

Northeastern University: Department of Mathematics
Math 3533 Combinatorial Mathematics SYLLABUS Spring 2011

Textbook: Introductory Combinatorics: Richard Brualdi, 5th edition (2010)
Key # 31644 **Classes:** Mon-Wed-Thurs 10:30 AM. **Classroom:** 460 Ryder

Instructor Prof. A. Iarrobino **Phone** 617-373-5524 **Office** 526 NI
e-mail. a.iarrobino@neu.edu

Office hour: Mon 11:50-12:10, 3:15-4:30; Wed. 1:30-2:30; Thurs: 1:45-3:00.
or by appointment.

Course Outline: We learned to count - integers- when we were very young. Sometimes counting can be subtle. This course is about principles and techniques for counting applied to a variety of problems. Techniques include permutations, combinations, generating functions, inclusion-exclusion, recurrence relations, Mobius function. Examples of applications include counting various chess arrangements, card hands, graphs, partitions, finding Fibonacci numbers.

This is a **problem-solving** course. Expect lots of word problems. Our task will be to figure out the underlying form or type of the problem and then apply the relevant principle(s) or technique(s). A good solution to a problem in this course is one that explains and justifies (in standard, coherent English), your reasoning and any computations you make. Often a counting identity arises from two ways to count the same set: for example, an $n \times n$ square of dots leads to an identity when counted diagonally vs. row-by-row.

There is often more than one way to solve a combinatorial problem. The kind of reasoning used in this course, combinatorial reasoning is useful in several other fields: computer science, operational research, mathematics of biology, operations research, probability and statistics. The way to acquire skill at this is to do many exercises. There is no substitute! Homework exercises will often be different from worked-out examples in the text. The level of difficulty of the exercises varies, with some marked * extra credit.

Goals: Students should

- A. understand the counting and other combinatorial techniques taught, and the definitions.
- B. be able to apply these techniques appropriately to word problems.
- C. be able to explain why they chose a given technique, and how it applies to the problem.
- D. be able to identify and use suitable problem-solving strategies.

Homework is an essential component of the course. HW relating to Wednesday-Thursday of the previous week, and Monday of a given week will be collected on alternate Thursdays at the start of class, with scoring as to completeness and content. Students may work jointly on the homework, but the write-ups must be done separately. I encourage you to come to office hours at least one day in advance to discuss problems you have been struggling with, or if there are points on which you need further clarification.

I will expect carefully written and worked out solutions to problems. While it is important to arrive at correct final answers, it is even more important to allow the reader (me, and also you) to be able to see and also understand how you did it. This will require clarity, and detail. We will practice in class.

Journal: You are invited to keep a journal either physical, or on Blackboard, which will be counted as extra credit to the before FE grade. This will record your thoughts/comments relevant to problem solving, course, doing mathematics. I will collect from time to time, or respond on Blackboard.

Grading: There will be quizzes and collected HW, most likely alternating on Thursdays. Quizzes and the HW will count as 40% of the grade; a midterm will count 20%. The final exam will count 40%. An optional written and/or oral report could count as Extra Credit towards the before final exam grade—please arrange with instructor before February 16. Likewise a journal may count as extra credit.

Attendance, class expectations. To abet focus, normally I will expect students not to use cell-phones, computers, etc. in the classroom. If you need to have a cell phone on, or need to leave early, please let me know in advance.

Studies have shown a strong correlation between good attendance at classes and performance. Attendance in class is strongly recommended.

Most classes will include both lecture, and practice in solving combinatorial problems.

Academic Honesty: Collaboration on quizzes and exams is not allowed. In Math 3353, academic dishonesty on a quiz or exam, or assignment leads to a zero on the work, as well as a letter detailing the incident to the Office of Student Conduct and Conflict Resolution (OSCCR). The minimum penalty for a finding of academic dishonesty by the student Judicial Hearing Board includes one year suspended disciplinary probation.

Student Code of Conduct: <http://www.northeastern.edu/osccr/academichonesty.html> or Student Handbook 2007-2008 p. 38-39.

Essential to the mission of Northeastern University is the commitment to the principles of intellectual honesty and integrity. Academic integrity is important for two reasons. First, independent and original scholarship ensures that students derive the most from their educational experience and the pursuit of knowledge. Second, academic dishonesty violates the most fundamental values of an intellectual community and depreciates the achievements of the entire University community. Accordingly, Northeastern University views academic dishonesty as one of the most serious offenses that a student can commit while in college.” (The website/handbook goes on to detail examples.)

Incomplete grade: requires a written understanding (contract) between the Instructor and student with details about what material will be made up and how. Incompletes are normally appropriate only for a student who is doing well, but becomes ill, or has a family emergency late in the semester. For further information about grades, see the Registrar site, <http://www.northeastern.edu/registrar/faq-grades.html> .

Concerns and conflicts: In case of concerns about the course that cannot be resolved by speaking with the instructor, please contact the Mathematics Department Undergraduate Director, Professor D. King, 437 Lake Hall, Phone 617-373-5679, e-mail d.king (at) neu.edu

This syllabus: I reserve the right to modify this syllabus according to needs that may arise during the semester. It is each student’s responsibility to be aware of any such changes that are announced in class or on Blackboard, whether or not the student is present at the time of the announcement.

The assignments are out of Fifth Edition of Brualdi. You may use an earlier edition, such as Fourth but you will have to figure out the HW adjustments: for example Chapter 2 and 3 are switched in the two editions, and there are errors in 4th that are fixed in 5th edition.

| Week | Topic | Section | HW Assignment |
|---------------|---|------------|------------------------------|
| 1 | January 10 Organizational Meeting. Examples of combinatorial thinking | | |
| January 10-14 | Counting Principles Permutations of Sets | 2.1 2.2 | p. 60 1,2, 6,9. |
| 2 | Martin Luther King Day (Jan 17, NU closed) | | |
| January 17-21 | Combinations of Sets Pascal’s Formula | 2.3 5.1 | p. 60 3,10,13,15 p. 154 3 |

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|--------------------------------|---|-------------------|--|
| 3 January 24-28 | Binomial Theorem Identities Multinomial Theorem | 5.2 5.3 5.4 | p. 155 5,7,8,9,10,15 p. 156 20*,25 p. 158 29 |
| 4 January 31- February 4 | Partially ordered sets (posets) Posets and Dilworth Theorem Inclusion-Exclusion | 4.5 5.6 6.1 | p. 160 48,49,50 p. 198 1,3, 32 |
| February 7-12 | Combinations with Repetitions Derangements Permutations with forbidden position | 6.2 6.3 6.4 | p. 198 6,7,9 p. 199 15 p. 199 11,12. 27, 28,29 |
| Feb. 14-18 | Induction Number Sequences Generating functions | 7.1 7.2 | Assigned in class. p. 257 1,2,3*,4*,8,9,12 p. 257 13,15,17,18,19 |
| February 21-25- | February 21 President's Day: NO CLASSES | | |
| | Exponential generating functions | 7.3 | p. 260 23,25 |
| | Linear recurrence relations – Fibonacci A geometric example | 7.4 7.6 | p. 261 31,34,37,38. Assigned in class |
| February 28- March 5 | Spring Break | | |
| March 7-11 | Permutations of multisets | 2.4 | p. 63 21,28 |
| | Review | | |
| | Midterm Exam March 10 | | |
| 7 March 14-18 | Combinations of multisets Pigeonhole Principle 1 Pigeonhole Principle 2 | 2.5 3.1 3.2 | p. 63 31,38,39 p. 83 4,5,9,14, 18,19 |
| March 21-25 | Ramsey Theorem Moebius inversion Special sequences- Catalan numbers | 3.3 6.6 8.1 | p. 85 23,24,26 p. 203 35,37,38,39,40. p. 202 32. p. 316 1,2,3,5* |
| March 28- April 2 | Difference sequences – Stirling numbers Partitions Partitions | 8.2 8.3 8.3 | p. 316 8,12,13 p. 317 21,22a,26,,28*,30 assigned in class |
| April 11-15 | A geometric problem Lattice Paths (or alternative topic) Lattice Paths (or alternative topic) | 8.4 8.5 8.5 | p. 319 31 p. 319 32 p. 319 36, 37* |
| April 18-21 | April 18 Patriot's Day (no classes) | | |
| | Review | | |
| | Reading Day (April 21) | | |
| Final Exam | Day and time TBA week of April 25. | | |