ISYE 2027 PROBABILITY WITH APPLICATIONS

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Credit: 3-0-3

Prerequisite(s): MATH 1552 and MATH 1553 or (MATH 15X2 and MATH 1522, minimum grade is C.

Co-equisite(s): MATH 2551 or MATH 2500 *
* The students are advised to take 2500 before 2027 because it is likely that the multivariate calculus will appear in ISYE 2027 before MATH 2500.

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.
3. Douglas C. Montgomery, George C. Runger, Applied Statistics and Probability for Engineers, 7th Edition, Wiley, 2018.

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

Course Outcomes

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

1. Grasp which distributions might be appropriate in modeling a particular situation
2. Understand measures of a distribution's location and spread
3. Model and analyze problems at a level of the newsvendor problem or the travel time for carousels and miniloads.
4. Understand the role of probability in decision making.
5. Understand how randomness affects system behavior and performance.
6. Compute probabilities and moments such as the expected value and variance of random variables and combinations/functions of random variables.
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 of the mean of a normal distribution.

Course outcome \ Program Outcomes	**1. identify, formulate solve engg prob by engg, sci & Math**	**2. produce solutions consider public health, safety, welfare, global, cultural, social, environ & economic**	**3 communicate with a range of audience**	**4 recognize ethical & professional responsibilities, make informed judgement consider resolutions in global, economic, environ and societal context.**	**5. effective on a team provide leadership, collaborative and inclusive envirn, plan tasks & meet objectives**	**6. develop and conduct experiment, analyze and interpret data & use engineering judgement to draw conclusions.**	**7. acquire and apply new knowledge using appropriate learning strategies**
1. Grasp which distribution might be appropriate a particular situation	H						
2. Understand measures of distribution's location and spread	H						
3. Model and analyze problems as newsvendor problem or the travel times							
4. Understand the role of probability in decision making							
5. Understand how randomness affects system behavior and performance							

6. Compute probabilities and moments	H						
7. Be able to use the central limit theorem to approximate probabilities…							

Evaluation of the important outcomes

- Course outcomes 1, 2, 6 will be assessed in selective final exam questions.

The approximate relationship from prior ABET a – k to new ABET 1 – 7.

OLD Criterion 3. Student Outcomes The program must have documented student outcomes that prepare graduates to attain the program educational objectives. Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.	NEW Criterion 3: Student Outcomes The program must have documented student outcomes that support the program educational objectives. Attainment of these outcomes prepares graduates to enter the professional practice of engineering. Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program.
(a) an ability to apply knowledge of mathematics, science, & engineering (e) an ability to identify, formulate, and solve engineering problems	(1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
(b) an ability to design and conduct experiments, as well as to analyze and interpret data	(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
(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 & safety, manufacturable, & sustainable	(2) An ability to apply engineering design to produce solutions that meet specified needs with consideration for public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
(d) an ability to function on multidisciplinary teams	(5) An ability to function effectively on a team whose members together provide leadership, create a collaborative & inclusive environment, establish goals, plan tasks, and meet objectives.
(f) an understanding of professional and ethical responsibility (h) the broad education necessary to understand the impact of engg solutions in a global, economic, environmental, & societal context (j) a knowledge of contemporary issues	(4) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
(g) An ability to communicate effectively.	(3) An ability to communicate effectively with a range of audiences.
(i) a recognition of the need for, and an ability to engage in life-long learning	(7) An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	Implied in 1, 2 and 6