# MATH 3322
# Matrix Computation
# 2025-26 Spring

Midterm Exam date: 9:00 am—10:30 am, Mar. 24, 2025

### Lecture

| | |
|---|---|
| **Time** | Tuesday and Thursday: 9:00 AM-10:30 AM |
| **Venue** | G002 CYT Bldg |
| **Instructor** | **Dr. Guibo YE** |
| E-mail | magbye@ust.hk |
| Office | Room 3419, Department of Mathematics |

### Tutorial

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|---|---|
| **session** | T1A |
| **Time** | Tuesday 05:00 pm -05:50 pm |
| **Venue** | Room 1027 LSK Bldg |
| **Teaching Assistant** | **Chu Yin King** |
| E-mail | ykchuac@connect.ust.hk |
| **session** | T1B |
| **Time** | Wednesday 12:00 pm-12:50 pm |
| **Venue** | Room 2304 (Lift 17-18) |
| **Teaching Assistant** | **LUO, Jianzhou** |
| E-mail | jluobn@connect.ust.hk |

### Course Description

**Course outline:** This course will introduce some basic matrix analysis theory and some popular matrix computation algorithms, and illustrate how they are actually used in data science. Specific topics include advanced linear algebra such as orthogonal projections and vector and matrix norms; the theories and computations of matrix factorizations such as QR decomposition, Singular Value Decomposition (SVD), and Schur decomposition; and applications to data analysis problems such as principle component analysis via SVD and collaborative filtering via matrix completion.

**Credits:** 3

**Prerequisites:** A passing grade in Math 2111/MATH2121/MATH2131

**Exclusion:** NIL

### Intended Learning Outcomes (ILOs)

Upon completion of this course, students are expected to be able to:

(1) Be equipped with of fundamental knowledge of matrix compuation
(2) Develop an understanding of basic algorithms of matrix decomposition
(3) Use matrix computational tools in data science
(4) Implement some algorithms by software such as MATLAB or Python.

### Assessment and Grading

**Homework:** There will be 5 or 6 problem sets. The homework is assigned in Canvas. Students should submit the homework online before the deadline.

**Examinations:** There will be a one hour and twenty minutes midterm exam on Mar. 24 9:00am–10:30am, and a 3-hour final exam arranged by ARO. The exams are all closed-book exams. No calculators or any electronic devices are allowed.

Make-up midterm policy:

- Under any circumstance, students who are unable to attend the midterm exam will **not** be offered a make-up midterm that takes place after the regular exam session.
- For students who have valid reasons for missing the midterm, the instructor may approve an early midterm, or assign the midterm marks according to the final exam performance.
- On other hand, for students who miss the midterm without a valid reason, the midterm score will be regarded as $0$. This includes self-claimed sickness without any medical statement.

The course will follow the make-up exam policy set by ARO for the final exam. Approval from the instructor, the dean, and ARO will be needed for applying for a make-up final exam.

**Grading Scheme:**

This course will be assessed using **criterion-referencing**, and grades will **not** be assigned using a curve. Your course total will be calculated by taking the following scheme:

| | Scheme | Address ILOs |
|---|---|---|
| Homework | 15% | 1, 2, 3, 4 |
| Midterm | 25% | 1, 2, 3 |
| Final | 60% | 1, 2, 3 |
| **Course Total** | 100% | |

**Letter Grades:** Students should aim at getting a course total of 35% or above to get a pass grade.

**Grade Descriptors:**

| Grades | Short Description A | Elaboration on subject grading description |
|---|---|---|
| A | Excellent Performance | The student has mastered almost all concepts and techniques of matrix computaion taught in the course, has excellent understanding of the deepest content of the subject, and acquired workable knowledge for further studies of matrix compuation and their applications. |
| B | Good Performance | The student has mastered most concepts and computational techniques of matrix decomposition taught in the course, yet the understanding of some challenging concepts may not be deep enough for further studies on related advanced subjects. |
| C | Satisfactory Performance | The student meets the minimum expectation of the instructor, has acquired some basic computational techniques of the subject, yet some concepts were not clearly understood. |
| D | Marginal Pass | The student is only able to recall some fragments of topics and is able to complete some of the easiest computations. |
| F | Fail | The student does not have sufficient understanding of even some fragments of topics, and is not even able to complete some of the easiest computations. |

## TEXTBOOKS AND OTHER RESOURCES

(1) Gene H. Golub and Charles F. Van Loan, Matrix computations, 4th Edition, JHU Press, 2013.
(2) Justin Solomon, Numerical Algorithms – Methods for Computer Vision, Machine Learning, and Graphics, CRC Press, 2015.
(3) Lloyd N.Trefethen and David Bau, III, Numerical Linear Algebra, SIAM, 1997.

## COURSE SCHEDULE (ABOUT 33 HOURS)

Keyword Syllabus:

(1) Introduction. Basic matrix operations
(2) Solvability of linear equations, Gaussian elimination, LU decomposition
(3) Case studies: Google's PageRank; Image Deblurring;
(4) QR decomposition; QR decomposition by projection; QR decomposition by Rotation
(5) Case studies: Least squares for MIMO and Linear regression.
(6) Eigenvalue, Eigenvectors, Power Iteration; QR algorithm; Practical QR algorithm

(7) Non-Symmetric Eigenvalue problems, Schur Decomposition
(8) Singular value decomposition
(9) Case studies: Least Squares, PCA, Matrix completion and recommender system

**Course AI Policy**

Students are allowed to consult any person (including the instructor, TA, classmates, friends outside HKUST) in any homework for ideas and hints, but are required to write up the solutions by themselves. You are required to **list the persons and references** you have consulted in every homework for all written homeworks.

The use of ChatGPT or other generative AI is allowed, and they are regarded as "persons" you have consulted, and therefore must be listed in your homework.

However, please be warned that at the current stage of development of AI, the response to problems in advanced courses is not quite reliable. Students should be critical of the response generated by AI and do not blindly copy the generated responses to your homework.

## Academic Integrity

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST's Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct.