Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

Expected Implementation in Academic Year	AY2020-2021
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Gary Greaves
Course Author Email	gary@ntu.edu.sg
Course Title	Discrete Mathematics
Course Code	MH1812
Academic Units	3
Contact Hours	38
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	None
Co-requisites	
Pre-requisite to	
Mutually exclusive to	CE1001, CZ1001, MH1301
Replacement course to	
Remarks (if any)	

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.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Identify which integers are congruent modulo a positive integer
ILO 2	Formulate, interpret, and manipulate logical statements
ILO 3	Identify valid and invalid arguments
ILO 4	Prove elementary mathematical results using various proof techniques
ILO 5	Apply basic tools for counting
ILO 6	Solve linear recurrence relations
ILO 7	Identify two equal sets and provide justification that these sets are equal
ILO 8	Manipulate relations and functions between sets
ILO 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, ternaryrelations.
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, Eulerpaths/cycles, Euler's theorem.
Graph Theory: complete graphs, bipartite graphs, handshaking lemma, adjacency matrix,Hamilton cycles, graph isomorphism.

Reading and References (if applicable)

1. Discrete Mathematics with Applications, 4th Edition, by Susanna S. Epp, Pub. ThomsonLearning, 2010 - , ISBN-10 04953913282.
2. Discrete Mathematics and Its Applications, 6th Edition, by Rosen, Pub. McGraw-Hill, 2007 -ISBN-10: 0072880082.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	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		

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
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		

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
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		

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
13	Graph Theory: complete graphs, bipartite graphs, handshaking lemma, adjacency matrix, Hamilton cycles, graph isomorphism.	9	Graph Theory		

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Flipped Classroom	Learn basic material through watching online pre-recorded lectures, which are accessible at view at one's own convenience and learning pace.
Lectures	Class time is devoted to a more in-depth discussion, QA sessions, and problem-based learning.
Tutorials	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.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Test/Quiz(Mid-semester Quiz: Short Answer Questions 1)	1,2,3	a, c, e, j, l	25		Individual	Analytic	Multistructural
2	Continuous Assessment (CA): Test/Quiz(Mid-semester Quiz: Short Answer Questions 2)	4,5,6,7	a, c, e, j, l	25		Individual	Analytic	Multistructural
3	Summative Assessment (EXAM): Final exam(Examination - Short Answer Questions (individual))	1, 2, 3, 4, 5, 6, 7, 8, 9	a, c, e, j, l	50		Individual	Analytic	Multistructural

Description of Assessment Components (if applicable)

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 environments.
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 returnedto the you. General feedback from the midterms is also given in the tutorial sessions.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Communication	Basic
Creative Thinking	Basic
Digital Fluency	Basic
Problem Solving	Basic

Course Policy

Policy (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. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

NIL

Policy (Absenteeism)

Absence due to medical or other reasonsIf 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, forthose 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 medicalpractitioner registered with the Singapore Medical Association.

Policy (Others, if applicable)

Diversity and inclusion policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:

- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;
- If you feel like your performance in the class is being impacted by your experiences outside of class;
- If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;

Please speak to your teaching team, our school pastoral officer or a peer or senior (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.