ISyE 2027C Probability with Applications

Course Information and Syllabus **Spring 2015**

Instructor: Dr. Craig A. Tovey cat@gatech.edu
Course Meeting Times: TuTh 12:05-1:25 Room 213 Instructional Center
Office Hours: Tu 1:30-2:30; Th 4:00-5:00 Room 420 Groseclose (Old ISyE)
Grader Office Hours: 1:30-2:30 Monday and Wednesday in the ISyE Studio (1st floor in Groseclose).
T.A. Office Hours: Monday 2:30-4, Tuesday 3-5, Wednesday 12:30-2:30, Thursday 3-5, Friday 2-5 in the ISyE Studio.
Note: The T.A. helps with course material but not with grading or course logistics.
Prerequisite: MATH 1502 or 1512, minimum grade C.
Corequisite: MATH 2401.
Textbooks: Bruce Hajek, Probability with Engineering Applications, Course Notes, available free at
http://www.ifp.illinois.edu/~hajek/Papers/probability.html

Dekking,Kraaikamp,Lopuhaa,and Meester, A Modern Introduction to Probability and Statistics: Understanding Why and How, Springer, London, 2005.

Grading

Homework Quizzes 25% Homework will be assigned weekly on t-square. Each week except the first, there will be a quiz similar to one of the homework problems assigned the previous week. The quiz will be closed-book and closed-notes, with no calculators allowed, but it will contain a list of all necessary formulas. Your homework quiz score for the semester will be the average of your 9 best quiz scores. Solutions to homework assignments will be posted afterwards on t-square.

Two Tests, 25% each will be given during the semester. Grading will be as follows: A:$90-100$; B:$80-89$; C:$65-79$; D:$50-64$; F:<50. Tests and the final exam will be closed-book and closed-notes with no calculators allowed. As with the quizzes, the tests and final exam will contain a complete list of formulas.

Final Exam, 25% will cover the course material from roughly the last third of the course, starting from where the 2nd Test leaves off. Keep in mind that much of the material is necessarily cumulative.
Brownies, in accordance with FERPA regulations, will no longer be given to students who get A's on tests. However, if you remind me, I will bake and bring brownies to the final exam.

Extra Credit points are added to your course score. Up to 3 extra credit points may be earned for especially good class participation.
Honor Code Policy: You are expected to follow the Georgia Tech Honor Code. Use during quizzes, tests or exams of unauthorized material such as notes or devices such as phones, will

result in a 0 score for the quiz, test or exam, as will copying answers from another student. *Attendance:* Every student is responsible for everything stated in class, including changes in test dates and material. See http://www.sga.gatech.edu/expectations for details on student and faculty expectations.

Course Objective: To learn the basic tools used in developing and analyzing probabilistic models.

Learning Outcomes:

1. Master fundamental definitions, formulas, and theorems for probability, including counting formulas for permutations and combinations, rules for adding and multiplying probabilities, conditional probability, pdfs, pmfs, and cdfs.
2. Grasp which distributions might be appropriate in modeling a particular situation.
3. Understand measures of a distribution's location (e.g. mean) and spread (e.g. variance).
4. Model and analyze problems at the level of warehouse picking of fast and slow moving items or the newsvendor problem.
5. Understand how randomness affects system behavior and performance.
6. Understand the role of probability in decision making.
7. Compute probabilities and moments such expected value and variance of random variables, and combinations and functions of random variables.
8. Use conditioning and the laws of total probability and expectation to write and solve recursions for steady state and exit time probabilities.
9. Be able to use the central limit theorem to approximate probabilities related to sums of independent identically-distributed random variables. Know how much probability is within 1,2,and 3 standard deviations of a normal distribution.

Syllabus

- Week 1 (Jan 6,8). Sets: de Morgan's laws. Experiments: sample spaces, events, probability. Counting to get probabilities in experiments with equally likely outcomes. In-class problem January 6: poker and/or keno probabilities. Reading: Chapter 1 of Hajek and Chapter 2 of Dekking *et al.*.

- Week 2 (Jan 13, 15). Independence and multiplication of probabilities. Conditional probability: Bayes rule, the law of total probability. Reading: Chapter 3 of Dekking *et al.*.

- Week 3 (Jan 20, 22) More counting and conditional probability. Sample spaces for experiments without equally likely outcomes. Reading: same as weeks 1,2.

- Weeks 4,5,6 (Jan 27, 29; Feb 3, 5, 10, 12) Discrete Random Variables. Bernoulli, Binomial, Geometric, Poisson distributions. Expected value of random variables and functions of random variables (the law of the unconscious statistician). Variance. Reading: Chapter 2 of Hajek, Chapters 4,7,8.1.

- Week 7 (Feb 17,19) Review and Test 1.

- Weeks 8,9,10 (Feb 24,26; March 3, 5, 10, 12) Sample spaces with real numbers. Continuous distributions and random variables. Expectation. Uniform, Exponential, and Normal distributions. Reading: Chapter 3 of Hajek, Dekking *et al.* Chapters 5,7,8.2.

- Week of March 18, 20: Semester break.

- Weeks 11,12 (March 24, 26; March 31, April 2) More than one random variable! Joint distributions. Reading: Hajek Chapter 4: sections 4.1 to 4.8. Dekking *et al.* Chapters 9,10,11.

- Week 13 (April 7, 9) Review and Test 2.

- Weeks 14,15 (April 14, 16, 21, 23). Poisson process (reading for Poisson process: Dekking *et al.* Chapter 12.) Law of large numbers, Central limit theorem and applications. Reading: Hajek 4.10; Dekking *et al.* 13,14.

- Final exam (April 30: 11:30AM to 2:20PM).

Homework 1 January 6, 2014 *be ready for a quiz January 13*

Instructions: do not convert fractions to decimals! An answer such as $\frac{3}{8}$ is good; an answer such as 0.375 is bad. You may use factorial notation in your answers. For example, an answer such as $\frac{2^5}{6!}$ is fine. You do not have to simplify fractions, but sometimes if you do you see that the answer has a simple form, and that shows you an easier way to solve the problem.

1. How many ways can 50 boys and 50 girls be placed in a line?

2. How many ways can 50 boys and 50 girls be placed in a line such that girls are in odd-numbered places and boys are in even-numbered places?

3. If 50 girls and 50 boys are randomly placed in a line, what is the probability that no girl is adjacent to another girl? Be careful.

4. Draw 4 cards from a standard (shuffled) deck of 52 cards. What is the probability that you get 4 of a kind? What is the probability that all 4 cards are the same suit? What is the probability that the 4 cards form a sequence (e.g. 2,3,4,5 or 9,10,J,Q) (the cards need not be drawn in that order – it is OK if you draw a 3, then a 5, then a 2, then a 4, for example.)

5. You play a game of poker in which you draw 7 cards and then discard 2 of them. What is the probability that you can get 4 of a kind? What is the probability that you can get a flush (all 5 cards are the same suit)?

Hajek: Chapter 1.7: Problems 1.1, 1.3 Dekking *et al.*: Chapter 2.7 Problems 1,3,6,7

For those who don't yet have the Dekking et al. textbook:

Dekking exercise 2.1: Let A and B be two events in a sample space for which $P(A) = 2/3, P(B) = 1/6$, and $P(A \bigcap B) = 1/9$. What is $P(A \bigcup B)$?

2.3 Let C and D be two events for which one knows that P(C) = 0.3, P(D) = 0.4, and $P(C \bigcap D) = 0.2$. What is $P(C^c \bigcap D)$?

2.6 When $P(A) = 1/3, P(B) = 1/2, and P(A \bigcup B) = 3/4$, what is (a) $P(A \bigcap B)$?; (b) $P(A^c \bigcup B^c)$?

2.7 Let A and B be two events. Suppose that $P(A) = 0.4, P(B) = 0.5$, and $P(A \bigcap B) = 0.1$. Find the probability that A or B occurs, but not both.