COURSE OUTLINE: MH1812

Course Title	**Discrete Mathematics**		
Course Code	**MH1812**		
Offered	Study Year 1, Semester 1		
Course Coordinator	Gary Greaves (Dr)	gary@ntu.edu.sg	6513 8652
Pre-requisites	None		
Mutually exclusive	CE1001, CZ1001, MH1301		
AU	3		
Contact hours	Flipped Classroom: 13, Lectures: 13, Tutorials: 12		
Approved for delivery from	AY 2020/21 semester 1		
Last revised	13 Jun 2020, 16:46		

Course Aims

This course serves as an introduction to various topics in discrete mathematics. Familiarity with formal analysis through simple problems in some basic discrete structures is a key objective rather than knowing these structures in depth. Specifically, the main aim is to learn topics from the following broad areas of discrete mathematics: number theory, logic, combinatorics, and graph theory.

This course aims to provide students with a solid mathematical foundation and is intended for first year computer science and computer engineering students.

Intended Learning Outcomes

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

1. Identify which integers are congruent modulo a positive integer
2. Formulate, interpret, and manipulate logical statements
3. Identify valid and invalid arguments
4. Prove elementary mathematical results using various proof techniques
5. Apply basic tools for counting
6. Solve linear recurrence relations
7. Identify two equal sets and provide justification that these sets are equal
8. Manipulate relations and functions between sets
9. Apply basic techniques in graph theory

Course Content

Elementary Number Theory: Types of numbers, Euclidean division, modular arithmetic, operator closure. Propositional Logic: Propositions, logical operators, compound propositions, truth tables, equivalent statements, De Morgan’s laws

Propositional Logic: Logical equivalence laws, order of operations, arguments, inference rules.

Predicate Logic: Predicates, quantification, negating quantifiers, determining truth values.

Predicate Logic: Conditional quantification, inference rules. Proof Techniques: Direct proof, proof by induction

Proof Techniques: Proof by contradiction, proof by contrapositive. Combinatorics: Principle of counting, combinations, permutations.

Linear Recurrence Relations: Solving by backtracking, solving by characteristic equation. Set Theory: Sets, union, intersection, set difference, set equivalence, cardinality, power sets

Set Theory: Cartesian products, double inclusion.

Relations: Relations, relations on a set, reflexivity, symmetry, antisymmetry, transitivity.

Relations: Equivalence relations, partial orders, matrix representation, composition, ternary relations.

Functions: Functions, injectivity, surjectivity, bijectivity, inverse, composition

Functions: Floor and ceiling, pigeonhole principle, countable sets, Cantor's diagonal argument.

Graph Theory: Graphs, vertices, edges, subgraphs, multigraphs, directed graphs, Euler paths/cycles, Euler's theorem.

Graph Theory: complete graphs, bipartite graphs, handshaking lemma, adjacency matrix, Hamilton cycles, graph isomorphism.

Assessment

Component	Course ILOs tested	EAB Graduate Attributes tested	Weighting	Team / Individual	Assessment Rubrics
Continuous Assessment					
Mid-semester Quiz					
Short Answer Questions 1	1, 2, 3	a, c, e, j, l	25	individual	See Appendix for rubric
Short Answer Questions 2	4, 5, 6, 7	a, c, e, j, l	25	individual	See Appendix for rubric
Examination (2 hours)					
Short Answer Questions	1, 2, 3, 4, 5, 6, 7, 8, 9	a, c, e, j, l	50	individual	See Appendix for rubric
		Total	**100%**		

Mapping of Course Intended Learning Outcomes to Engineering Accreditation Board (EAB) Graduate Attributes

Category	Core				
EAB's 12 Graduate Attributes*					
(a) ●	(b)	(c) ○	(d)	(e) ○	(f)
(g)	(h)	(i)	(j) ○	(k)	(l) ○

Overall statement

This course serves as an introduction to various topics in discrete mathematics. Familiarity with formal analysis through simple problems in some basic discrete structures is a key objective rather than knowing these structures in depth. Specifically, the main aim is to learn topics from the following broad areas of discrete mathematics: number theory, logic, combinatorics, and graph theory. This course aims to provide students with a solid mathematical foundation and is intended for first year computer science and computer engineering students.

Course Student Learning Outcomes		**EAB Graduate Attributes**
1	Identify which integers are congruent modulo a positive integer	a
2	Formulate, interpret, and manipulate logical statements	a
3	Identify valid and invalid arguments	a
4	Prove elementary mathematical results using various proof techniques	j
5	Apply basic tools for counting	a
6	Solve linear recurrence relations	a
7	Identify two equal sets and provide justification that these sets are equal	a
8	Manipulate relations and functions between sets	a
9	Apply basic techniques in graph theory	a

***Legend:**
● Fully consistent (contributes to more than 75% of Student Learning Outcomes)
◐ Partially consistent(contributes to about 50% of Student Learning Outcomes)
○ Weakly consistent (contributes to about 25% of Student Learning Outcomes)
[Blank]Not related to Student Learning Outcomes

The graduate attributes as stipulated by the EAB, are:

a. **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
b. **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety , cultural, societal, and environmental considerations.
d. **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e. **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
f. **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g. **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.
h. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i. **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
j. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k. **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary envir onments.

l. **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Formative Feedback

Component 2 and 3: formative feedback is written in your midterm scripts, which are returned to the you. General feedback from the midterms is also given in the tutorial sessions.

Learning and Teaching Approach

Flipped Classroom (13 hours)	Learn basic material through watching online pre-recorded lectures, which are accessible at view at one's own convenience and learning pace.
Lectures (13 hours)	Class time is devoted to a more in-depth discussion, QA sessions, and problem-based learning.
Tutorials (12 hours)	Tutorials provide an opportunity to present and discuss line-by-line solutions to problems as well as time for more focused tuition for smaller class sizes.

Reading and References

1. Discrete Mathematics with Applications, 4th Edition, by Susanna S. Epp, Pub. Thomson Learning, 2010 - , ISBN-10 0495391328
2. Discrete Mathematics and Its Applications, 6th Edition, by Rosen, Pub. McGraw-Hill, 2007 - ISBN-10: 0072880082.

Course Policies and Student Responsibilities

Absence due to medical or other reasons
If you are sick and unable to attend a midterm you must:

1. Send an email to the instructor regarding the absence; write to the instructor in advance, for those who have mid-term of other course or other pre-scheduled event to attend.
2. Submit the original Medical Certificate* to an administrator.

There are no make-up tests.
*The Medical Certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

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
Gary Greaves (Dr)	MAS-05-03	6513 8652	gary@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/ Activities
1	Elementary Number Theory: Types of numbers, Euclidean division, modular arithmetic, operator closure. Propositional Logic: Propositions, logical operators, compound propositions, truth tables, equivalent statements, De Morgan's laws	1, 2	Elementary Number Theory and Propositional Logic
2	Propositional Logic: Logical equivalence laws, order of operations, arguments, inference rules.	2, 3	Propositional Logic
3	Predicate Logic: Predicates, quantification, negating quantifiers, determining truth values.	2	Predicate Logic
4	Predicate Logic: Conditional quantification, inference rules. Proof Techniques: Direct proof, proof by induction	3, 4	Predicate Logic and Proof Techniques
5	Proof Techniques: Proof by contradiction, proof by contrapositive. Combinatorics: Principle of counting, combinations, permutations.	4, 5	Proof Techniques and Combinatorics
6	Linear Recurrence Relations: Solving by backtracking, solving by characteristic equation. Set Theory: Sets, union, intersection, set difference, set equivalence, cardinality, power sets	6, 7	Linear Recurrence Relations and Set Theory
7	Set Theory: Cartesian products, double inclusion.	7	Set Theory
8	Relations: Relations, relations on a set, reflexivity, symmetry, antisymmetry, transitivity.	8	Relations
9	Relations: Equivalence relations, partial orders, matrix representation, composition, ternary relations.	8	Relations
10	Graph Theory: Graphs, vertices, edges, subgraphs, multigraphs, directed graphs, Euler paths/cycles, Euler's theorem.	8	Functions
11	Functions: Functions, injectivity, surjectivity, bijectivity, inverse, composition	8	Functions
12	Functions: Floor and ceiling, pigeonhole principle, countable sets, Cantor's diagonal argument.	9	Graph Theory
13	Graph Theory: complete graphs, bipartite graphs, handshaking lemma, adjacency matrix, Hamilton cycles, graph isomorphism.	9	Graph Theory

Appendix 1: Assessment Rubrics

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

Point-based marking (not rubrics based)

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

Point-based marking (not rubrics based)

Rubric for Examination: Short Answer Questions (50%)

Point-based marking (not rubrics based)