The Hong Kong Polytechnic University

Subject Description Form

Subject Code	AMA2751
Subject Title	Linear Algebra II
Credit Value	3
Level	2
Pre-requisite	Linear Algebra (AMA1751)
Objectives	Building upon the foundational matrix algebra and basic spectral theory introduced in AMA1751, this subject aims to provide a comprehensive, modern treatment of linear algebra by blending abstract algebraic structures with numerical and computational techniques. While AMA1751 focuses on concrete Euclidean spaces and basic matrix operations, this subject transitions to coordinate-free abstract spaces and rigorous numerical analysis. Students will learn to formulate rigorous proofs regarding abstract vector spaces and linear transformations, while simultaneously understanding the stability, complexity, and implementation of algorithms used to solve large-scale matrix problems.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: (a) Construct rigorous mathematical proofs to analyze abstract algebraic structures. (b) Apply advanced theoretical frameworks and matrix representations to solve mathematical and applied problems. (c) Evaluate the computational complexity, numerical stability, and sensitivity of algorithmic solutions.
Subject Synopsis/ Indicative Syllabus	<u>Abstract Vector Spaces & Dual Spaces</u> Abstract vector spaces, subspaces, direct sums, and quotient spaces, definition of linear transformation, kernel and range, matrix representations under arbitrary bases, linear functionals, dual bases, dual maps. <u>Spectral Theory & Jordan Canonical Form</u> Invariant subspaces under an operator, restriction operators, and upper-triangular representations, the minimal polynomial, the Cayley-Hamilton Theorem, and generalized eigenspaces, Jordan blocks, the existence and uniqueness of the Jordan Canonical Form. <u>Matrix Norms & Conditioning</u> Vector and matrix norms, induced matrix norms, condition number. <u>Numerical Factorizations & Iterative Methods</u> QR decompositions, numerical eigenvalue algorithms, Power Method, Inverse Power Method, and Shifted Power Method, introduction to the QR algorithm.

<table>
<tr><td>Teaching/Learning Methodology</td><td>The subject will be delivered through lectures and tutorials. Lectures will introduce the theoretical framework, mathematical proofs, and algorithmic structures. Tutorials will focus on proof-writing exercises, analytical problem-solving, and discussing the implementation details of numerical algorithms. Students will be guided on how to translate mathematical algorithms into code for their out-of-class assignments.</td></tr>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>
<table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="3">Intended subject learning outcomes to be assessed (Please tick as appropriate)</td></tr>
<tr><td>a</td><td>b</td><td>c</td></tr>
<tr><td>1. Assignments/Quizzes</td><td>20%</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>2. Midterm Test</td><td>20%</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>3. Examination</td><td>60%</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Total</td><td>100%</td><td colspan="3"></td></tr>
</table>

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

The subject focuses on the knowledge, skills, and understanding of abstract linear algebra; thus, an exam-based assessment is the most appropriate evaluation method, featuring a 60% final examination. Continuous assessment methods, comprising midterm test, quizzes, and assignments (40%), are included to ensure steady student progress. A written examination is held at the end of the semester.</td></tr>
<tr><td>Student Study Effort Required</td><td>
<table>
<tr><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lecture</td><td>26 Hrs.</td></tr>
<tr><td>▪ Tutorial</td><td>13 Hrs.</td></tr>
<tr><td>Other student study effort:</td><td></td></tr>
<tr><td>▪ Assignments/Quizzes</td><td>48 Hrs.</td></tr>
<tr><td>▪ Self-study</td><td>48 Hrs.</td></tr>
<tr><td>Total student study effort</td><td>135 Hrs.</td></tr>
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<tr><td>Reading List and References</td><td><u>References</u>:</td></tr>
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	Steven Leon and Lisette de Pillis	Linear Algebra with Applications 10th Edition	Pearson 2019
	Roger A. Horn, Charles R. Johnson	Matrix Analysis	Cambridge University Press, 2012
	Lloyd N. Trefethen and David Bau III	Numerical Linear Algebra, 25th Anniversary Edition	SIAM, 2022
	Gene H. Golub and Charles F. Van Loan	Matrix Computations, 4th Edition	Johns Hopkins University Press 2013
	William Ford and David Stapleton	Numerical Linear Algebra with Applications: Using MATLAB and Octave, 2nd Edition	Academic Press, 2025