COURSE OUTLINE: MH7002

Course Title	**Discrete Methods**		
Course Code	**MH7002**		
Offered	Study Year 4, Semester 1		
Course Coordinator	Bernhard Schmidt (Prof)	bernhard@ntu.edu.sg	6513 2009
Pre-requisites	MATH programme, Study Year 4 and a minimum CGPA of 4.0. (Application is subject to approval.)		
AU	4		
Contact hours	Lectures: 39, Tutorials: 12		
Approved for delivery from	AY 2022/23 semester 2		
Last revised	11 Apr 2023, 13:25		

Course Aims

This course provides an introduction to foundational theory and algorithms of discrete mathematics. Instead of covering a variety of approaches and algorithms, the course focusses on those methods that have proved to be superior to alternative techniques and have become "workhorses" in modern applied mathematics. For instance, the theory of the Simplex Algorithm is worked out carefully, while other less practical or less efficient algorithms for linear programming are not covered. Aside from the algorithmic aspect, the course has a substantial theoretical component: graph theory, proofs of correctness of algorithms, and the structure of polyhedra.

Intended Learning Outcomes

Upon successfully completing this course, you should be able to:

1. Describe how basic graph and network flow algorithms work and correctly apply those algorithms to specific problems.
2. Compute the automorphism groups of small or highly structured graphs.
3. Apply various representations of trees and find proofs for properties of trees (in particular, of minimum spanning trees).
4. Apply maximum flow and minimum cost flow algorithms to solve combinatorial problems that are defined in a graph theoretic setting.
5. Compute the decomposition of a convex polyhedron into the sum of a polytope, a cone, and a linear subspace.
6. Explain how the Simplex Algorithm is implemented in tableau form and why it terminates if appropriate pivot selection rules are applied.
7. Explain why the interplay between the primal and dual simplex algorithm is essential for solving practical linear programs.

Course Content

Properties of graphs

Eigenvalues of graphs

Graph isomorphism and automorphism

Trees, minimum spanning trees, Pruefer codes

Maximum flow problems, Ford-Fulkerson algorithm, Edmonds-Karp algorithm

Minimum cost flow problems, network simplex algorithm

Structure of polyhedra

Primal and dual simplex algorithm

Assessment

Component	Course ILOs tested	SPMS-MAS Graduate Attributes tested	Weighting	Team / Individual	Assessment Rubrics
Continuous Assessment					
Mid-semester Quiz					
Short Answer Questions 1	1, 2, 3	**1.** a, c **2.** b	25	individual	See Appendix for rubric
Short Answer Questions 2	4, 5, 6, 7	**1.** a, c **2.** b	25	individual	See Appendix for rubric
Examination (3 hours)					
Short Answer Questions	1, 2, 3, 4, 5, 6, 7	**1.** a, c **2.** b	50	individual	See Appendix for rubric
		Total	**100%**		

These are the relevant SPMS-MAS Graduate Attributes.

1. Competence

a. Independently process and interpret mathematical theories and methodologies, and apply them to solve problems

c. Discover patterns by abstraction from examples

2. Creativity

b. Build on the connection between subfields of mathematics to tackle new problems

Formative Feedback

Feedback will be given after each midterm on common mistakes and level of difficulty of the problems. For the final exam, comments on answers and common errors will also be given to students after the exams are marked. Feedback can also be given through discussion within tutorial lessons.

Learning and Teaching Approach

Lectures (39 hours)	Help the students understand the motivation and definitions of the concepts and notions, approaches to solving the problems in pursuant to learning outcomes.
Tutorials (12 hours)	Develop communication and presentation skills, help the students understand better the concepts and notions better and the techniques in problem solving.

Reading and References

J. H. van Lint, R. M. Wilson, A Course in Combinatorics (2001, 2nd Edition), Cambridge University Press, ISBN 978-0521006019

Ravindra K. Ahuja, Thomas L. Magnanti, James B. Orlin, Network Flows (2011), Nabu Press, ISBN 978-1179434308

Course Policies and Student Responsibilities

(1) General
Students are expected to complete all tutorial

questions. Students are expected to take responsibility to follow up with course notes, tutorials and course related announcements if they are absent.

(2) Absenteeism
Absence from tests and the final examination without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies.

(3) Absence Due to Medical or Other Reasons
If you are sick and not able to attend the tests, you have to submit the original Medical Certificate (or another relevant document) to the administration to obtain official leave. In this case, the missed assessment component will not be counted towards the final grade. There are no make-up tests.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the Academic Integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Bernhard Schmidt (Prof)	SPMS-MAS-05-24	6513 2009	bernhard@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/ Activities
1	Properties of graphs	1	Lecture Notes, Chapter 1
2	Eigenvalues of graphs	1	Lecture Notes, Chapter 1
3	Graph isomorphism and automorphism	1, 2	Lecture Notes, Chapter 1
4	Trees, minimum spanning trees, Pruefer codes	3	Lecture Notes, Chapter 1
5	Maximum flow problems, Ford-Fulkerson algorithm, Edmonds-Karp algorithm	4	Lecture Notes, Chapter 3
6	Maximum flow problems, Ford-Fulkerson algorithm, Edmonds-Karp algorithm	4	Lecture Notes, Chapter 3
7	Maximum flow problems, Ford-Fulkerson algorithm, Edmonds-Karp algorithm, Midterm Test 1	1, 2, 3, 4	Lecture Notes, Chapter 3
8	Minimum cost flow problems, network simplex algorithm	4	Lecture Notes, Chapter 3
9	Minimum cost flow problems, network simplex algorithm	4	Lecture Notes, Chapter 3
10	Structure of polyhedra	5	Lecture Notes, Chapter 4
11	Structure of polyhedra, Midterm Test 2	3, 4, 5	Lecture Notes, Chapter 4
12	Primal and dual simplex algorithm	6, 7	Lecture Notes, Chapter 4
13	Primal and dual simplex algorithm	6, 7	Lecture Notes, Chapter 4

Appendix 1: Assessment Rubrics

Rubric for Mid-semester Quiz: Short Answer Questions 1 (25%)
Point based marking

Rubric for Mid-semester Quiz: Short Answer Questions 2 (25%)
Point based marking

Rubric for Examination: Short Answer Questions (50%)
Point based marking