MATH 3012: APPLIED COMBINATORICS
COURSE POLICIES AND EXPECTATIONS
SPRING 2010
(UPDATED 19 MARCH 2010)

1. Course Information and Goals

Course	MATH 3012G: Applied Combinatorics (3.00 Credit Hours)
CRN	20949
Prerequisites	D or higher in MATH 1502 (or equivalent) Computer Science majors should take CS 1050 before MATH 3012
Instructor	Mitchel T. Keller, Graduate Teaching Assistant
Email	keller@math.gatech.edu (I generally reply within 24 hours, except on weekends)
Time/Location	MWF 1305–1355 in Skiles 249
Office Hours	M 1400-1500, W 0930-1030, F 1030-1130 and by appointment
Office	Skiles 138A (404.492.7649 (Google Voice) or 404.894.6365 (Direct to office))
Website	`http://t-square.gatech.edu`
Text	Trotter and Keller, *Applied Combinatorics*. Spring 2010 Edition. **On T-Square. No physical text required!**
Supplies	TurningTechnologies ResponseCard XR transmitter (provided free as part of pilot)

Teaching philosophy. Over time, I've come to view teaching and learning as a shared journey on which my students and I embark each semester. I am the subject matter expert responsible for providing information and guidance, setting expectations, and assessing how well students meet those expectations. My students are responsible for much hard work, including reading the text, participating in class activities, and doing out-of-class assignments, regardless of whether or not they are graded. There is only so much that can be conveyed in fifty minutes, and my own personal experience and educational research agree that students get far less out of a fifty-minute lecture than their professors hope. Thus, I have chosen to take an approach that is more work both for you and for me but has better results. I endeavor to create an environment that is highly conducive to learning. Yes, I still lecture, but rarely is it for fifty minutes. Instead, I expect that you read before coming to class and provide reactions to that reading. I use that information to develop the plan for the class session, which will likely involve me talking for a while and more time with students working together in small groups to grapple with the material, often after answering a question via clickers. I'll be there to support, guide, and correct misconceptions. Sure, I could expect you to do this alone outside of class, but over time I've realized a few things about working in groups. As a student, I usually understood something better when I went over it with classmates, even if I was the one who thought I understood it completely and explained it to a peer. As a researcher, I am more productive and effective when I collaborate. Friends in industry report that teams are increasingly used to produce the best results. Furthermore, having me there to help in the early stages ensures that we're traveling together on this journey.

Why Applied Combinatorics? Combinatorics is one of the areas of mathematics that is most frequently used in computer science. A principal reason for this is that the models provided in combinatorics are discrete, which aligns with the problems studied in computer science moreso than the continuous models you encountered in calculus. The topics we will study in this course are especially important to the design and analysis of algorithms. The tools developed in this course are also of importance in some engineering fields, most notably computer engineering and industrial engineering (in the form of optimization). Combinatorial mathematics is also increasingly becoming important in the social and life sciences, providing a way to model relationships and connections between objects under study.

Combinatorics is a subject area that you really must develop a gut-level feeling about. Often, we will avoid stating things as general principles in order to reinforce that you should be developing an intuition to carry with you, rather than memorizing a formula. **This course is likely different from every other mathematics course you have taken!** You will almost never hear talk of derivatives or limits in this course, for example. We will draw many pictures to illustrate our discussions, but they (generally) won't be graphs of functions like you would draw in calculus. I think combinatorics is the most beautiful area of mathematics, and I hope that by the end of the semester, I will have convinced you to share my view.

Course description and goals. The catalog describes the content of MATH 3012 as "Elementary combinatorial techniques used in discrete problem solving: counting methods, solving linear recurrences, graph and network models, related algorithms, and combinatorial designs." In order to cover this content, we will focus on three main areas: discrete structures, enumeration, and algorithms and optimization. Discrete structures will include strings, sets, graphs, digraphs, and posets (the last being one of my favorite subjects). Enumeration will be a recurring theme throughout the course. We will focus on basic enumeration (counting) techniques and see how they can be applied to many discrete problems. These techniques are particularly important in the analysis of how efficient an algoritm is. We will also look at some slightly more sophisticated (but still fundamental!) enumeration techniques such as generating functions and recurrence relations. The end of the course will focus heavily on algorithms for graphs and posets.

It's one thing to list the topics for a course but another to say what you as students will be able to do upon successfully completing the course. The course goals I have set for students in this course are listed below.

(1) Students will apply fundamental enumeration techniques and algorithms to solve problems involving discrete structures.
(2) Students will analyze a discrete mathematical model to identify important structural or enumerative properties in order to solve problems related to the model.
(3) Students will evaluate unfamiliar problems to determine if a discrete structure provides an appropriate model and develop such a model.
(4) Students will investigate a real-world problem and propose combinatorial techniques that could be used to solve it.
(5) Students will communicate mathematical ideas using standard written English.

Instructional methods. I hope the material above has helped you understand that this course will not use the instructional methods that predominate at Georgia Tech. (A math instructor who wants you to write sentences and paragraphs? What is the world coming to?) Getting some extra shut-eye or reading *The Technique* in class is going to be pretty hard, as there will be lots of interaction, even when I'm presenting at the board. Outside of class, I expect that you will spend between two and three hours working on this class for every hour you spend in class. That means six to nine hours per week working on applied combinatorics outside class, and I expect you to distribute that throughout the week in order to keep up. Procrastinating to weeks of tests will likely result in disaster. In class, I'll use clicker questions to check how well you understand something I just explained, and depending on responses, we might move into an activity. Usually an activity will require you to work with three peers to answer a question. These sorts of teaching and learning activities will be chosen to help you prepare for the various assessments in the course and to achieve the course goals.

2. Assessment and Grading

Grade components. Your grade in this course will be based on five categories of work: Preparation and Participation, Homework and Quizzes, Writing Assignments and Group Project, Tests, and the Final Exam. These categories and their weights are described below.

Preparation and Participation: This category contains two subcategories: reading questions and class participation.

- To make the most effective use of time in class, **reading questions** will be assigned via T-Square prior to most class meetings. You are responsible for reading the assigned section(s)

of the text and giving short (one- to three-sentence) responses to questions *in your own words*. The questions will generally check your understanding of what you've read so that I can tailor the class plan. Thus, reading question responses must submitted by 0900 the day of the class meeting. Each reading assignment will be graded with either a 0 or a 1. A score of 1 will be assigned if you submit the assignment on time and your response reflects that you've read the material, even if you didn't understand it all. A score of 0 will be assigned if you fail to submit the assignment, miss the deadline, or submit the assignment but your response does not sufficiently reflect that you read the material. The reading questions will be worth five percent of your grade. Your grade on reading assignments will be an integer between 0 and 5 determined using the following guidelines:

Score	Description
5	At least 95% of reading assignments with scores of 1
4	At least 85% of reading assignments with scores of 1
3	At least 75% of reading assignments with scores of 1
2	At least 65% of reading assignments with scores of 1
1	At least 55% of reading assignments with scores of 1
0	Less than 55% of the reading assignments with scores of 1

- The size of this class creates some challenges for effective teaching and learning. To create an environment that provides the best opportunities for students to learn, this will be a very active class. To facilitate this, you will receive credit for **class participation**. Class participation will be worth five percent of your grade. Your participation grade will be determined primarily by your responses to clicker questions in class. Whether your answer is correct or incorrect does not matter, simply that you are in class and responding to questions. This participation will allow me to adjust class plans on the fly and to keep all students involved.

Score	Description
5	At least 95% of clicker questions answered
4	At least 85% of clicker questions answered
3	At least 75% of clicker questions answered
2	At least 65% of clicker questions answered
1	At least 55% of clicker questions answered
0	Less than 55% of clicker questions answered

  Although clicker questions will be the primary basis for determining participation grades, I will consider participation in meaningful discussions related to the class on the T-Square Forums in borderline situations.

Homework and Quizzes: Homework problems will be assigned for each chapter of the text. Due dates for each set of problems will be posted on T-Square and the homework will be collected in class on those dates. Homework is due at the posted time, so if you must miss class, submit in advance! (A *legible* scanned copy emailed to me is acceptable under extreme circumstances.) Late homework will not be accepted. A nonempty (usually proper) subset of the problems will be graded.

A small number of unannounced quizzes will be given in class, usually leading up to tests as a way of giving you an opportunity to practice test-like problems that you must solve on your own.

I will drop the lowest homework or quiz grade (or one zero for a homework set or quiz not submitted) in computing this grade component. Each remaining homework set and quiz will be counted equally in computing your homework/quiz grade, which will be 10 percent of your final grade.

Writing Assignments and Group Project: There will be two individual writing assignments (each requiring two to three pages) and a group project as part of the requirements for this course. The individual writing assignments will be worth 10% of your course grade. (Either 5% each or 3% for the first and 7% for the second, which ever results in a higher grade for you.) The group project will be worth 15% of your course grade. The group project will require a written report and a virtual presentation (a video or computer animation presentation). Due dates for the writing

assignments will be announced when they are assigned, but both will be due well before Spring Break. Full details regarding the group project will be provided by mid-February, but the three important dates for the group project are 9 April 2010 (preliminary drafts due), 19 April 2010 (final drafts due), and 28 April 2010 (virtual presentations due).

Tests: There will be three tests this semester. They will be given on 19 February 2010, 31 March 2010, and 23 April 2010. The attached course schedule gives an estimate of the material each test will cover, but that is subject to change as the term progresses. Any changes will be announced in class and on T-Square. Tests will include a take-home component which will be due at the start of the next class meeting after the test. These take-home components will allow you more time to tackle applied problems or questions that require you to put the material together into a bigger picture. Each test will be worth 11% of your final grade.

Final Exam: The final exam will be held on Wednesday, 5 May 2010, from 1450 to 1740 in Skiles 249. The final exam will be comprehensive and worth 22% of your final grade.

Grade computation. All questions on the homework and exams will be graded based on the following holistic five-point scale:

5 Excellent work communicated through a well-written solution/proof (∼A+)
4 Good work with minor errors or small gaps in explanation (∼A)
3 Good work with more serious errors or insufficiently clear explanation (∼B)
2 Significant, but incomplete, explanation that could clearly lead to a correct answer/proof (∼C)
1 Some ideas that might lead to a complete solution/proof are presented (∼D)
0 No progress, no relevant information, or illegible

Note that grades of 0 and 1 are considered unacceptable.

Your score on a multi-problem homework, quiz, test, or exam will be the average of the scores on the individual problems. Your final grade in the course will be determined by computing the weighted average of your score on each component using the weighting described above. This will be evaluated against the five-point scale to determine your letter grade. (Rubrics translating to scores between 0 and 5 will be provided for the writing assignments and group project.) Do not interpret these scores as percentages! For example, if we have a test with five problems on it, and you receive scores of 2, 3, 5, 4, and 3, your average score on the test is 3.4, which is a B based on our scale, rather than being a 68%.

The table below summarizes weights for each category of work this semester.

Category	Due date(s)	Weight
Reading questions	Most classes	5%
Participation	Daily	5%
Homework and Quizzes	Weekly HW	10%
Writing Assignments	Multiple	10%
Group Project	Multiple	15%
Test I	19 Feb 2010	11%
Test II	31 Mar 2010	11%
Test III	23 Apr 2010	11%
Final	5 May 2010	22%

Final grades in this course, however, will be determined by the judgment of the instructor. In particular, **you must pass the final exam in order to pass the class.**

Make-up tests and late work. I discourage make-ups, and generally will not approve them unless required by Institute policy. Any student with a valid reason for missing a test **must obtain permission from me at least two weeks before the test date**. Note that Test II is the Monday after Spring Break and our final exam is on Wednesday of finals week. No student will be allowed to take the final exam outside the scheduled time except as established by Institute policy. I encourage you to review the final exam schedule now and ask me if you have any questions.

Late submission of assignments will not be allowed except under extraordinary, unforeseen circumstances. For assignments to be submitted via T-Square, submission will automatically be shut down at the

assignment's due date and time. In the event you are unable to come to class on days when assignments to be submitted in class are due, you should email them as Adobe PDF files to keller@math.gatech.edu prior to the end of the class meeting in which they are due.

Feedback. Feedback beyond numerical grades will be given at several times during the semester. This feedback will take several forms such as a comment from me during an activity or formal feedback on a draft. At times, you will be expected to give feedback to your peers on their work. You will also be given opportunities to review your progress on an assignment or in the course overall to determine if you are making adequate progress. Giving and receiving feedback are valuable skills that you will need in the future, both as a student and in your career. Feedback should be given respectfully, and you should work to use feedback to improve your work in the future. Prior to formal feedback opportunities, we will discuss our expectations for feedback as a class. Feedback provides an important chance to take stock of progress in the course and make corrections before an assignment is due or before the end of the term.

3. Groups and Forums

Groups. This semester you will work with classmates in groups almost every day. Most of the time, this will be as part of designated groups. Since this is an upper-division class, you will be allowed to form your own groups (according to instructions given during the second week of class). To facilitate our groups, we'll use a couple decks of playing cards. One deck will have white backs, and the other will have gold backs. (We are at Georgia Tech after all!) The rank of a card is its value (Ace, Two, ..., Queen, King), and its suit is the symbol (hearts ♡, diamonds ♢, spades ♠, clubs ♣) on the card. You will be assigned to a color-rank group consisting of the four students with the same rank and card back color (so "White Kings" or "Gold Sevens"). You will also be assigned to a rank group ("Kings" or "Sevens") that combines the two color-rank groups having the same rank. I'll have a set of cards to use to randomly call on students in class, and I might also assign roles in your groups for that class meeting based on the suit of your card.

Forums. The forums feature of T-Square will also be used for this class. This will give you an opportunity to discuss the course content online with your classmates. In some instances, you'll use the forums to communicate with your group members about the group project, but I also encourage you to discuss the reading, homework problems, practice tests, and the content of individual class meetings. On T-Square, you will find places where you can conduct discussions that only your group members will see. There is also a place where general discussion about each chapter we will cover can take place. Feel free to discuss the homework, reading, or what happened in class here. Note that I will generally not monitor the forums other than the one designated for questions directed to me and the one designated for reporting typos in the text. That means that as a group or the entire class, you should discuss questions online *before* bringing them to my attention. A benefit of posing questions to me online rather than via email is that everyone in the class benefits from the opportunity to see the answer.

4. Homework

Homework will be assigned for each chapter of the text and due dates will be posted on T-Square. A nonempty (usually proper) subset of the homework problems will be graded, and the graded homework will be returned to you. I do not plan to post solutions for homework problems, but will try to post comments about common problems students encountered in order to help you prepare for the tests. Even if I do not assign all of the problems from a chapter, I encourage you to work them all, as practice will help you improve your combinatorial intutition. Mathematics is not a spectator sport! The only way to learn mathematics is by getting your hands dirty, and you will only accomplish that in this course by solving homework problems. If you get stuck, you're more than welcome to post a question on the T-Square forum, send me an email, or visit with me in my office.

Collaboration on homework. You are permitted to work in groups of at most four students when solving homework problems. (I anticipate your collaboration will be primarily with members of your color-rank group. However, I will not make this a requirement.) You must, however, write up your solutions for the problems on your own. The process of explaining your solution in writing (using complete sentences whenever possible!) will help you better understand the material. Each member of a group that worked

together on a homework set must write at the top of their homework submission "I collaborated on this assignment with _____." where the other group members' names are used to fill in the blank.

5. Course Policies

Timeliness: Timeliness is expected. Class starts at 1305 and ends at 1355. Late arrivals and early departures are disruptive to the class and are to be avoided except in emergency situations. If you must depart class early, please find a seat near the door in order to minimize disruptions.

Attendance: Attendance contributes to your grade in the form of participation points for clicker question responses, but otherwise attendance is not taken or required. However, you certainly are expected to attend class. You are also expected to sit with your group (specifically your color-rank group, but if you want to sit with your whole rank group, that's fine) so that you can work with them during class.

Technology use in class: Other than times where class activities require them, I discourage use of laptops, smart phones, or other electronic devices during class. Students are expected to discontinue use of electronic devices if the instructor or another student deems them distracting.

Noise from telephones, etc.: Audible noises from cellular telephones and computers will not be tolerated. This includes the noise made by some models when set to vibrate. Please turn your phone off or set it on silent before class begins.

Showing and explaining work: For all problems submitted for grading (homework, quizzes, tests, exams, etc.), your answer should be written using **complete sentences to explain how you reached your answer**. Your explanations are important not just to receive partial credit in cases where your answer is not correct but also to support your answer and receive full credit when correct. **Correct answers that are not fully supported by explanations using complete sentences will generally not receive full credit.**

Technology use on assignments: You are free to use any calculator or computer algebra system (Wolfram | Alpha, *Mathematica*, MATLAB, *Maple*, etc.) on homework. (An explanation of the form "This is the answer because *Mathematica* said so" is not acceptable unless I approve it in advance, which I may do if it's a computation that's not part of our course material.) Unless specified otherwise *in writing*, you may not use a calculator, computer, cellular telephone, personal digital assistant, or any other electronic or manual calculating device during a quiz, test, or exam.

Regrades: If you have questions about the grading of anything in this class, you must return it directly to me (not my mailbox) within one week of the date it was handed back. Attach a separate piece of paper indicating what you want regraded and the reasons you feel a regrade is appropriate. Do not write anything on the item to be regraded itself. I reserve the right to retain photocopies of any and all graded work prior to returning it to prevent regrade abuse.

Record retention: You should retain all graded materials returned to you until after final grades have been posted. You will need them to support any claim that your grade was inaccurately computed.

Collaboration: You are encouraged to form informal study groups to work exercises and problems and enhance your understanding of the material. Formal groups will be assigned for certain activities and the group project. See the information above regarding collaboration on homework for details on how you may work together on problems to be graded. For quizzes, tests, and exams, unless otherwise specified *in writing*, you are to work completely alone without the aid of texts or notes. You are only allowed to use one clicker transmitter in class; if you are caught using two or more, you will be reported to the Office of Student Integrity.

These policies and the course schedule are subject to change depending on how the semester progresses. Any changes will be announced in class, on T-Square, and with an updated version of this document. The update date will be clearly indicated in the document's title.

6. Institute Policies

Academic Integrity. As I hope you are aware by now, Georgia Tech takes academic integrity very seriously. Please review the Honor Code at `http://www.honor.gatech.edu/`. All work in this course must be completed in a manner consistent with the Georgia Tech Honor Code and Student Code of Conduct. I encourage you to make use of any old tests, exams, quizzes, and homework from previous incarnations of this course. The more exercises and problems you work, the more successful you will be in this course. The tests and exam you will see in this course will not be identical to those given in previous semesters. I will provide old test questions leading up to each of the midterm exams.

Cheating via any means is unethical and unacceptable. Unless specified *in writing*, you are to work completely alone without the aid of notes or texts on quizzes, tests, and exams.

Merriam-Webster's Online Dictionary defines *plagiarize* as "to steal and pass off (the ideas or words of another) as one's own : use (another's production) without crediting the source". Plagiarism is unacceptable in this course. When submitting writing assignments and the group project, you must properly quote and cite any references used. Note that paraphrasing a writer's text without giving attribution is plagiarism. If you are familiar with your discipline's style for citations, you may use it. Otherwise, please use the MLA or APA style for citations.

Behavior contrary to the above expectations will not be tolerated and will be handled via the appropriate channels. If you have questions regarding academic integrity policies in this course, talk to me. If you have other academic integrity questions, consult with a member of the Honor Advisory Council, either during drop-in office hours (posted online at the address above) or by making an appointment through the Council's chair via email at honor@gatech.edu. (I am a member of the Council and hold office hours for HAC. If you would feel more comfortable speaking with another Honor Advisor, you can see which office hour is mine on the schedule posted on the HAC website.)

At all times, in all things you do in this course, keep the Georgia Tech Honor Challenge in mind:

I commit to uphold the ideals of honor and integrity by refusing to betray the trust bestowed upon me as a member of the Georgia Tech community.

Special needs. Any students with disabilities or other special needs, who need special accommodations in this course are invited to share these concerns or requests with the instructor as soon as possible. Students with disabilities are also referred to the ADAPTS Office in Suite 210 of the Student Services (Flag) Building.

Incomplete grades. Incomplete grades will be assigned only under extraordinary circumstances in accordance with the Georgia Tech Catalog and other policies provided by the Office of the Registrar. If you feel an incomplete grade is warranted, you must contact me *before* final grades are due on 10 May 2010.

Grade appeals. In the event that you feel you received an incorrect final grade, you should contact me as soon as your grade is posted. You must contact me no later than the end of your next term in residence (Georgia Tech Catalog V.A.6), generally Fall 2010. The full grievance process can be found in Georgia Tech Catalog XX.

7. Support Services

Tutoring. I should be considered your first resource in this class. However, if you need additional tutoring support, there are resources available. The School of Mathematics maintains a tutoring facility known as the Math Lab in Skiles 257. It is staffed by undergraduate and graduate teaching assistants Monday through Thursday from 1100 to 1700. (The Math Lab is not open the first week of classes or during finals week.) A schedule of tutors can be found on the School of Mathematics website.

Writing. Unfortunately, Georgia Tech does not have a writing center to assist undergraduates. However, I am happy to discuss the writing of your group project with you and give you feedback in advance of the date for first drafts. You may also find these resources from the Vanderbilt University Writing Studio useful.