COURSE INFORMATION: MATH 554 Discrete Applied Mathematics II
(Mathematical Methods in Discrete Applied Mathematics)
Spring 2013

Time and Place: 3:15pm, Tuesday and Thursday, at 102, Engineering 1 Bldg.

Instructor: Hemanshu Kaul

Office: 125C, Engineering 1.

Phone: (312) 567-3128

E-mail: kaul@iit.edu

Office Hours: 12noon-1pm Tuesday and Thursday, and by appointment.
Emailed questions are also encouraged.

Course Communications: http://www.math.iit.edu/∼kaul/TeachingSpr13/Math554.html
Check the course webpage regularly for homework assignments, announcements, and a lecture log (useful when you miss a class and when reviewing for an exam).
I often send emails with comments regarding HW problems, Exams, etc. Make sure your IIT email account is active and working.

Textbook: There is no required textbook. See below for a discussion of various possible textbooks.

Grade Break-down: Homework worth 35%; One mid-term exam worth 25%; Final exam worth 25%; and a project worth 15%. The grading scale will be no more strict than A:85-100, B:75-84, C:65-74, D:55-64.

Examinations: There will be a mid-term exam and a final exam. The exam dates and their precise topics will be announced in class and on the course webpage. Each of the exams might include a take-home component. Make-up exams will be given only in case of a documented emergency.

Project: Each student, in consultation with the instructor, will pick a topic or a research paper not covered in class. He/She will be expected to write a 5-10 page summary of the paper in their own words and present it in a 30 minute lecture in class. The summary should include a short background/ history of results in the area, description of the problem with examples, and overview of the results and the proof techniques used therein. The topic/ paper must be finalized by March 14th. All reports must be submitted by 26th April.

Prerequisites: You need to have some familiarity with the topics listed below. Don't worry if you don't know each and every topic listed below, in that case you just need to be willing to learn whenever something is needed in the course.

1. Graph Theory: Trees, bipartite graphs, spanning trees, independent set, clique, vertex and edge covers, connectivity, chromatic number, edge chromatic number. Books - *West, Intro to Graph Theory*; *Diestel, Graph Theory, 3rd ed.*

2. Combinatorics: Basic Counting (permutations and combinations, various ways of sampling, partitions of integers), pigeonhole principle, Inclusion-Exclusion principle. Books - any standard undergrad textbook like *Brualdi, Introductory Combinatorics*; *Roberts and Tesman, Applied Combinatorics*; *van Lint and Wilson, A Course in Combinatorics*

3. Linear Algebra: Vector spaces - definition and lots of examples, linear independence, spanning set, basis and dimension of a vector space, eigenvalues of a matrix. Book - any standard undergrad textbook.

4. Probability: Random variables (discrete and continuous), expectation, conditional expectation, variance, elementary properties of distributions like Bernoulli, Binomial, discrete uniform, continuous uniform, exponential, poisson, normal; discrete Markov chains. Books - any

standard textbook like *Stirzaker, Elementary Probability*; *Grimmett and Stirzaker, Probability and Random Processes*.

Course Description - Topics and Textbooks: This graduate-level course in Discrete Mathematics will introduce students in Applied Mathematics, Computer science, and Engineering, to the use of tools and techniques from various fields of mathematics like Probability, Linear Algebra, Algebra, and Stochastic processes, to existential and algorithmic problems arising in Graph Theory, Combinatorics, and Computer science.

The tools considered would include Probabilistic Methods, Linear Algebra methods, Combinatorial Nullstellensatz, Entropy, Martingales and large deviation bounds, Markov chain Monte Carlo, etc. These tools will be applied to various fundamental problems like - Graph and Hypergraph coloring, Intersecting families of sets, Ramsey problems, Extremal problems on Graphs and on Set systems (Hypergraphs), Optimization problems on discrete structures, Sampling and counting discrete structures, etc.

There is no one textbook that covers all the topics that I plan to present. So, it will be important that you attend classes regularly and take lecture notes. *Jukna, Extremal Combinatorics with applications to computer science* contains material on Probabilistic, linear algebraic, and algebraic methods. *Habib, McDiarmid, Ramirez-Alfonsin, and Reed, Probabilistic methods for algorithmic discrete mathematics* has a lot of relevant survey articles.
For Probabilistic Methods, *Alon and Spencer, Probabilistic Method, 2nd (or 3rd) ed.* is the best reference.
For Linear Algebra methods, *Babai and Frankl, Linear Algebra Methods in Combinatorics* available at *http://www.cs.uchicago.edu/research/publications/combinatorics* is the standard reference.
For MCMC, *Levin, Peres, and Wilmer, Markov Chains and Mixing Times* is a good reference.

Homework: A total of 5-7 homework will be assigned over the semester. Each homework will be announced on the course webpage.

You are allowed to discuss homework problems with your classmates (and no one else). However, the solutions should be written by you alone. Any use of external help/ solutions, etc. will be considered a violation of IIT code of Academic Honesty and prosecuted accordingly. Solutions for homework and exams must be written clearly, legibly, and concisely, and will be graded for both mathematical correctness and presentation. Points will be deducted for sloppiness, incoherent or insufficient explanation, or for lack of supporting rationale.

To improve your mathematical writing quickly, start by writing draft solutions to homework early. A day or two later after you have had time to forget what you wrote, read it. If it doesn't make sense or convince you, rewrite it. Writing a solution requires saying what you mean and meaning what you say. Be intellectually honest. Intellectual dishonesty includes: 1) stating a "reason" without understanding its relevance. 2) Claiming a conclusion when you know you haven't proved it. 3) Giving an example and claiming you have proved the statement for all instances. **Include enough detail in your solutions so that your explanation is convincing to someone who hasn't thought about the problem before**. The proofs/ arguments should be presented so that your classmates could read them and follow the logic (step-by-step).

HELP: You are encouraged to ask questions during class, or in office hours, or through email. If you are having trouble solving a homework problem, I will be glad to direct you in the right direction. The same goes for any concept/ proof you have difficulty understanding. Don't hesitate to ask for help! I cannot help you if you don't take the initiative.

In addition to office hours, you can also walk-in to my office (if I am available). In past, a lot of my students have regularly communicated with me over email. I encourage you to do the same, if that suits you better.

Reasonable accommodations will be made for students with documented disabilities. In order to receive accommodations, students must obtain a letter of accommodation from the Center for Disability Resources and make an appointment to speak with me as soon as possible.