

Syllabus for MATH 21-240, Matrix Algebra with Applications, Section 1

Carnegie Mellon University, Spring 2020

Instructor: Dr. Neranga Fernando

Office: WEH 7115

E-mail: fneranga@andrew.cmu.edu

Office phone: 412-268-5608

Office hours: Monday 3pm – 5pm, Thursday 4pm – 5pm.

Meeting times and location: MWF, 11.30am – 12.20pm at BH A51.

Course Content: Vectors and matrices, the solution of linear systems of equations, vector spaces and subspaces, orthogonality, determinants, real and complex eigenvalues and eigenvectors, linear transformations.

Textbook: *Linear Algebra and Its Applications*, by David C. Lay, Steven R. Lay and Judi J. McDonald, 5th edition.

Web materials: All class announcements, material, and grades will be posted on Canvas.

Tests:

You will be taking a 50-minute test in recitation meeting starting from the third week on the days given below. The lowest test score will be dropped. If you miss a test for any reason, that will be considered as the dropped test grade. There will be NO make-up tests.

Here are the dates you will be taking a test:

Test 1 (January 28), Test 2 (February 11), Test 3 (March 3), Test 4 (March 24), Test 5 (April 7), Test 6 (April 21)

Homework:

Homework is due within the first ten minutes of the recitation meeting every other Tuesday starting from the second week, i.e. on Tuesdays you are not taking a test, with the exception of Week 9. Late homework will be accepted for up to three days (Friday) with a 10% penalty. Discussion on homework is allowed, but each student must prepare and submit their own assignment. No homework grade will be dropped.

Here are the due dates of homework:

Homework 1 (January 21), Homework 2 (February 4), Homework 3 (February 18), Homework 4 (February 25),
Homework 5 (March 31), Homework 6 (April 14)

You should only submit the homework problems with an asterisk, but it is strongly advised that you do all of assigned homework since the tests will closely resemble the homework problems.

Final exam:

There will be a cumulative final exam in this course. Date, time and location of the final exam are to be determined. Unless you have a very serious, well-documented, and compelling reason to miss the final exam, there will be NO make-up final exam.

Grading: The course grade will be determined as follows:

Final exam: 30%

Tests: 50% (10% each since the lowest test grade is dropped)

Homework: 20%

Letter grades are determined numerically:

$A \geq 90$, $90 > B \geq 80$, $80 > C \geq 70$, $70 > D \geq 60$, $60 > R$

The grade I (Incomplete) will be given only if you have at least a C in class before the final exam, have completed all homework and tests before the final exam, and have missed the final exam for a valid reason. An incomplete grade is given at the discretion of the instructor.

Calculators : Calculators are NOT permitted on tests and the final exam.

Additional resources:

Course TA information and recitation meetings on Tuesdays:

<i>Name and Email</i>	<i>Recitation meeting time and location</i>	<i>Office hours and location</i>
Yilun Wu, yilunw@andrew.cmu.edu	Section A, 10.30am – 11.20am, SH 208	Wed 4.30pm – 5.30pm, Fri 10.30am – 11.30am, WEH 6215
Wentao Yang, wentaoyang@cmu.edu	Section B, 11.30am – 12.20pm, WEH 5421	Tue 6.30pm – 7.30pm, Thu 2pm – 3pm, WEH 7207
Wentao Yang, wentaoyang@cmu.edu	Section C, 1.30pm – 2.20pm, BH 255A	Tue 6.30pm – 7.30pm, Thu 2pm – 3pm, WEH 7207

Academic Honesty: Collaboration on tests and final exam is NOT allowed.

A necessary prerequisite to the attainment of the goals of the University is maintaining complete honesty in all academic work. Students are expected to present as their own only that which is clearly their own work in tests and in any material submitted for credit. Students may not assist others in presenting work that is not their own. Offenders are subject to disciplinary action.”

For more on Academic Integrity see: <https://www.cmu.edu/policies/student-and-student-life/academic-integrity.html>

Important:

- 1) Any student with a disability is encouraged to meet with the instructor during the first week of classes to discuss accommodations. The student must bring a current Memorandum of Accommodations from the Office of Disability Resources.
- 2) If you are an athlete and have conflicts with an important class activity (quiz, mid-term, or final), you should let your instructor know before the end of second week of classes. You should also bring an official letter from the Office of Athletics.
- 3) All electronic devices (mobile phones, laptops etc.) should be turned off during class time, recitation meetings, tests and final exam.

Syllabus: Syllabus is subject to change. It is your responsibility to be aware of any changes the instructor may make to the syllabus as they are announced in class. Students are responsible for all information given when they are absent.

Schedule of Topics and Suggested Homework Exercises

Week 1: January 13 - 17

Section 1.1 Systems of Linear Equations 1, 3, 5, 7, 9, 11, 13, 15*, 17, 19, 21, 23, 25*, 27*, 29*

Sections 1.2 Row Reduction and Echelon Forms 1, 2, 3*, 7, 9, 11, 13*, 15*, 17*, 19*, 21*

Week 2 (partial): January 21 – 24

Monday, January 20: Martin Luther King, Jr. Day

Tuesday, January 21: Homework 1 – Sections 1.1 & 1.2

Section 1.3 Vector Equations 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25

Section 1.4 The Matrix Equation $A\mathbf{x} = \mathbf{b}$ 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33

Week 3: January 27 - 31

Section 1.5 Solution Sets of Linear Systems 1, 3, 5, 7, 9, 11, 13, 15*, 17*, 19*, 21, 23, 27, 29, 31, 33, 35

Tuesday, January 28: Test 1

Section 1.7 Linear Independence 1*, 3, 5*, 7, 9, 11*, 13, 15, 17*, 19, 21*, 23, 25, 27*, 29, 31*, 33 - 38

Section 1.8 Introduction to Linear Transformations 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23,, 29, 31, 33, 35

Week 4: February 3 – 7

Section 1.9 The Matrix of a Linear Transformation 1, 3, 5, 7, 9, 11, 13, 15, 17*, 19, 21, 23*, 25, 27, 29, 31, 35

Tuesday, February 4: Homework 2 - Sections 1.5 & 1.7

Section 1.6 Applications of Linear Systems 1*, 3 (a) & (b), 5*, 7, 11*, 13

Section 1.10 Linear Models in Business, Science and Engineering 1, 5, 7, 9 (in 5 & 7, do not solve the system)

Week 5: February 10 - 14

Section 2.1 Matrix Operations 1*, 3, 5, 7, 9, 11, 15*, 17, 19, 21, 23, 25, 27, 31

Tuesday, February 11: Test 2

Section 2.2 The inverse of a Matrix 1, 3, 5, 7*, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33*, 35, 37*

Section 2.3 Characterizations of Invertible Matrices 1, 3*, 5, 7*, 11, 13, 15, 17, 19, 21, 23, 31, 33*

Week 6: February 17 - 21

Section 2.8 Subspaces of \mathbb{R}^n 1*,3, 5*, 7*, 9, 11, 13, 15, 17*, 19, 21*, 23, 25, 27, 29, 31, 33, 35

Tuesday, February 18: Homework 3 – Sections 1.9, 1.6, 2.1, 2.2

Section 2.9 Dimension and Rank 1, 3, 5, 7, 9, 11, 13*, 15*, 17, 19, 21, 23

Section 4.1 Vector Spaces and Subspaces 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33

Week 7: February 24 – 28

Section 4.2 Null Spaces, Column Spaces and Linear Transformations 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 31, 33, 35

Tuesday, February 25: Homework 4 – Sections 2.3, 2.8 & 2.9

Section 4.3 Linearly Independent Sets; Bases 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 29, 31, 33, 35

Section 4.4 Coordinate Systems 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 32, 37

Week 8: March 2 – 6

Section 4.5 The Dimension of a Vector Space 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29

Tuesday, March 3: Test 3

Section 4.6 Rank 1, 3, 5, 7, 9, 11, 13, 15, 17, 27, 28, 29, 30

Section 4.8 Applications to Difference Equations 1, 3, 5, 7, 9, 11, 13, 15, 25, 27, 29, 31, 35

Monday – Friday, March 9 – 13: Spring break, no classes

Week 9: March 16 - 20

Section 4.9 Applications to Markov Chains 1, 3, 5, 7, 9, 11, 13

Section 3.1 Introduction to Determinants 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39

Section 3.2 Properties of Determinants 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, , 43

Week 10: March 23 - 27

Section 3.3 Cramer's Rule, Volume, and Linear Transformations 1, 3, 5*, 7, 9*, 11, 13, 15, 17, 19, 21, 23*, 25, 27, 29, 31*

Tuesday, March 24: Test 4

Section 5.1 Eigenvectors and Eigenvalues 1, 3, 5, 7, 9, 11, 13, 15, 17*, 19*, 21, 23*, 25, 27, 29, 31

Section 5.2 The Characteristic Equation 1, 3, 5, 7, 9, 11*, 13, 15, 17*, 19*, 21

Week 11: March 30 – April 3

Section 5.3 Diagonalization 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31

Tuesday, March 31: Homework 5 – Sections 3.3, 5.1 & 5.2

Section 5.4 Eigenvectors and Linear Transformations 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 29

Section 5.5 Complex Eigenvalues 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25

Week 12: April 6 – April 10

Section 5.7 Applications to Differential Equations 1*, 3*, 5, 7, 9, 11, 13

Tuesday, April 7: Test 5

Section 6.1 Inner Product, Length, and Orthogonality 1*, 3, 5, 7, 9, 11, 13, 15, 17, 19*, 23*, 25*, 27, 29

Section 6.2 Orthogonal Sets 1*, 3, 5, 7, 9*, 11, 13*, 15, 17, 19, 21*, 23, 27, 29, 33

Week 13 (partial): April 13 – 17

Section 6.3 Orthogonal Projections 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21

Tuesday, April 14: Homework 6 – Sections 5.7, 6.1 & 6.2

Section 6.4 The Gram-Schmidt Process 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23

Friday, April 17: Spring Carnival, no classes

Week 14: April 20 – April 24

Section 6.5 Least-Squares Problems 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 25

Tuesday, April 21: Test 6

Section 7.1 Diagonalization of Symmetric Matrices 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 35

Section 7.2 Quadratic Forms 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27

Week 15: April 27 – May 1

Section 7.3 Constrained Optimization 1, 3, 5, 7, 9

Section 7.4 The Singular Value Decomposition 1, 3, 5, 7, 9, 11, 13, 15, 17, 19

Review

May 1, Friday, Last day of classes
Final Exam is based on all sections covered in class.