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Math 475-Introduction to Combinatorics

## 1.**General Identifying Information**

**Institution Name:** University of Wisconsin­­–Madison

**Course Subject, Number and Title:** Introduction to combinatorics, Math 475.

**Credits:** 3

**Requisites:** Math 320, 340, 341 or 375.

**Meeting Time and Location:** Tuesday and Thursday 11:00am-12:15pm, 1333 Sterling hall.

**Instructional Modality:** In-person; Lectures will not be recorded since there is no lecture capture system in the classroom.

**Instructor Contact Info:**

Name: Shengwen Gan

Office: Van Vleck 807

Email: [sgan7@wisc.edu](mailto:sgan7@wisc.edu)

Office hour: TBD

**TA Contact Info (if applicable):**

TBD

## 2.**Course Overview**

**Canvas link:** <https://canvas.wisc.edu/courses/386574>

Textbook: *Introductory combinatorics* (5th edition) by Richard A. Brualdi

(I uploaded a pdf version on Canvas)

## **Homework and Other Assignments**

There will be about 5 problems every week.

Please upload the pdf version of your homework to **Assignment** in Canvas.

## **Exams, Quizzes, Papers and Other Major Graded Work**

There will be two in-class Midterm Exams.

Midterm 1: Feb. 27 Tuesday, 11am – 12:15pm

Midterm 2: Apr. 4 Thursday, 11am-12:15pm

The Final Exam is on May 9, 7:25pm - 9:25pm.

## **Course Schedule/Calendar**

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| --- | --- | --- | --- |
| Week | Tuesday | Thursday | Homework  (due on Friday) |
| 1 (Jan.22-26) | Introduction | Ch2 | No homework |
| 2 (Jan. 29 – Feb. 2) | Ch2 | Ch2 |  |
| 3 (Feb. 5 – Feb. 9) | Ch3 | Ch4 |  |
| 4 (Feb. 12 – Feb. 16)) | Ch4 | Ch5 |  |
| 5 (Feb. 19 – Feb. 23) | Ch5 | Ch5, some review |  |
| 6 (Feb. 26 – Mar. 1) | Midterm 1 | Ch6 |  |
| 7 (Mar. 4 – Mar. 8) | Ch6, Ch7 | Ch7 |  |
| 8 (Mar. 11 – Mar. 15) | Ch7 | Ch7 |  |
| 9 (Mar. 18 – Mar. 22) | Ch8 | Ch8 |  |
| 10 (Mar. 25 – Mar. 29) | Spring break | Spring break |  |
| 11 (Apr. 1 – Apr. 5) | Ch11, some review | Midterm 2 |  |
| 12 (Apr. 8 – Apr. 12) | Ch11 | Ch11 |  |
| 13 (Apr. 15 – Apr. 19) | Ch11, Ch14 | Ch14 |  |
| 14 (Apr. 22- Apr. 26) | Ch14 | Ch14 |  |
| 15 (Apr. 29 – May. 3) | Ch14 |  |  |

## **Grading:**

## Homework: 20%

## Two Midterms: 25%+25%

Final: 30%

**Homework:**

Homework is assigned weekly on Canvas-Assignment. It should be submitted to Canvas-Assignment before Friday midnight every week. Late submission is accepted within 48 hours after the deadline with 20% penalty. In the final calculation of the grades for homework, the two lowest grades will be dropped. Because of the two drops, **I will not allow any excuse for extension of the homework,** like:out of town, get a cold, engaged in some activities…

A student with McBurney accommodation can talk to me about some other adjustments.

**Final letter grades will be curved.**

**A tentative cut-off:**

𝐴 ≥ 92% > 𝐴𝐵 ≥ 89% > 𝐵 ≥ 82% > 𝐵𝐶 ≥ 79% > 𝐶 ≥ 70% > 𝐷 ≥ 60% > 𝐹

**Course Goal:**

The student will master the basic counting strategies, such as staged thought-experi-

ments, inclusion/exclusion, generating functions, and recurrence relations, and use these

strategies to solve a wide variety of counting problems.

• The student will become familiar with the basic objects that are used in combinatorics,

such as permutations and combinations of sets and multisets, binomial and multinomial

coefficients, the Catalan numbers, the Stirling numbers, and the partition numbers.

• The student will be able to analyze a given combinatorial problem using the standard

theorems of combinatorics, such as the pigeonhole principle, the Newton binomial the-

orem, the multinomial theorem, the Ramsey theorem, the Dilworth theorem, the Euler

theorem.

• After the student solves a combinatorial problem, the student can explain how the solu-

tion was obtained, and why it is correct. This explanation typically justifies the counting

strategy used, identifies the appropriate concepts, and identifies the relevant theorem to

invoke. The student can also support their argument by displaying examples or coun-

terexamples.

• The student can convey his or her arguments in oral and written form in English, using

appropriate mathematical terminology, notation, and grammar.

**Course learning outcomes:**

By the end of the course, the student should be able to solve

the following 20 problems, and other problems of a similar nature.

• Each day a student walks from her home to school, which is located 10 blocks east and

14 blocks north from home. She always takes a shortest walk of 24 blocks. How many

different walks are possible?

• Consider the set of integers from 1 to 20 inclusive. This set has how many 3-element

subsets, such that no two consecutive integers are in the subset?

• Two red rooks and four blue rooks are placed on a 6-by-6 chessboard, so that no two

rooks can attack each other. In how many ways can this be done?

• A bagel store sells six different kinds of bagels. Suppose you choose 16 bagels at random.

What is the probability that your choice contains at least one bagel of each kind?

• Construct a permutation of 12345678 whose inversion sequence is 66142100.

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• Compute the sum of the cubes of the first million positive integers.

• Find the number of integers between 1 and a million inclusive, that are not divisible by

4, 5, or 6.

• Find the number of integers between 1 and a million inclusive, that are neither perfect

squares nor perfect cubes.

• How many ways are there to put 14 indistinguishable marbles into 4 distinguishable

boxes?

• For each row of Pascal’s triangle, find the sum of the squares of the entries in that row.

• Find the number of permutations of 12345678 for which exactly three integers are in

their natural position.

• At a party, seven gentlemen check their hats. In how many ways can their hats be

returned, so that no gentleman receives his own hat?

• A subway has six stops on its route from its base location. There are 10 people on the

subway as it departs its base location. Each person exits the subway at one of its six

stops, and at each stop at least one person exits. In how many ways can this happen?

• Find the number of 1-by-100 chessboards for which the squares of the chessboard can be

colored red, white, and blue so that no two squares colored red are adjacent.

• Find the number of 1-by-100 chessboards for which the squares of the chessboard can be

colored red, blue, green, and orange such that an even number of squares are colored red

and an even number are colored green.

• Find the exponential generating function for the sequence of cubes 0, 1, 8, 27, . . .

• Find the number of 100-digit integers with all digits odd, such that 1 and 3 each occur

a nonzero, even number of times.

• Start with a set S with 100 elements. Consider the partially ordered set consisting of

all subsets of S, with partial order by inclusion. What is the cardinality of the largest

antichain in this partially ordered set?

• Choose 100 equally spaced points around a circle. Find the number of ways to join the

100 points in pairs, so that the resulting 50 line segments do not intersect.

• Find the number of different necklaces that contain eight red and ten blue beads.