MA4541: COMPUTATIONAL LINEAR ALGEBRA

Effective Term
Semester A 2022/23

Part I Course Overview

Course Title
Computational Linear Algebra

Subject Code
MA - Mathematics
Course Number
4541

Academic Unit
Mathematics (MA)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
MA2503 Linear Algebra

Precursors
MA3525 Elementary Numerical Methods

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

This course introduces mathematical concepts of computer arithmetic and numerical linear algebra. It develops computational methods and techniques for solving various matrix computation problems and their applications in science/ engineering.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	explain at high level concepts from numerical linear algebra, matrix analysis and scientific computation.	15	x		
2	solve linear systems algorithmically by Gaussian elimination, partial pivoting and Cholesky decomposition.	15		x	
3	present backward stability analysis to evaluate accuracy of numerical solutions.	10		x	
4	apply computational methods to find least squares solutions to linear systems.	20		x	x
5	solve matrix eigenvalue problems by iterative methods.	25		x	x
6	evaluate numerical calculations and analyze solutions of linear algebra problems with computer software packages.	15	x	x	x

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Learning through teaching is primarily based on lectures.	1, 2, 3, 4, 5, 6	39 hours in total

2	Take-home assignments	Learning through take-home assignments helps students apply concepts and perform numerical methods of solving linear systems, least squares and matrix eigenvalue problems.	1, 2, 3, 4, 5, 6	after-class
3	Project(s)	Learning through project(s) helps students implement mathematical and computational techniques in solving practical problems involving numerical linear algebra. It also helps students to communicate and collaborate effectively in the team.	6	after-class

Assessment Tasks / Activities (ATs)

	ATs	**CILO No.**	**Weighting (%)**	**Remarks (e.g. Parameter for GenAI use)**
1	Test	1, 2, 3, 4	20	Questions are designed for the first part of the course to see how well students have learned mathematical concepts and computational techniques of solving linear systems and least squares problems.
2	Hand-in assignments	1, 2, 3, 4, 5, 6	15	These are skills based assessment which enables students to implement methods of numerical linear algebra in linear systems, least squares and matrix eigenvalue problems.
3	Project	6	5	Students are assessed on their ability in applying numerical and computational methods for solving more sophisticated problems in linear algebra, as well as on the presentation of results with analysis.

Continuous Assessment (%)

40

Examination (%)
60

Examination Duration (Hours)
3

Additional Information for ATs
40% Coursework
60% Examination (Duration: 3 hours, at the end of the semester)
For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

Assessment Rubrics (AR)

Assessment Task
1. Test

Criterion
Ability in problem solving

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
2. Hand-in assignments

Criterion
Understanding of concepts and applications

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
3. Project

Criterion
Creativity and Team work ability

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
4. Examination

Criterion
Comprehensive ability in independent problem solving

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Part III Other Information

Keyword Syllabus
Matrix analysis. Linear systems of equations. Condition number and backward stability analysis. Orthogonalization and least squares. Matrix eigenvalue problems and singular value decomposition. Conjugate gradient and related iterative methods for linear systems. Lanczos and Arnoldi methods for eigenvalue problems.

Reading List

Compulsory Readings

	Title
1	D. Bau and L. N. Trefethen, Numerical Linear Algebra, SIAM, 1997.
2	J. W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997.

Additional Readings

	Title
1	G. H. Golub and C. F. Van Loan, Matrix Computations, 4th edition, The Johns Hopkins University Press, 2013.