE 121 next semester, so do not sell it back to the bookstore at the end of this semester.

Web Page

We will post some things, including homework assignments, the tentative course schedule, and this syllabus, on the course web page using Coursesite. To reach it, go to

<http://coursesite.lehigh.edu/>

and log in with your usual e-mail address and password. You will also be able to access your grades through the system. You are responsible for keeping track of your grades and general progress in the course.

Active Learning Activities

This year, we are incorporating active learning techniques into the 8:10-9:00 section of the course. We will be attempting a "Flipped classroom" model for this section. Students will view video lectures prior to class and come prepared to ask questions, do group exercises, and, work on homework problems. Please note that each lecture contains several quizzes. You must complete each quiz before proceeding further in the video. You will only have one try at each quiz. I can see your quiz results, thus will know who has and who has not completed the lecture video on time.

Big Problems and Mini-Projects

- Seven of the nine homework assignments will include one “big problem” that requires significant effort and thoughtfulness to solve
- Two of the nine homework assignments will be “Mini-Projects” that require more effort than a “big problem”.

Grading Policy 9:10-10:00

Your final numeric score will be determined as follows:

20% : Homework and Mini-Projects (9 assignments)

10% : Class participation as determined by me

45% : Midterm exams (3 of them, 15% each)

25% : Final Exam

Grading Policy 8:10-9:00

To be determined. Similar to the other section except credit for in class exercises will also be included in your grades

Plus and minus grading will be used for final grades. Final grades will be "curved".

Class participation requires that you actually be in class, thus data on class attendance will be taken. To facilitate this, assigned seating will be used so that I can quickly determine who is missing each day. If you have to miss a class for a legitimate reason, and you inform me in advance, I will excuse the absence within reason.

Course Philosophy

I see this course as a partnership between the textbook, lectures, and homework; all of them work to help you learn. Tests serve to ensure that you are learning the material, but they cannot test everything all at once. There will be problems on the homework that are much harder than anything that would be on a test. The homework is supposed to be hard, just like training for a sport. You should allocate enough time for it; ideally, you should start it well before office hours, so you can use office hours efficiently.

Academic Honesty

Integrity and Honesty are vital in life, especially for engineers, since the systems we design or modify can improve people's quality of life, or can do irreparable harm. Using probability and statistics ethically requires that we state all of the facts and assumptions in as clear a manner as possible, to avoid "lying with statistics". We are also bound by honor to give credit where it is due. In this class, you might ask others for help with a homework assignment. Once you write up your answer in your own words to turn in, it is a good idea to include a mention of their help on any particular problem. It is dishonest to copy homework solutions from past years that you might obtain or have. On quizzes and

exams, of course, your work should be entirely your own. Violations of academic honesty will result in disciplinary proceedings.

Here is the statement of the Lehigh Student Senate on academic integrity: “We, the Lehigh University Student Senate, as the standing representative body of all undergraduates, reaffirm the duty and obligation of students to meet and uphold the highest principles and values of personal, moral and ethical conduct. As partners in our educational community, both students and faculty share the responsibility for promoting and helping ensure an environment of academic integrity. As such, each student is expected to complete all academic course work in accordance to the standards set forth by the faculty and in compliance with the University's Code of Conduct. “

Typical Difficulties

Here, we list some of the problems that students typically encounter in the course. You won't understand some of the terms right now, but look back at this section as the course goes along and you will understand it better.

The hardest part of this course is usually figuring out which type of probability distribution to use in a particular situation. That is, "word problems" are what this course is all about. This is not made easier by the fact that the names of the distributions, like the names of the chemical elements, have no apparent system to them. It takes a lot of practice to become familiar with what tool to use for any particular situation, so hang in there, practice, and it will eventually "click" for you.

Other difficulties tend to be:

- Accidentally reporting the probability of something NOT happening, instead of it happening, or vice versa.
- Getting mixed up between "all parts are not bad" and "not all parts are bad".
- Figuring out when an approximation is justifiable.
- Remembering the difference between "independent" and "mutually exclusive".
- When to use $\text{Var}(X_1+X_2+X_3)$ and when to use $\text{Var}(3*X_1)$

Schedule Notes

Do not purchase your Winter break airline tickets before the schedule for final exams is posted. You will not be allowed to "take the exam early because you have already purchased a non-refundable airline ticket". The last possible day for the exam is

Wednesday, Dec. 19th.

Syllabus statements:

Accommodations for Students with Disabilities:

If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, Williams Hall, Suite 301 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

The Principles of Our Equitable Community:

Lehigh University endorses The Principles of Our Equitable Community [http://www.lehigh.edu/~inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf]. We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.

My Exam Policy

Aside from verified disability accommodations, no exemptions from exams will be given, and no exam scores will be dropped. Only verifiable excuses will be considered for missing an exam: you must inform me prior to the exam, and you must supply me with a written excuse from a doctor or the Dean of Students.