Introduction to Combinatorics (MATH 39A)
Summer 2020

Instructor: Olivier Bernardi

NOTE: This is a preliminary version.

Type of instruction: This will be an online **synchronuous** class. Your online presence during class time (M,Tu,W,Th 11:10am-1:10pm) is **mandatory**.

Instructor's email: bernardi@brandeis.edu.

Course description and objective: MATH 39A (Introduction to Combinatorics) is a course designed for math and computer science majors, but which is also relevant to other sciences and economics majors.

Combinatorics is a central branch of mathematics concerned with the description and analysis of discrete data structures, such as graphs, lattice paths, finite groups, etc. The goal is to find hidden patterns in such structures, in order to answer various kinds of questions:

- do these structures decompose into simpler components?
- can these structures be given an alternative description?
- is there a simple formula for the number of such structures?
- what is the typical large scale behavior of such structures?

Learning goals: The goal of the course is to learn some concepts and methods useful for *combinatorial reasoning*. Combinatorial reasoning is the type of logical reasoning one uses to play games such as *Chess, Brainstorm, etc.* It is a type of mathematical reasoning which is essential in all branches of science (and is especially important in computer science, discrete mathematics and game theory). Unlike a calculus class, the focus is not on equations and computations, but rather on the exploration of the logical structure of problems, and the analysis of the possible outcomes.

The topics covered during the semester are divided into two parts:

Graph theory: We will define *graphs* and several related concepts. Graphs represent networks (for instance, networks of people, networks of computers, etc), and are omnipresent in science. We will discuss several topics including *spanning trees*, *planarity*, *colorings*, *Eulerian and Hamiltonian cycles*, *flows and matchings*.

Enumeration: We will develop tools and methods for counting various mathematical structures. Counting is important to do discrete probability, and to design and analyze efficient algorithms. We will discuss several topics including *permutations and combinations*, *pigeonhole principle*, *inclusion-exclusion*, and *generating functions*.

Prerequisite: COSI 29A or MATH 23B. This is a proof-based class.

Textbook: The recommended book is *Applied combinatorics* by Alan Tucker, 5th edition or later (anyone is ok – I will not assign problems from the textbook). However this is not a required book, as the course will be self-contained.

Expectation of students' effort: Success in this course is based on the expectation that students will spend a minimum of 2 hours of study time per for each hour of class (reviewing class material, completing homeworks, preparation for exams, etc.).

Grading Policy: The grade will be based at 40% on the weekly homework assignments and at 60% on two 2-hour exams (30% each).

Late homework policy: Late homework will not be accepted, unless you get a special extension (to be requested and approved in advance).

Date of exams: to be determined.

Disabilities: If you are a student with a documented disability on record at Brandeis University and wish to have a reasonable accommodation made for you in this class, please see me immediately.

Academic Integrity: You are expected to be familiar with, and to follow, the University's policies on academic integrity. Please consult Brandeis University Rights and Responsibilities for all policies and procedures. All policies related to academic integrity apply to in-class and take home projects, assignments, exams, and quizzes. Students may only collaborate on assignments with permission from the instructor. Allegations of alleged academic dishonesty will be forwarded to the Director of Academic Integrity. Sanctions for academic dishonesty can include failing grades and/or suspension from the university.