ISYE 2027 PROBABILITY WITH APPLICATIONS

Prepared Prof. Foley, Spring 2013

Credit: 3-0-3

Prerequisite(s): MATH 1502 or MATH 1512 or (MATH 15X2 and MATH 1522, minimum grade is C.

Co-equisite(s): MATH 2401

Catalog Description:
Topics include probability, conditional probability, density and distribution functions from engineering, expectation, conditional expectation, laws of large numbers, and the central limit theorem.

Texts

1. Dekking, F. M. C. Kraaikamp, H. P. Lopuhaa, and L. E. Meester, *A Modern Introduction to Probability and Statistics: Understanding Why and How*, Springer, London, 2005.
2. Hajek, B. *Probability with Engineering Applications*, Course Notes, available at http://www.ifp.illinois.edu/~hajek/Papers/probability.html, free.

Objective
The objective of this course is to learn the basic tools used in developing and analyzing probabilistic models.

Topical Outline

Topics	Weeks
Basic Definitions and Properties: Sample spaces, events, and the axioms of probability. Basic relationships involving the probability of complements and unions of events. Finite sample spaces with equally likely outcomes. Counting techniques including the multiplication principle, permutations, combinations, and the binomial theorem.. Conditional probabilities and independent events. The birthday problem. The law of total probability and Baye's Theorem.	5
Random Variables: Definition of a random variable. Discrete random variables and probability mass functions. Continuous random variables and probability density functions. Cumulative distribution functions. Important discrete distributions including Bernoulli, binomial, geometric and Poisson. Important continuous distributions including uniform, exponential, and normal. Expectation of a random variable. Uses and shortcomings of the mean in decision making. Markov's inequality. The Poisson approximation to the Binomial. Functions of a random variable. Expectations of functions of random variables and the law of the unconscious statistician. The variance of a random variable. Chebyshev's inequality. Selected applications such as insurance, the newsvendor problem, and travel times in order picking and carousels.	6

Random Vectors: Joint, marginal and conditional distributions. Conditional expectations. Functions of random vectors including the minimum, maximum, and sums. Means and variances of linear combinations of random variables. Selected applications such as travel times in miniload as/rs systems.	
Limit Theorems and their applications: Laws of large numbers and the Central Limit	3

Outcomes

At the end of this course, students will be able to:

1. Grasp which distributions might be appropriate in modeling a particular situation (Program outcomes a, b, c, e, i) H M L M L
2. Understand measures of a distribution's location and spread (Program outcomes a, b, c, e, i) H M L M L
3. Model and analyze problems at a level of the newsvendor problem or the travel time for carousels and miniloads. (Program outcomes a, c, e, i) H H M L
4. Understand the role of probability in decision making (Program outcomes a, c, e, i) H H M L
5. Understand how randomness affects system behavior and performance Program outcomes a, c, e, i) H H M L
6. Compute probabilities and moments such as the expected value and variance of random variables and combinations/functions of random variables Program outcomes a, c, e, i) H H M L
7. Be able to use the central limit theorem to approximate probabilities related to sums of i.i.d. random variables. Know how much probability is within 1, 2 and 3 standard deviations o f the mean of a normal distribution. Program outcomes a, c, e, i) H H M L

Course outcome \ Program Outcomes	a. apply math	b. Design, conduct experiment, analyze interpret data	c. Design system	d. team	e. problem solving	f. prof/ and ethical responsibilities	g. communication	h. global, eco, envi and soc context	i. Life-ling learning	j. Contemporary	k. use tools for eng. practice
1. Grasp which distribution might be appropriate a particular situation	High	Medium			Medium						
2. Understand measures of distribution's location and spread	High	Medium			Medium						
3. Model and analyze problems as newsvendor problem or the travel times	High		High		Medium						Medium
4. Understand the role of probability in decision making	High		High		Medium						Medium
5. Understand how randomness affects system behavior and performance	High		High		Medium						
6. Compute probabilities and moments	High		High		Medium						
7. Be able to use the central limit theorem to approximate probabilities…	High		High		Medium						

Evaluation of the important outcomes

Three or more important outcomes will be evaluated from direct questions in the Final exam:

1. Students should be able to demonstrate which distributions might be appropriate in modeling a particular situation
2. Students should be able to compute mean, variance, moment of continuous and discrete distributions.
3. Students should be able to derive distribution functions.

ISyE ABET Student Outcomes a - k

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) an ability to function on multidisciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.