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

Course Overview

Expected Implementation in Academic Year	AY2021-2022
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Kiah Han Mao
Course Author Email	hmkiah@ntu.edu.sg
Course Title	Combinatorics
Course Code	MH4300
Academic Units	4
Contact Hours	51
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	(MH1101 and MH1201 and MH1301) or (MH1201 and MH1301 and MH1802)
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

This final year mathematics course aims to equip you to apply concepts in symbolic methods and combinatorics to solve a variety of problems related to algorithms. The tools developed in the course are useful for future graduate courses in mathematics, applied mathematics and engineering.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Define a generating function and describe its role in enumerating combinatorial structures.
ILO 2	Distinguish between ordinary, exponential and multivariate generating functions.
ILO 3	Apply the symbolic method to compute combinatorial structures related to algorithms. Such structures include as trees, strings, permutations and mappings.
ILO 4	Apply a variety of methods to extract asymptotic information from generating functions.

Course Content

Generating functions
Asymptotic approximations
Analytic combinatorics
Trees
Strings
Permutations
Words and mappings

Reading and References (if applicable)

An Introduction to the Analysis of Algorithms (2nd Ed.) by Sedgewick and Flajolet. Addison-Wesley, 2013 ISBN: 978-0321905758

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Motivation of Analysis of Algorithms, Methods of Solving Recurrences	1	1.1, 1.4, 1.5, 1.6, 2.1, 2.2, 2.4, 2.5	In-person	
2	Generating Functions	1,2	3.1, 3.2, 3.3, 3.4, 3.8	In-person	
3	Generating Functions (Continued)	1,2,3,4	3.1, 3.2, 3.3, 3.4, 3.8	In-person	
4	Asymptotic Approximations	4	4.1, 4.2, 4.4, 4.5	In-person	
5	Asymptotic Approximations (Continued)	4	4.1, 4.2, 4.4, 4.5	In-person	
6	Analytic Combinatorics	1,2,3	5.2, 5.3, 5.4, 5.5	In-person	
7	Analytic Combinatorics (Continued)	1,2,3	5.2, 5.3, 5.4, 5.5	In-person	
8	Trees	1,3,4	6.1, 6.4, 6.7, 6.8, 6.12	In-person	
9	Strings	1,3,4	8.2, 8.3	In-person	
10	Permutations	1,3,4	7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7,7.8	In-person	
11	Permutations (Continued)	1,3,4	7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8	In-person	
12	Words and Mappings	1,3,4	9.2, 9.3, 9.4, 9.5, 9.7, 9.8	In-person	

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
13	Words and Mappings (Continued)	1,3,4	9.2, 9.3, 9.4, 9.5, 9.7, 9.8	In-person	

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures	Derivation and demonstration: Explains the motivation behind the symbolic enumeration method. Presents systematic ways to solve problems related to the concepts developed. Derives generating functions and use them to obtain asymptotic estimates. Problem solving: Develops competence in solving a variety of problems related to combinatorics.
Tutorials	Derivation and demonstration: Explains the motivation behind the symbolic enumeration method. Presents systematic ways to solve problems related to the concepts developed. Derives generating functions and use them to obtain asymptotic estimates. Problem solving: Develops competence in solving a variety of problems related to combinatorics. Peer Instruction: Develops communication and presentation skills and deepen understanding. You will have the opportunity to work with peers and present your solution to the class.

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): Assignment()	1,2,3,4	1.a,b,c,d, 2.a,b,c, 5.a	25		Individual	Holistic	Extended Abstract
2	Continuous Assessment (CA): Test/Quiz(Mid-semester quiz - Short Answer Questions)	1,2,3	1.a,b,c, 2.a,c	25		Individual	Holistic	Extended Abstract
3	Summative Assessment (EXAM): Final exam(Short Answer Questions)	1,2,3,4	1.a,b,c, 2.a,c	50		Individual	Holistic	Extended Abstract

Description of Assessment Components (if applicable)

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
b. Formulate mathematical statements precisely using rigorous mathematical language
c. Discover patterns by abstraction from examples
d. Use computer technology to solve problems, and to communicate mathematical ideas
2. Creativity
a. Critically assess the applicability of mathematical tools in the workplace
b. Build on the connection between subfields of mathematics to tackle new problems
c. Develop new applications of existing techniques
5. Character
a. Act in socially responsible and ethical ways in line with the societal expectations of a mathematics professional, particularly in relation to analysis of data, computer security, numerical computations and algorithms

Formative Feedback

Assignment: Feedback is given after each individual assignment is returned. Students are allowed to resubmit for higher grades.

Midterms: Feedback is given after the midterm on the common mistakes and the level of difficulty.

NTU Graduate Attributes/Competency Mapping

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

Attributes/Competency	Level
Collaboration	Intermediate
Digital Fluency	Basic
Learning Agility	Basic
Problem Solving	Intermediate
Transdisciplinarity	Intermediate

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)

You are encouraged to collaborate on the assignments because peer-to-peer learning helps you understand the subject better and working in a team trains you to better communicate with others. As part of academic integrity, crediting others for their contribution to your work promotes ethical practice.
You have to submit individual assignments, and hence, do take note of this collaboration policy:

- You have to write up every solution by yourself, even if you collaborated with others to solve the problem.
- You are to explicitly identify your collaborators in the assignment. If you did not work with anyone, you should write "Collaborators: none". If you obtained a solution through research (e.g., on the web), you must acknowledge the source, but write up the solution in your own words. If no collaboration statement is made at all, you will receive a warning. In case this happens repeatedly, a penalty will be applied.
- It is a violation of this policy to submit a problem solution that you cannot orally explain.
- It is a violation of the collaboration policy for you to permit anyone other than the lecturers and tutors to see your written solutions. Ideas may be shared, but do not share your written solutions with other students.
- If you have any questions about the collaboration policy, or if you feel that you may have violated the policy, please talk to the lecturers.

Policy (Absenteeism)

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.

Appendix 1: Assessment Rubrics

Rubric for Tutorials: Assignment (25%)
Point-based marking

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

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