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

Course Overview

Expected Implementation in Academic Year	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Andrew James Kricker
Course Author Email	ajkricker@ntu.edu.sg
Course Title	Linear Algebra I
Course Code	MH1200
Academic Units	4
Contact Hours	51
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	Nil
Co-requisites	
Pre-requisite to	
Mutually exclusive to	CE1104, CY1602, CZ1104, MH2800, MH2802, SC1004
Replacement course to	
Remarks (if any)	

Course Aims

This is a core course for mathematics students and a suitable elective for engineering students. This course provides a grounding on vectors, matrices, and solving systems of linear equations that is fundamental for future mathematics courses and also many practical applications.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Vectors: Do basic vector manipulation: addition, scalar multiplication, matrix-vector product. Compute dot products, and interpret in terms of length and angle. Visualize linear combinations of vectors in 2 and 3 dimensions.
ILO 2	Solving systems of linear equations: Apply the principle of Gaussian elimination to solve linear equations. Identify the number of solutions to a system of linear equations in row echelon form. Apply the column and row pictures of matrix multiplication as appropriate to solve problems. Find the LU decomposition of a matrix. Identify when a matrix is invertible and compute inverses in this case.
ILO 3	Determinants: Compute determinants via Gaussian elimination. Derive the cofactor and “big” formulas for the determinant.
ILO 4	Vector Spaces: Determine if a given set is a vector space. Apply the concepts of linear independence and span. Find bases for the four fundamental subspaces associated to a matrix. Derive the relationships between these four fundamental subspaces.
ILO 5	Orthogonality: Find the projection of a vector onto a subspace. Find the least squares solution to an inconsistent system of linear equations.

Course Content

The course begins by introducing vectors and matrices, and basic operations on them. We then move into the fundamental topic of solving system of linear equations and learn the Gaussian elimination algorithm, an idea that pervades the entire course. In the second half of the course, we revisit these ideas in a more abstract way, learning about general vector spaces, linear independence, and the fundamental subspaces associated with a matrix. These ideas are then applied to finding the least squares solution to an inconsistent system of linear equations.

Reading and References (if applicable)

Reading: Elementary Linear Algebra, International Metric Edition. Author: Ron Larson. Publisher: Cengage. ISBN-13: 9781337556217

Reference: Elementary Linear Algebra: Applications Version. Authors: Howard Anton, Chris Rorres, Anton Kaul. Wiley, 12th Edition (2019). ISBN-10: 1119666147

Reference: Linear Algebra Done Right, by Sheldon Axler. Publisher: Springer. ISBN-13:978-3031410253

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Introduction to the course. Basics about vectors. The fundamental operations on vectors.	1	Larson: Section 4.1.	In-person	Wooclap activity.
2	Systems of linear equations. Elementary row operations. Gaussian elimination.	2	Larson 1.1, 1.2, 1.3.	In-person	Wooclap activity.
3	Echelon forms, Gauss-Jordan elimination, Analysing the number of solutions to a system of linear equations.	2	Larson 1.2.	In-person	Wooclap activites.
4	Matrix view of elimination, matrix operations	2	Larson Chapter 2.	In-person	Wooclap activities.
5	Continued development of basic theory of matrices. Matrix algebra. Comparison with the real numbers.	2	Larson 2.1, 2.2.	In-person	Wooclap activities.

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
6	The theory of elementary matrices. Invertible matrices and the theory of invertibility.	5	Larson 2.3, 2.4.	In-person	Wooclap activities.
7	The definition of a determinant. The elementary properties of determinants.	3	Larson 3.1, 3.3.	In-person	Wooclap activities.
8	The two big theorems about determinants. The relationship between determinants and elementary matrices.	3	Larson 3.2, 3.3.	In-person	Wooclap activities.
9	The axioms of a subspace. Proving sets are or are not subspaces. Proving basic properties of subspace.	4	Larson 4.2, 4.3.	In-person	Mid-term exam held in Week 9. Wooclap activities during the lecture.
10	The concept of the span of a set of vectors.	4	Larson 4.4.	In-person	Wooclap activities.
11	The concept of linear independence of a list of vectors.	4	Larson 4.4.	In-person	Wooclap activities in class.

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
12	The definition of a basis for a subspace. The definition of the dimension of a subspace. Algorithms for manipulating bases of subspaces.	4	Larson 4.5.	In-person	Wooclap activities.
13	Various subspaces associated to a matrix. The row space, the column space, the null space. The rank-nullity theorem.	4	Larson 4.6.	In-person	Wooclap activities.

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures (39 hours)	Examples and Explanation: Motivates the concepts in the learning objectives through examples. The general theory and principles are then explained. This also introduces more abstract mathematical reasoning. Problem Solving: Develops competence in solving a variety of problems and gaining familiarity with mathematical proofs.
Tutorial (12 hours)	The emphasis in lectures is on a survey of the course material with a discussion of higher-level concepts and of how they fit together. The tutorial on the other hand is an opportunity to work directly with students on concrete and detailed realizations of the theory. By direct interactions with their teacher and facilitated interactions with their peers, students gain practice and reinforcement of key learning objectives. In addition, misconceptions can be easily addressed in the tutorials.

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(Quizzes (5))	All	A1-A4, B1-B4, C1	10		Individual	Analytic	Extended Abstract
2	Continuous Assessment (CA): Test/Quiz(Mid-term Test)	1-8	A1-A4, B1-B4, C1	30		Individual	Analytic	Extended Abstract
3	Summative Assessment (EXAM): Final exam(Examination (2 hours))	All	A1-A4, B1-B4, C1	50		Individual	Analytic	Extended Abstract
4	Continuous Assessment (CA): Class Participation(Wooclap questions in class.)	All	A1-A4, B1-B4, C1	10		Individual	Analytic	Extended Abstract

Description of Assessment Components (if applicable)

Item 1 (Quizzes): This will be short quizzes of approximately 20-25 minutes held during the tutorials. They will consist of 1-2 fairly simple problems to check basic understanding.

Item 2 (Mid-term exam): This will be a 90 minute written exam held under exam conditions in a university exam hall. There will be a wide range of levels of difficulty in the questions, including basic checks of knowledge through to some challenging details.

Item 3 (Final exam): To test student's understanding of foundational techniques as well as how they have synthesized their knowledge from different parts of the course,

Item 4 (In class Wooclap activity): This will consist of a few questions asked by Wooclap during every lecture. In a typical week 4 questions will be asked, leading to a total of 48 questions over the semester. A correct answer earns 1 point up to a maximum of 40. The total grade out of ten will be calculated via the formula min(40,#answered correctly)/4.

Formative Feedback

Feedback will be given to you through the continuous assessment quizzes given throughout the course and the weekly problem sets that are covered in tutorial.

Common mistakes on a quiz or in the midterm will be discussed in the provided solution sets.

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	Intermediate
Curiosity	Intermediate
Learning Agility	Intermediate
Problem Solving	Intermediate
Embrace Challenge	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)

Required policy is discussed in Academic Integrity and Absenteeism sections.

Policy (Absenteeism)

Absence due to medical or other reasons:
If you are unable to attend a quiz or midterm due to a medical or other valid reason you should follow the SPMS guidelines for applying for short leave given here:
https://www.ntu.edu.sg/spms/admissions/undergrad/academic-guide#Content_C030_Col00.

In the case of an absence from a quiz or mid-term while short leave has been granted by SPMS a make-up test will be arranged.

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 In-class Wooclap activity (10%)
Point-based marking (not rubric based)

Rubric for Quizzes (10%)
Point-based marking (not rubric based)

Rubric for Mid-term Test (30%)
Point-based marking (not rubric based)

Rubric for Final Examination (50%)
Point-based marking (not rubric based)