IE111: Engineering Probability and Statistics
Fall 2009

Instructor

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Course

Class hours: MWF 9:10-10:00 or 10:10-11:00, Mohler 453

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 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 IE 111, only to see them struggle all semester long and end with very unsatisfactory grades.

Course Website: Course materials, slides, assignments and solutions will be posted on Blackboard. Check it regularly.

Course Description: This course is an introductory course to the fields of Probability and Statistics designed for engineering students. The course focuses primarily on the study of Probability Theory. We may also cover some Statistics toward the end. Probability Theory is of great use in all branches of Engineering in 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.

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).

Textbook: "Applied Statistics and Probability for Engineers": Fourth 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 4 midterm (50-minute) exams, at (approximately) the ends of chapters 2, 3, 4, and 5 (see schedule). The final will be cumulative, but with extra emphasis on chapter 5. We may also use some parts of the Supplemental CD, so do not use it as a drink coaster. In newer editions the CD has been replaced with online resources. Also, you will almost surely use the same textbook when you take IE 121 next semester, so do not sell it back to the bookstore at the end of this semester.

Course Objectives: Upon completion of this course, you will:

- 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 probability theory to solve probability problems.

- Be able to apply the theory of expectation to solve decision problems involving the maximization of expected return

Coursework

Exams: You will have four one-hour in-class exams and a final exam. The final exam will be cumulative, but Chapter 5 will be featured more. The exams will be open-book, open-notes. No make-up exams will be given, and no credit will be given for any missed exam.

Homework: You will have regular homework assignments (see the schedule). Homework assignments must be turned in during class on the day the assignment is due. No credit will be given for any homework assignment turned in late. If you wish to have a late assignment graded for no credit, we will be happy to oblige.

Homework must be typed or written neatly and with problems in the correct order. If we have difficulty reading or following your homework, we will not go to great lengths to decipher it!

I strongly encourage you to consult with your colleagues when you're working on the homework. However, you will not understand the material thoroughly or do well on the exams unless the work that you turn in is ultimately your own. Therefore, you must write up your answers alone, and without looking at anything you wrote down while working with your group. This means that if you solved the problem with a friend, you're going to have to go home and solve it all over again, by yourself. **The work you turn in must be your own.**

In your write-up, you must cite everyone with whom you worked or consulted about each problem, as well as any books or other references (other than the textbook and the lecture slides) that you used to solve the problem. For example: "I worked with Friendly McPal on this assignment," or "I got help from Smarty McPants about problem #3," or "I consulted Statistics for Dummies, Section 4.2, by Dopey McBrain when solving question #2." Any breach of this policy will be considered an act of plagiarism, and no credit will be given for such assignments. **Repeat offenses will be grounds for failure for the course.**

Re-grade requests: If you disagree with the grade you received on a homework or exam problem, you may submit a request for that problem to be re-examined. This request must be turned in in writing no more than 48 hours after you receive the graded assignment. It must contain a clear explanation, in no more than one paragraph, of why you feel the grade you received is incorrect. Once we re-examine your work and decide whether to change your grade, our decision will be final.

Class Preparation and Participation: You are expected to come to class regularly and to be prepared for each class by reading the relevant sections of the textbook ahead of time. I will post slides on Blackboard in advance so that you may bring them to class if you wish. In addition, you are expected to participate in class discussions and

ask questions when you are confused. A portion of your grade will be based on class participation.

Extended Absences: If you believe you will miss two or more consecutive lectures due to illness, holidays, family emergencies, etc., please contact me as early as possible so that we can develop a plan for you to make up the missed material. Under no circumstances will I give credit for missed homework or exams unless you have discussed your absence with me *in advance*.

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.

Recording devices in the classroom: Any voice or video recording device may be used only with the approval of all participants of the given course.

Grading: Your grade will be calculated as follows:

22%	Homework (11 assignments)
5%	Class participation
48%	Midterm exams (4 of them, 12% each)
25%	Final Exam

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

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 $\mathrm{Var}(X_1 + X_2 + X_3)$ and when to use $\mathrm{Var}(3X_1)$

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, University Center 212 (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. 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.

Tentative Course Schedule

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 final exam is Wednesday, Dec. 16.

Date	Topic	Chapter	Notes
8/24	General Introduction		
8/26	Sample Spaces and Events	2-1	
8/28	Interpretations of Probability, Addition Rules	2-3	
8/31	Counting	2-1.4	
9/2	Counting	2-1.4	HW 1 due
9/4	Counting	2-1.4	Last day to Drop/Add
9/7	Conditional Probability	2-4	
9/9	Multiplication and Total Probability Rules	2-5	HW 2 due
9/11	Independence	2-6	
9/14	Bayes' Theorem, Exam review	2-7	
9/16	Exam 1		
9/18	Return Exam 1		
9/21	Random Variables	2-8	HW 3 Due
9/23	Discrete Random Variables	3-1	
	Probability Mass Functions	3-2	
9/25	Cumulative Distribution Functions	3-3	
	Binomial, Hypergeometric Distributions	3-6, 3-8	
9/28	Hypergeometric Distribution	3-8	HW 4 Due
9/30	Geometric, Negative Binomial, Discrete Uniform	3-5, 3-7	
10/2	Mean and Variance	3-4	
10/5	PACING BREAK, no class		
10/7	Mean and Expectation problems	3-4	
10/9	Variance, Chebyshevs Inequality, Exam review	3-4	HW 5 due
10/12	Exam 2		
10/14	Return Exam 2		
10/16	Poisson Distribution and process	3-9	HW 6 due
10/19	Continuous Random Variables	4-1	
	Probability Density Functions	4-2	
	CDFs, Mean, Variance	4-3, 4-4	
10/21	Go over Exam 2 results		
10/23	Continuous Uniform Distribution	4-5	
	Normal Distribution	4-6	HW 7 due
10/26	Normal Distribution	4-6	
	Normal Approximation to Binomial	4-7	
10/28	Continuity Correction, Exponential Distribution	4-8	
10/30	Exponential Distribution	4-8	
	More on Poisson Process including Erlang	4-9	HW 8 due
11/2	Exam 3		
11/4	Return Exam 3		

Date	Topic	Chapter	Notes
11/6	More on Poisson Process including Erlang	4-9	
11/9	Beta, Lognormal, Weibull Distributions	4-10, 4-11	Last day to drop with a W is 11/10/08.
11/11	Joint Discrete Distributions	5-1	HW 9 due
11/13	Joint Distributions; Covariance, Correlation Properties of E, V, COV	5-3	
11/16	Joint Continuous Distributions	5-2	
11/18	Covariance, Correlation, Properties of E, V, COV	5-3	
11/20	Linear Combinations of Random Variables	5-5	HW 10 due
11/23	Exam 4		
11/25	Thanksgiving Break, no class		
11/27	Thanksgiving Break, no class		
11/30	Distributions of Functions of Variables	5-6	
	Bivariate Normal	5-4	
12/2	Multivariate Normal, Multinomial	5-1.6	
12/4	Review.		Last Day of Classes. Last day to drop with WP/WF. HW 11 due