Math/CS 335: Probability, Computing, and Graph Theory

Fall, 2016

Course Description: Randomization is a powerful tool in both discrete mathematics and computer science. A randomized algorithm is one which makes use of randomness. Such algorithms are often robust and fast, though there is a small probability that they return the wrong answer. The analysis of such algorithms requires tools from probability theory. Randomized algorithms can provide approximate answers to NP complete problems in polynomial time, but understanding this requires tools from graph theory. This course will cover a selection of topics related to applications of probability theory in theoretical computer science, graph theory, and combinatorics.

Class Details:

Instructor:	David White
Office:	Olin 202
Extension:	6644
Email:	david.white@denison.edu
Class Times:	1:30pm-2:20pm MW, 1:30-3:20 F, Olin 220
Drop-in Hours:	2:30-3:30pm M, 11:20-12:20 W, 12:20-1:20pm F, and by appointment
Web Resources:	http://personal.denison.edu/~whiteda/335spring2016.html

Course Goals:

1. Develop creative problem-solving strategies and confidence when facing hard problems. Learn to mold theory-based approaches to solve real-world problems. Learn to recognize a familiar problem in unfamiliar contexts.
2. Learn how to read the textbook, how to figure out the big picture, and how to focus on the relevant details without being overwhelmed.
3. Learn numerous randomized algorithms, frameworks for their analysis, and how to create your own randomized algorithms. Come to appreciate the power of randomized algorithms for a swath of applications across computer science.
4. Develop group work skills, test-taking skills, and writing skills. Become proficient at re-writing for clarity once you figure a problem out.
5. Develop time management skills, metacognitive skills, and the habit of thinking intentionally about your learning and your goals.

Homework:	45%	Quizzes, Activities, & Presentations:	10%
Final Project:	10%	First Midterm	15%
Participation:	5%	Second Midterm	15%

Text and Materials:

- *Probability and Computing: Randomized Algorithms and Probabilistic Analysis*, by Mitzenmacher and Upfal, 2005. ISBN 0521835402.
- *Graph Theory*, Reinhard Diestel, Electronic Edition 2005. Available from http://www.math.ubc.ca/~solymosi/2007/443/GraphTheoryIII.pdf

- (Optional) *Randomized Algorithms* by Motwani and Raghavan. At the library.
- (Optional) *The Probabilistic Method* by Alon and Spencer. At the library.

Exams: Each exam will cover material presented in class, homework, and the assigned readings. The best way to study is to attend all class meetings and to do all homework problems carefully. The first midterm exam will be Monday, October 10 to be taken some time during the block of 4-10pm. The second midterm will be Wednesday, November 16, also 4-10pm. Each should take about 2 hours. The final project will consist of a presentation in the last week of class and an 8-10 page written portion due Tuesday, December 20 by 4pm.

Homework: The bulk of your work in this class will be weekly homework sets. These problems will be drawn mostly from the textbooks, and will often require creative thinking. Collaboration on homework is strongly encouraged, and several assignments will be partner based. When you write up solutions, you must cite any sources (including other students) that you used. For team assignments it is your responsibility to make sure you can solve all the problems on the homework, and some will reappear on exams.

Part of the goal of the course is practicing your writing skills, so you are expected to hand in clear and readable submissions in which you show all work for written problems and leave detailed and useful comments on any code. Homework will be collected on Fridays at the beginning of class. Late homework will not be accepted. All homework must be typeset in LaTeX.

Additionally, you are expected to keep up with the reading. The goal of class will NOT be to review the reading. Instead, we'll apply the ideas in the reading to new problems. Several classes will contain an open-note quiz on the reading, and every class will begin with a chance for you to ask questions on the reading. Expect to spend about 10-12 hours per week outside of class on reading and homework. I am happy to answer questions, and I encourage you to come to my drop-in hours if you are confused about anything. You will get the most out of this time if you attempt the homework first and come with specific questions already prepared.

Communication: It cannot be stressed enough how essential communication is to succeeding in this course. After identifying topics that may be giving you trouble, please communicate this information to me. There's no such thing as a bad or unwelcome question. Additionally, please communicate with each other. I view the class as a team trying to learn the material together. Collaboration will help all parties achieve this goal, as explaining concepts and examples to each other is a great way to learn.

Grading Scale: A standard 10% grading scale will be used. Therefore, 60% is required to pass the class, 70% will be a C-, 80% will be a B-, and 90% will be an A-.

Keys to Success

- Prior to exams, be able to solve every quiz and homework problem under time pressure. Have a perfect, hand-written copy of each of the homework exercises assigned from the book. Be confident using the approaches we've learned on new problems, and recognizing when to use each approach.
- Review the material from class the same day it is given. Find a way to attach this new knowledge to things you already understand. Study a bit every day rather than in bursts just before an exam.

- Focus note-taking in class on these connections you made to your unique prior knowledge, not on material already in the book, handouts, or slides.
- Read the textbook slowly and carefully, at your desk, with a notebook nearby to write down questions and work out reasons for steps you don't understand. Pay particular attention to examples, and try to work them out yourself before reading the solution.
- Start homework early. Give yourself time to get stumped and to get past these difficulties. It is usually impossible to complete these assignments in one sitting, due to the creativity required in solving these problems.
- Keep a list of key definitions and theorems you frequently use, and commit them to memory throughout the course. Test your memory each week.

Disability: Any student who feels he/she may need an accommodation based on the impact of a disability should contact me privately as soon as possible to discuss his/her specific needs. I rely on the Academic Support & Enrichment Center in Doane 104 to verify the need for reasonable accommodations based on documentation on file in that office.

Academic Integrity: The students and faculty of Denison University and the Department of Mathematics and Computer Science are committed to academic integrity and will not tolerate any violation of this principle. Academic honesty, the cornerstone of teaching and learning, lays the foundation for lifelong integrity.

Academic dishonesty is, in most cases, intellectual theft. It includes, but is not limited to, providing or receiving assistance in a manner not authorized by the instructor in the creation of work to be submitted for evaluation. This standard applies to all work ranging from daily homework assignments to major exams. Students must clearly cite any sources consulted, including classmates who have been collaborators on the homework and online sources of aid. Neither ignorance nor carelessness is an acceptable defense in cases of plagiarism.

As is indicated in the Denison Student Handbook, available through my.denison.edu, instructors must refer every act of academic dishonesty to the Associate Provost, and violations may result in failure in the course, suspension, or expulsion. (For further information, see the Academic Misconduct and Sanctions sections of the Student Handbook or Section VII.B. of the Faculty Handbook.)

I expect that we will all abide by the honor code in this course. Collaboration on homework is permitted, but please do not use resources outside of me, your fellow students, and the textbook. Collaboration on quizzes and exams is not permitted. Students should not search for solutions online.

Appropriate Use of Course Materials: The materials distributed in this class, including the syllabus, exams, handouts, study aides, and in-class presentations, may be protected by copyright and are provided solely for the educational use of students enrolled in this course. You are not permitted to re-distribute them for purposes unapproved by the instructor; in particular you are not permitted to post course materials or your notes from lectures and discussions online. Unauthorized uses of course materials may be considered academic misconduct.

Email: I will frequently contact you via email. Please check your email regularly. I will also check my email regularly, but often not after 8pm.

Topics: A rough schedule of topics follows, but is subject to change. The schedule on the course webpage supersedes the schedule here:

Week 0: Introduction to the course. First randomized algorithms.

Week 1: Introduction to probability theory and random variables. Analysis of Randomized Algorithms using Linearity of Expectation and the Union Bound.

Week 2: Bernoulli, Binomial, Geometric random variables. Coupon Collector. QuickSort.

Week 3: Variance, Markov and Chebyshev, computing the median, streaming computation

Week 4: Chernoff Bounds, set balancing, packet routing

Week 5: Graph theory, randomized min cut, balls and bins

Week 6: Exam, Poisson distribution, hashing

Week 7: random graphs and fall break

Week 8: Game Theory

Week 9: Ramsey Theory and the Probabilistic Method. Expectation Argument.

Week 10: Derandomization, Sample and Modify, MAX SAT, finding large cut sets

Week 11: Cryptography - RSA, Miller-Rabin, AKS, Exam 2

Week 12: Thanksgiving break

Week 13: Second Moment Method, Lovasz Local Lemma, Satisfiability

Week 14: Markov Chains

Week 15: Big Data, Final Presentations