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Matrix Algebra for Engineers

The Hong Kong University of Science and Technology

About this Course

This course is all about matrices, and concisely covers the linear algebra that an engineer should know. We define matrices and how to add and multiply them, and introduce some special types of matrices. We describe the Gaussian elimination algorithm used to solve systems of linear equations and the corresponding LU decomposition of a matrix. We explain the concept of vector spaces and define the main vocabulary of linear algebra. We develop the theory of determinants and use it to solve the eigenvalue problem.

After each video, there are problems to solve and I have tried to choose problems that exemplify the main idea of the lecture. I try to give enough problems for students to solidify their understanding of the material, but not so many that students feel overwhelmed and drop out. I do encourage students to attempt the given problems, but if they get stuck, full solutions can be found in the lecture notes for the course.

The mathematics in this matrix algebra course is presented at the level of an advanced high school student, but typically students would take this course after completing a university-level single variable calculus course. There are no derivatives or integrals in this course, but student's are expected to have a certain level of mathematical maturity. Nevertheless, anyone who wants to learn the basics of matrix algebra is welcome to join.

Lecture notes may be downloaded at
http://www.math.ust.hk/~machas/matrix-algebra-for-engineers.pdf

Watch the course overview video at
https://youtu.be/IZcyZHomFQc

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Taught by: Jeffrey R. Chasnov, Professor
Department of Mathematics

Level	Beginner
Commitment	4 weeks of study, 3-4 hours/week
Language	English Volunteer to translate subtitles for this course
How To Pass	Pass all graded assignments to complete the course.
User Ratings	★★★★☆ 4.8 stars

Syllabus

WEEK 1

MATRICES

In this week's lectures, we learn about matrices. Matrices are rectangular arrays of numbers or other mathematical objects and are fundamental to engineering mathematics. We will define matrices and how to add and multiply them, discuss some special matrices such as the identity and zero matrix, learn about transposes and inverses, and define orthogonal and permutation matrices.

11 videos, 25 readings, 4 practice quizzes

1. **Video:** Course Overview
2. **Reading:** Welcome and Course Information
3. **Practice Quiz:** Diagnostic Quiz
4. **Reading:** Get to Know Your Classmates
5. **Video:** Introduction
6. **Video:** Definition of a Matrix
7. **Reading:** Practice: Construct Some Matrices
8. **Video:** Addition and Multiplication of Matrices
9. **Reading:** Practice: Matrix Addition and Multiplication
10. **Reading:** Practice: AB=AC Does Not Imply B=C

11. **Reading:** Practice: Matrix Multiplication Does Not Commute
12. **Reading:** Practice: Associative Law for Matrix Multiplication
13. **Video:** Special Matrices
14. **Reading:** Practice: AB=0 When A and B Are Not zero
15. **Reading:** Practice: Product of Diagonal Matrices
16. **Reading:** Practice: Product of Triangular Matrices
17. **Practice Quiz:** Matrix Definitions
18. **Video:** Transpose Matrix
19. **Reading:** Practice: Transpose of a Matrix Product
20. **Reading:** Practice: Any Square Matrix Can Be Written as the Sum of a Symmetric and Skew-Symmetric Matrix
21. **Reading:** Practice: Construction of a Square Symmetric Matrix
22. **Video:** Inner and Outer Products
23. **Reading:** Practice: Example of a Symmetric Matrix
24. **Reading:** Practice: Sum of the Squares of the Elements of a Matrix
25. **Video:** Inverse Matrix
26. **Reading:** Practice: Inverses of Two-by-Two Matrices
27. **Reading:** Practice: Inverse of a Matrix Product
28. **Reading:** Practice: Inverse of the Transpose Matrix
29. **Reading:** Practice: Uniqueness of the Inverse
30. **Practice Quiz:** Transposes and Inverses
31. **Video:** Orthogonal Matrices
32. **Reading:** Practice: Product of Orthogonal Matrices
33. **Reading:** Practice: The Identity Matrix is Orthogonal
34. **Video:** Rotation Matrices
35. **Reading:** Practice: Inverse of the Rotation Matrix
36. **Reading:** Practice: Three-dimensional Rotation
37. **Video:** Permutation Matrices
38. **Reading:** Practice: Three-by-Three Permutation Matrices
39. **Reading:** Practice: Inverses of Three-by-Three Permutation Matrices
40. **Practice Quiz:** Orthogonal Matrices
41. **Discussion Prompt:** Week One Discussion

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Graded: Week One

WEEK 2

SYSTEMS OF LINEAR EQUATIONS

In this week's lectures, we learn about solving a system of linear equations. A system of linear equations can be written in matrix form, and we can solve using Gaussian elimination. We will learn how to bring a matrix to reduced row echelon form, and how this can be used to compute a matrix inverse. We will also learn how to find the LU decomposition of a matrix, and how to use this decomposition to efficiently solve a system of linear equations.

7 videos, 6 readings, 2 practice quizzes

1. **Video:** Introduction
2. **Video:** Gaussian Elimination
3. **Reading:** Practice: Gaussian Elimination
4. **Video:** Reduced Row Echelon Form
5. **Reading:** Practice: Reduced Row Echelon Form
6. **Video:** Computing Inverses
7. **Reading:** Practice: Computing Inverses
8. **Practice Quiz:** Gaussian Elimination
9. **Video:** Elementary Matrices
10. **Reading:** Practice: Elementary Matrices
11. **Video:** LU Decomposition
12. **Reading:** Practice: LU Decomposition
13. **Video:** Solving (LU)x = b
14. **Reading:** Practice: Solving (LU)x = b
15. **Practice Quiz:** LU Decomposition
16. **Discussion Prompt:** Week Two Discussion

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Graded: Week Two

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WEEK 3

VECTOR SPACES

In this week's lectures, we learn about vector spaces. A vector space consists of a set of vectors and a set of scalars that is closed under vector addition and scalar multiplication and that satisfies the usual rules of arithmetic. We will learn some of the vocabulary and phrases of linear algebra, such as linear independence, span, basis and dimension. We will learn about the four fundamental subspaces of a matrix, the Gram-Schmidt process, orthogonal projection, and the matrix formulation of the least-squares problem of drawing a straight line to fit noisy data.

More

13 videos, 14 readings, 4 practice quizzes

1. **Video:** Introduction
2. **Video:** Vector Spaces
3. **Reading:** Practice: Zero Vector
4. **Reading:** Practice: Examples of Vector Spaces
5. **Video:** Linear Independence
6. **Reading:** Practice: Linear Independence
7. **Video:** Span, Basis and Dimension
8. **Reading:** Practice: Orthonormal basis
9. **Practice Quiz:** Vector Space Definitions
10. **Video:** Gram-Schmidt Process
11. **Reading:** Practice: Gram-Schmidt Process
12. **Video:** Gram-Schmidt Process Example
13. **Reading:** Practice: Gram-Schmidt on Three-by-One Matrices
14. **Reading:** Practice: Gram-Schmidt on Four-by-One Matrices
15. **Practice Quiz:** Gram-Schmidt Process
16. **Video:** Null Space
17. **Reading:** Practice: Null Space
18. **Video:** Application of the Null Space
19. **Reading:** Practice: Underdetermined System of Linear Equations
20. **Video:** Column Space
21. **Reading:** Practice: Column Space

22. **Video:** Row Space, Left Null Space and Rank
23. **Reading:** Practice: Fundamental Matrix Subspaces
24. **Practice Quiz:** Fundamental Subspaces
25. **Video:** Orthogonal Projections
26. **Reading:** Practice: Orthogonal Projections
27. **Video:** The Least-Squares Problem
28. **Reading:** Practice: Setting Up the Least-Squares Problem
29. **Video:** Solution of the Least-Squares Problem
30. **Reading:** Practice: Line of Best Fit
31. **Practice Quiz:** Orthogonal Projections
32. **Discussion Prompt:** Week Three Discussion

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Graded: Week Three

WEEK 4

EIGENVALUES AND EIGENVECTORS

In this week's lectures, we will learn about determinants and the eigenvalue problem. We will learn how to compute determinants using a Laplace expansion, the Leibniz formula, or by row or column elimination. We will formulate the eigenvalue problem and learn how to find the eigenvalues and eigenvectors of a matrix. We will learn how to diagonalize a matrix using its eigenvalues and eigenvectors, and how this leads to an easy calculation of a matrix raised to a power.

13 videos, 20 readings, 3 practice quizzes

1. **Video:** Introduction
2. **Video:** Two-by-Two and Three-by-Three Determinants
3. **Reading:** Practice: Determinant of the Identity Matrix
4. **Reading:** Practice: Row Interchange
5. **Reading:** Practice: Determinant of a Matrix Product
6. **Video:** Laplace Expansion

7. **Reading:** Practice: Compute Determinant Using the Laplace Expansion
8. **Video:** Leibniz Formula
9. **Reading:** Practice: Compute Determinant Using the Leibniz Formula
10. **Video:** Properties of a Determinant
11. **Reading:** Practice: Determinant of a Matrix With Two Equal Rows
12. **Reading:** Practice: Determinant is a Linear Function of Any Row
13. **Reading:** Practice: Determinant Can Be Computed Using Row Reduction
14. **Reading:** Practice: Compute Determinant Using Gaussian Elimination
15. **Practice Quiz:** Determinants
16. **Video:** The Eigenvalue Problem
17. **Reading:** Practice: Characteristic Equation for a Three-by-Three Matrix
18. **Video:** Finding Eigenvalues and Eigenvectors (1)
19. **Reading:** Practice: Eigenvalues and Eigenvectors of a Two-by-Two Matrix
20. **Reading:** Practice: Eigenvalues and Eigenvectors of a Three-by-Three Matrix
21. **Video:** Finding Eigenvalues and Eigenvectors (2)
22. **Reading:** Practice: Complex Eigenvalues
23. **Practice Quiz:** The Eigenvalue Problem
24. **Video:** Matrix Diagonalization
25. **Reading:** Practice: Linearly Independent Eigenvectors
26. **Reading:** Practice: Invertibility of the Eigenvector Matrix
27. **Video:** Matrix Diagonalization Example
28. **Reading:** Practice: Diagonalize a Three-by-Three Matrix
29. **Video:** Powers of a Matrix
30. **Reading:** Practice: Matrix Exponential
31. **Video:** Powers of a Matrix Example
32. **Reading:** Practice: Powers of a Matrix
33. **Practice Quiz:** Matrix Diagonalization
34. **Discussion Prompt:** Week Four Discussion
35. **Video:** Concluding Remarks
36. **Reading:** Please Rate this Course
37. **Reading:** Acknowledgments

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Graded: Week Four

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How It Works

GENERAL

How do I pass the course?

To earn your Course Certificate, you'll need to earn a passing grade on each of the required assignments—these can be quizzes, peer-graded assignments, or programming assignments. Videos, readings, and practice exercises are there to help you prepare for the graded assignments.

More

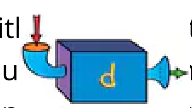
What do start dates and end dates mean?

View the course in catalog

Once you enroll, you'll have access to all videos, readings, quizzes, and programming assignments (if applicable). If you choose to explore the course without purchasing, you may not be able to access certain assignments. If you don't finish all graded assignments before the end of the course, you can reset your deadlines. Your progress will be saved and you'll be able to pick up where you left off.

Related Courses

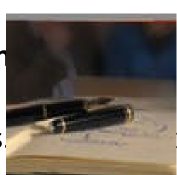
What are due dates? Is there a penalty for submitting my work after a due date?



Calculus: Single Variable Part 2 - Differentiation

University of Pennsylvania

Witl there are suggested due dates to help you manage your schedule and keep cou piling up. Quizzes and programming assignments can be submitted late without con owever, it is possible that you won't receive a grade if you submit your peer-graded assignment too late because classmates usually review assignment within three days of the assignment deadline.



Effective Communication Capstone Project

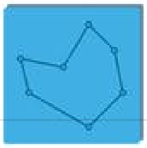
University of Colorado Boulder

Can t an assignment?

Yes o improve your grade, you can always try again. If you're re-attempting a peer-graded assignment, re-submit your work as soon as you can to make sure there's enough time for your classmates to review your work. In some cases you may need to wait before re-submitting a programming assignment or quiz. We encourage you to review course material during this delay.

Combinatorics and Probability

University of California San Diego, National Research University Higher School of Economics



Delivery Problem

University of California San Diego, National Research University Higher School of Economics

Software Design Threats and Mitigations

University of Colorado System