CSCI 6110

(Spring 2023)

Applied Combinatorics and Graph Theory

Prof. N. Adlai A. DePano

[T,Th 3:30 p.m. – 4:45 p.m.; Venue: MTH 320 & via Zoom]

Introductory Notes

Welcome to the Spring 2023 offering of CSCI 6110, "Applied Combinatorics and Graph Theory." This course is a look into the important areas of combinatorics and graph theory, sources of many indispensable tools in every computer scientist's "bag of tricks." We will review (and in many cases, introduce) theoretical results and then apply them to interesting problems in computer science. We should have occasion to explore the following two platforms:

1. *GraphBase*, a platform developed by Stanford's Donald Knuth to address two goals:
   - "demonstrate the art of literate programming;" and
   - "provide a useful means for comparing combinatorial algorithms and for evaluating methods of combinatorial computing."
2. *LINK*, a software system for discrete mathematics (graphs, for example), freely available via the internet.

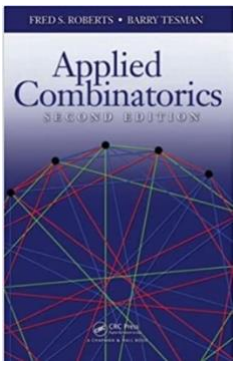
The listed prerequisite for this course (CSCI 4101) implies a prior knowledge of programming using an advanced structured language (such as Java or C++), familiarity with data structures and their use, a grasp of computational models and algorithm analysis (big "O" notation and asymptotic complexity), and that much-sought but hard-to-define commodity needed for an advanced course like this -- *mathematical maturity*.

Catalog Entry

CSCI 6110 Applied Combinatorics and Graph Theory 3 cr.

Prerequisites: CSCI 4101 or consent of department. A study of combinatorial and graph theoretic techniques for complexity analysis. Includes generating functions, recurrence relations, Polya's theory of counting, planar directed and undirected graphs, and NP-complete problems of combinatorial or graph-theoretic nature. Application of techniques to analysis of algorithms in graph theory, as well as more general problems, such as sorting and searching.

Required Text



The required text for this course is *Applied Combinatorics* (2nd ed.) by Fred Roberts and Barry Tesman, Chapman and Hall/CRC, 2009 (ISBN 9781420099829). Most of the lecture material will be based on this text. We will augment material from this book (it is already quite substantial and rich in content) from other sources. In particular, we will participate in the pedagogical technique called "guided discovery" and will use material developed for this approach by Prof. Kenneth Bogart of Dartmouth College.

Learning Objectives:

At the conclusion of this course, the successful student should be able to:

1. Exhibit familiarity with a range of combinatorial and graph theoretical notions and applications;
2. Apply techniques of combinatorics and graph theory to solve a variety of applied problems;
3. Assess the correctness and efficiency of algorithms in combinatorics and graph theory;
4. Use accepted terminology in describing algorithms of a combinatorial and/or graph theoretical nature; and
5. Read extant literature about combinatorial and/or graph theoretical algorithms with a deeper understanding of the underlying techniques and algorithmic analysis tools.

Course (Coarse?) Outline

We will attempt to cover the following topics (adjustments may be made as we go along):

1. Introduction
    - What is Combinatorics?
    - Three Problem Classes
    - History and Application
2. Basic Tools of Combinatorics
    - Basic Counting Rules
    - Intro to Graph Theory
3. The Counting Problem
    - Generating Functions
    - Recurrence Relations
    - Principle of Inclusoin and Exclusion
    - Polya Theory of Counting
4. The Existence Problem
    - Pigeonhole Principle
    - Experimental Design
    - Coding Theory
    - Existence Problems in Graph Theory
5. Combinatorial Optimization
    - Matching and Covering
    - Optimization with Graphs and Networks
6. The Stanford *GraphBase*
    - Features
    - Experiments
    - Enhancements
7. *LINK*
    - Features
    - Experiments
    - Enhancements

Course Format

The course will be done primarily in two formats -- lecture and group work. Student participation is, obviously, a requirement. Group activity exercises will be assigned and will be performed in

class in group setting. Students may also be assigned projects based on the *GraphBase* and *LINK* platforms. Some programming may be required in these projects.

Course Grades

Grades will be based on a final exam, two in-class tests, and the assigned activity exercises. The weights assigned to these grade components are as follows:

Tests & Exams	70%
Activity Exercises	30%

The test component will be computed in the following manner: Two "midterm" tests and the final exam counted twice give four grades. The highest three will be used to compute the test component of your final grade. For instance if your in-class test grades are 70 and 80, and your final exam grade is 75, then the grades 80, 75, 75 (*i.e.*, highest three of 70, 80, 75, 75) will be used.

Numerical grades translate to their letter grade counterparts using the following table:

90 – 100	A	80 – 89	B	60 – 79	C
50 – 59	D	< 50	F		

The tentative dates for the two "midterm" tests are Mar. 2nd and Apr. 11th. The final exam schedule is firm: **Tuesday, May 16th, 2023.**

Assigned Work Policy

Assigned work (whether individual or group) are a crucial part of the learning process in this course. It is by "getting one's hands dirty" that one absorbs or arrives at the subtle points of theoretical issues. Policies that apply to assigned work are as follows:

1. Individual work (but not group work) will (typically) be assigned at least a week prior to its due date.
2. ***"Late" work will be penalized***. Every full day that assigned work is late doubles the penalty of the previous day, starting with one percentage point deducted on the first day. So in practice, an assignment that is turned in a week late automatically gets an F, having already incurred a penalty of -64! However, it is understood that during the course of the semester, life doesn't always follow a smooth path; therefore, everyone is entitled to a "free pass," that is, ***the lowest activity score will be dropped from the final computation of grades***.
3. ***Unintelligible=wrong=no credit***. You are expected to communicate your thoughts clearly. Submitted homework is expected to be neat, solutions (if required) appearing *in order*, and, in general, clearly explained by accompanying explanations in English. One suggestion is to work out problems on scratch paper and to recopy them for the final submission.
4. ***Individual assignments are expected to be your own personal effort***. However, there is very little one can do to prevent you from "consulting" with each other on homework assignments. In a controlled setting, this can be beneficial to you. After all, teaching one another and working together are important skills. However, it is essential that your homework submissions reflect *your own personal analysis and solution*. It is suggested that you try to work on the problem on your own, and then only when you get stuck should you begin discussion with your colleagues. The interaction should be two-way − you contributing to it as well as profiting from it. When writing the final submission. try to recreate the arguments on your own. Only when you can do this can

you truly say that you have learned from the group effort. Needless to say, ***this joint work policy applies only to homework, and not to examinations!***

Office Hours

The instructor should normally be available for consultation at his office (MATH 308) during the following times:

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Mon, Wed    12:00 noon - 3:00 p.m.;
Tue, Thu     1:30 p.m. - 3:00 p.m. (via Zoom only)
            other times by appointment only
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You are encouraged to make use of these periods for your personal profit and for me to get to know students better. Questions and suggestions are especially welcome at these times. The instructor may be contacted as well through the following channels:

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Office phone: (504)280-7370, (504)280-6594 (department office);
Fax:          (504)280-7228
e-mail:       ndepano@uno.edu or adlaidep@yahoo.com
Cell phone:   (504)722-0352 (exercise discretion with this)
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Attendance Policy

Attendance will be taken regularly. For students enrolled in the online section, attendance will be determined by the student's frequency and duration of "visits" to the Moodle course site. Although not specifically included as one of the criteria for the final grade, attendance can have an impact on borderline cases. Good attendance is an indication of the dedication of the student to the learning enterprise. Also, activity exercises in groups will not be credited towards those who are not in attendance at the time the activity was performed. We conclude this section with the following statement from Academic Affairs concerning health issues and attendance:

> Students should evaluate their health status regularly, refrain from coming to campus if they are ill, and seek appropriate medical attention for treatment of illness. Students should notify (email) their instructors about their absence as soon as possible, so that accommodations can be made. In the event of COVID-19 illness, students should also complete the Campus Reporting Form:
>
> https://uno.guardianconduct.com/incidentreporting
>
> Please note that medical excuse may be required at the discretion of the department chair and/or college dean.

Academic Integrity

Academic integrity is fundamental to the process of learning and evaluating academic performance. Academic misconduct will not be tolerated. Academic misconduct includes, but is not limited to, the following: cheating, plagiarism, tampering with academic records and examinations, falsifying identity, and being an accessory to acts of academic dishonesty. Refer to the Code of Conduct for further information.

Students With Special Needs

Finally, it is University policy to provide, on a flexible and individualized basis, reasonable accommodations to students who have disabilities that may affect their ability to participate in course activities or to meet course requirements. Students with disabilities should contact the Office of Disability Services as well as their instructors to discuss their individual needs for accommodations. For more information, please go to *https://www.uno.edu/disability-services*.