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

Course Overview

The sections shown on this interface are based on the templates UG OBTL+ or PG OBTL+
If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to Data Transformation Status for more information.

Expected Implementation in Academic Year	AY2024-2025
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Li Yi
Course Author Email	yili@ntu.edu.sg
Course Title	High Dimensional Probability
Course Code	MH4520
Academic Units	4
Contact Hours	52
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	MH1201 Linear Algebra II; MH2500 Probability and Introduction to Statistics; MH3100 Real Analysis I
Co-requisites	
Pre-requisite to	
Mutually exclusive to	MH7009 Topics in Probability and Statistics I
Replacement course to	
Remarks (if any)	

Course Aims

The course will expose you to basic high-dimensional probability theory and concentration inequalities in data science and machine learning. This course will contain mathematical findings from the past 20-30 years, which are more recent than those typically covered in undergraduate coursework. You are welcome to take this course if you are interested in probability theory and intending to pursue research in data science or machine learning in the future. If you have a passion for mathematics, you might be pleased to know that this course offers proximity to the frontier of advanced mathematics and mathematical research; if you are pursuing a career in data science or machine learning, you might be pleased to know that this course provides essential preparation for understanding a substantial amount of machine learning literature.

Students are expected to have *mastered* MH1201, MH2500 and MH3100.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Being able to define the singular value decomposition of a matrix and prove the related properties. Being able to use singular value decomposition to prove linear algebraic statements.
ILO 2	Being able to describe what concentration of measure phenomenon is and observe the phenomenon in a general context.
ILO 3	Being able to define classical fast-decay variables such as subgaussian and subexponential variables and prove their properties; being able to prove new propositions using the basic properties.
ILO 4	Being able to prove and apply concentration inequalities of scalars
ILO 5	Being able to apply the concentration inequality of Lipschitz functions
ILO 6	Being able to state, prove and apply Johnson-Lindenstrauss Lemma; being able to descibe, identify and apply the generalizations of Johnson-Lindenstrauss Lemma
ILO 7	Being able to define subgaussian vectors and prove basic properties; being able to use the basic properties to prove new inequalities
ILO 8	Being able to prove and apply concentration inequalities of matrices

Course Content

1. Singular values of matrices, singular value decomposition of matrices
2. Subgaussian variables and subexponential variables
3. Bernstein and Chernoff inequalities
4. Concentration of Lipschitz functions of Gaussian random variables
5. Johnson-Lindenstrauss Lemma
6. Subgaussian vectors
7. Matrix Bernstein inequality and its applications
8. Non-commutative Khintchine inequality

Reading and References (if applicable)

Roman Vershynin. High-Dimensional Probability: An Introduction with Applications in Data Science. Cambridge University Press, 2018. ISBN: 978-1108415194

NOTE: The above readings comprise the foundational readings for the course and more up-to-date relevant readings will be provided when they are available

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Review of probability theory and linear algebra; singular value decomposition	1		In-person	
2	Concentration of Gaussian variables, subgaussian variables, Khintchine inequality	2,3,4		In-person	
3	Subexponential variables	3,4		In-person	
4	Concentration of Measure Phenomenon on Spheres and Gauss spaces	5		In-person	Quiz 1
5	Concentration of Lipschitz Functions	5,6		In-person	
6	Concentration of Lipschitz Functions	5,6		In-person	
7	Johnson-Lindenstrauss Lemma	6		In-person	
8	Random vectors, subgaussian vectors	7		In-person	Quiz 2
9	Matrix Bernstein inequality	8		In-person	

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
10	Applications of matrix Bernstein inequality, including the covariance estimation problem	8		In-person	
11	More applications of matrix Bernstein inequality	8		In-person	
12	Noncommutative Khintchine inequality	8		In-person	Quiz 3
13	Application of Noncommutative Khintchine Inequality	8		In-person	

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Standard teaching	During tutorials, students will be encouraged to present their solutions and answer questions from other students to facilitate their learning of the subject.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Summative Assessment (EXAM): Final exam(Point-based marking (not rubric based))	1-8	Not applicable	55	Individual	Analytic	Multistructural
2	Continuous Assessment (CA): Test/Quiz(In-class quizzes)	1-8	Not applicable	45	Individual	Analytic	Multistructural

Description of Assessment Components (if applicable)

The final exam will be a comprehensive test on the course content and could be challenging. In-class quizzes are quick closed-book tests on the content covered in the previous few weeks and are not supposed to be challenging. For quizzes, students will be sitting apart from each other and submit their answers within limited given time. There are three quizzes, each having a weightage of 15%.

Formative Feedback

There will be three quizzes distributed evenly across the semester. They will be graded and returned to the students

NTU Graduate Attributes/Competency Mapping

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

Attributes/Competency	Level
Creative Thinking	Advanced
Problem Solving	Advanced

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 expected to complete all assigned readings, activities, assignments, attend all classes punctually and complete all scheduled assignments by due dates. You are expected to take responsibility to follow up with assignments and course related announcements. You are expected to participate in all project critiques, class discussions and activities.

Policy (Absenteeism)

This course contains quizzes. There will be no make-up opportunities for missing a quiz. If you miss a quiz, you are advised to obtain an official Leave of Absence (LOA) from your School so that the weightage of the quiz will be redistribution in the calculation of your final grade.

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.