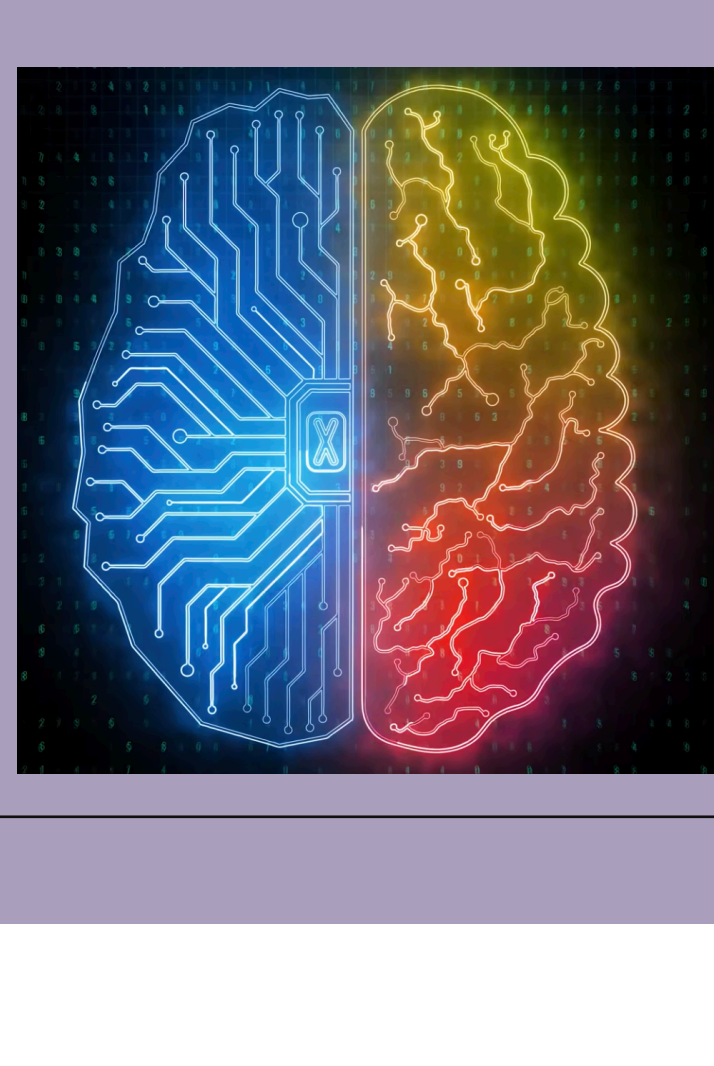


Linear Algebra

Part II



MTH 225

Dr. John Gemmer: gemmerj@wfu.edu

Office: Manchester 388

Course Website: <http://users.wfu.edu/gemmerj/math225S25.html>

(homework, lecture notes, solutions will be posted on the course website)

Canvas: The course syllabus, course notes, and grades will be posted on Canvas

Office Hours: T 1:00-3:00, W 1:00-2:00, Th 1:00-3:00

Class Meeting Times: MWF 9:00-9:50

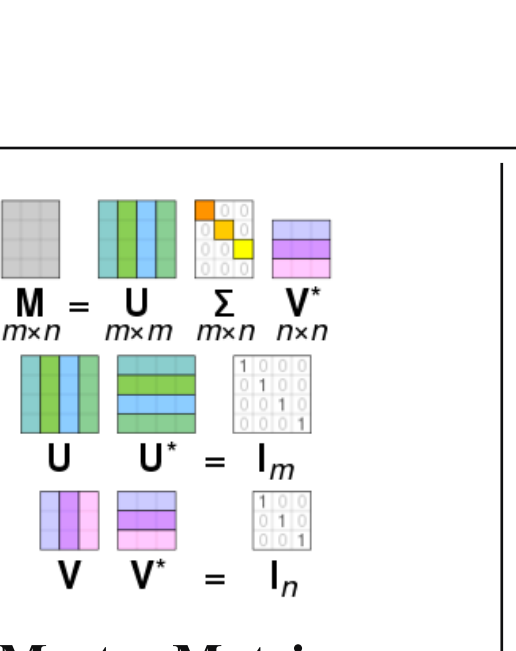
Class Location: Kirby-Manchester B02

Study Sessions: Tuesday 7-9 in Manchester Hall

COURSE DESCRIPTION

This is a second course in linear algebra. Linear algebra is central to modern applications such as Google PageRank, sabermetrics, machine learning, linear models, principal component analysis, quantum mechanics, and as well as to pure mathematics. The primary goal of this course is to develop an understanding of many of the basic tools in linear algebra so that you can later apply it to many different contexts. In your first linear algebra course the emphasis was on subspaces and linear maps on Euclidean space. In this course we will study finite dimensional vector spaces and linear maps where the field of scalars can be more exotic. We will also study inner product spaces on these more general spaces. With this additional structure, we will study unitary, Hermitian, and normal matrices as well as the singular value decomposition, polar decomposition, and the exponential of matrices. Along the way we will apply the theory we develop to topics in Fourier analysis, least squares solutions, differential equations, Markov chains, and iterated maps.

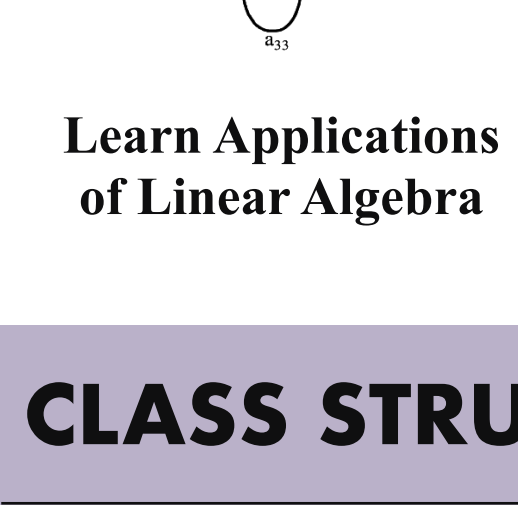
REQUIREMENTS



Prerequisites:

Linear Algebra (MTH 121) and Discrete Mathematics (MTH 117)

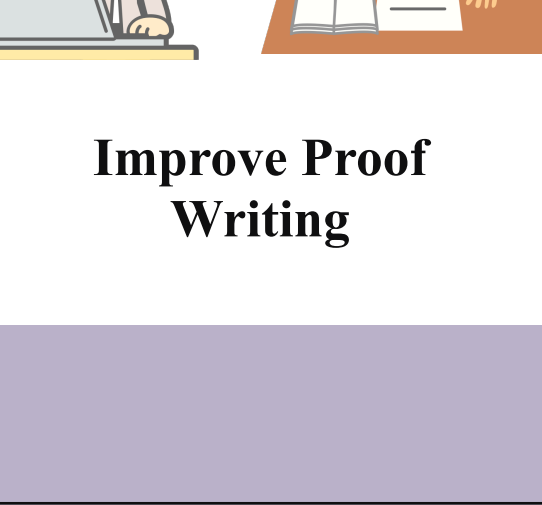
OBJECTIVES



Master Abstract Vector Spaces



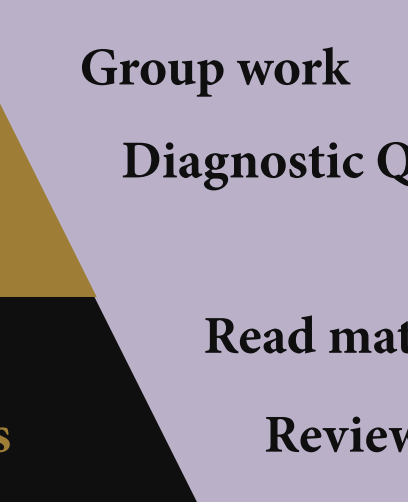
Master Matrix Decompositions



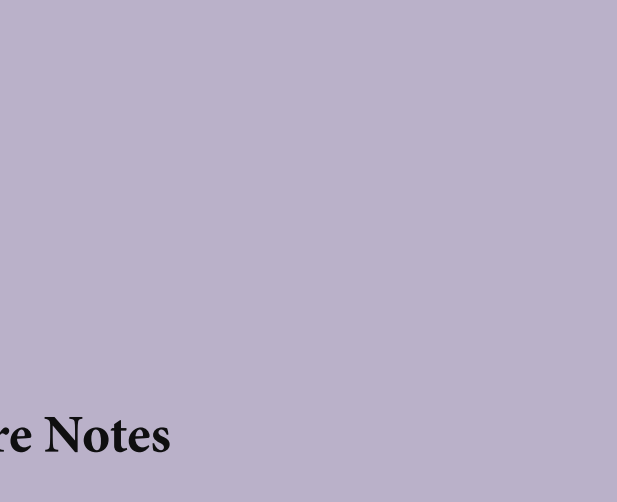
Master Linear Transformations



Learn Applications of Linear Algebra

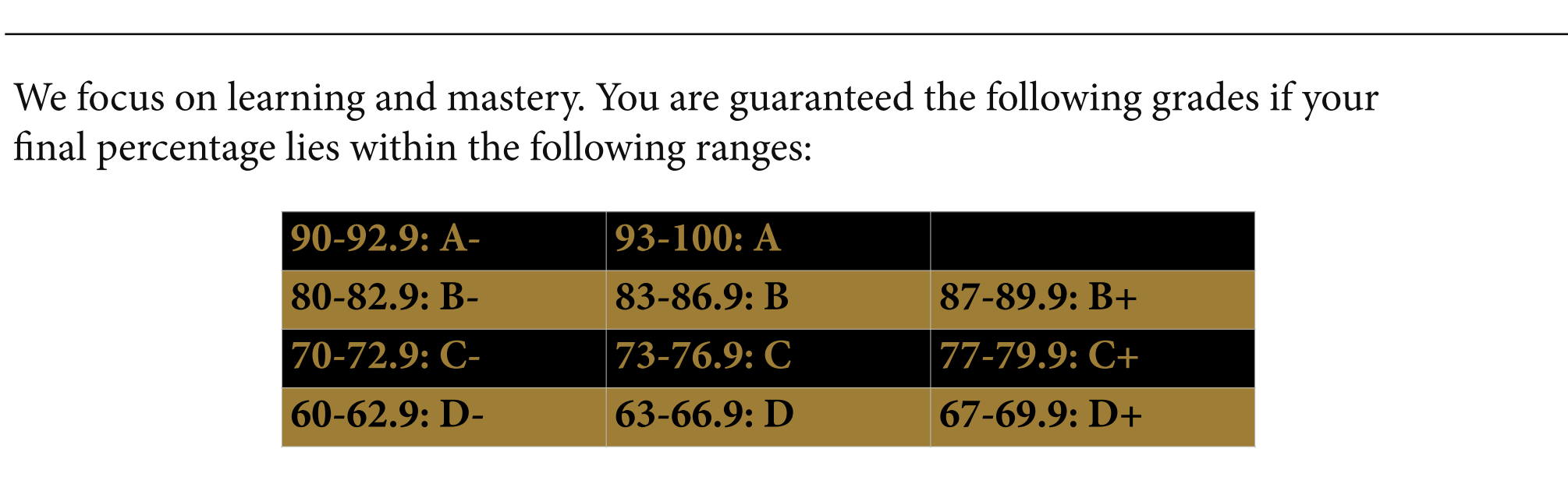


Master Inner Product Spaces



Improve Proof Writing

CLASS STRUCTURE



EVALUATION

We focus on learning and mastery. You are guaranteed the following grades if your final percentage lies within the following ranges:

90-92.9: A-	93-100: A	
80-82.9: B-	83-86.9: B	87-89.9: B+
70-72.9: C-	73-76.9: C	77-79.9: C+
60-62.9: D-	63-66.9: D	67-69.9: D+

Classworks (5%)
Structured in class group assignments
Grades based on attendance

Quizzes (10%), at least one dropped
5-10 minutes
In class on most Mondays

Weekly Homework (25%), at least 1 dropped
Open book, collaboration allowed with citation
Homework is due on most Wednesdays in class

Two summative assessments (30%)
In class, closed notes

Final Exam (35%)
Comprehensive
In class, closed notes

Classworks: Throughout the course there will be a several announced and unannounced class works. These will consist of structured group assignments that will be completed during class time. These assignments will generally be exploratory allowing students to synthesize concepts through a "hands on" approach. Classworks will be graded based on attendance.

Quizzes: On most Mondays there will be a short 5-10 minute in-class quizzes. These quizzes will consist of a very short problem that will test your knowledge of the prior lectures and homework. These quizzes are to help both the students and the instructor understand concepts that students may be struggling with. All quizzes will be announced in class. There will be no "pop" quizzes. There are no retakes for missed quizzes, however I will drop the lowest quiz score from your final grade.

Weekly Homework: Homework will be assigned most weeks on Tuesday and due in class the following Wednesday. Late homework will not be accepted under any circumstances. However, I will drop at least one homework assignment from your grade. While you are allowed to collaborate with your colleagues, homework must consist of solutions that show all steps, be your own work and be written clearly using complete sentences as appropriate (see homework policy). All homework will be submitted in class on paper. I will not accept digital versions of your homework unless you need to miss class.

Summative Assessments: There will be two in class summative assessments in the course and a cumulative final exam.

Late Work Policy: Except in very extreme circumstances, I do not accept late assignments or reschedule exams. If you have a situation in which you cannot make an exam for personal reasons, you must arrange accommodations with the instructor to schedule the exam **before the scheduled exam date**. If you have a legitimate emergency situation, I will make sure that all students in the course will have access to the same exception to this policy.

If you need to miss class due to a university sponsored activity, such as athletics. Please contact the faculty member as soon as possible to reschedule due dates.

COURSE ENVIRONMENT

Names/Pronouns
You **deserve** to be addressed in the manner you prefer. To guarantee that I address you properly, you are welcome to tell me your pronoun(s) and/or preferred name at any time, either in person or via email.

Diversity
We embrace diversity of age, background, beliefs, ethnicity, gender, gender identity, gender expression, national origin, religious affiliation, sexual orientation, and other visible and non-visible categories. **I do not tolerate discrimination.**

Accessibility
I want you to succeed in this course. Wake Forest University provides reasonable accommodations to students with disabilities. If you are in need of an accommodation, then please contact me privately as early in the term as possible. Retroactive accommodations may not be provided. Students requiring accommodations must also consult the Center for Learning, Access, and Student Success (118 Reynolda Hall, 336-758-5929, <http://class.wfu.edu>). For personal issues, stress, health problems or life circumstances see shs.wfu.edu. Contact me if you have other special circumstances. **I will find resources for you.**

Title IX
You **deserve** a community free from discrimination, sexual harassment, a hostile environment, sexual assault, domestic violence, dating violence, and stalking. If you experience or know of a Title IX violation, you have many options for support and/or reporting; see titleix.wfu.edu/.

Emergency Fund
You **deserve** a learning environment in which all of your physiological and safety needs are met. If you are experiencing situations in which these needs are not met, e.g. you do not have adequate housing or sufficient food security, the Chaplain's Office has an emergency fund which can provide support: <https://chaplain.wfu.edu/care-support/chaplains-emergency-fund/>. In situations in which you need immediate assistance there is emergency funding available through the Department of Mathematics and Statistics. If you are in need of emergency help you are encouraged to reach out to a faculty member in the Department of Mathematics and Statistics who will work with the chair of the department to address your needs.

Course Resources
The department has a limited amount of funding for class materials. If you cannot afford class materials, you are encouraged to contact the chair of the department privately as early in the term as possible. Due to the limited amount of funds, students must exhaust all other sources of funding before applying to the department for assistance.

The Honor Code
At Wake Forest, we expect you to behave as honorable citizens of the class, the university, and the world as a whole. When you complete an assignment with your name on it, you are representing that everything you are turning in is your own work. That means that you do not copy from other students, textbooks, or websites. If at any time I become aware of cheating or plagiarism in this course, I will submit the information to the honor council.

TENTATIVE COURSE CALENDAR

Vector Spaces and Linear Transformations

Week 1:
1. 1/13: Going over the syllabus, Solving systems of equations, **Ch. 1: Section 1**
2. 1/15: Introduction to complex numbers, **Lecture Notes**
3. 1/17: Introduction to complex numbers/modular arithmetic, **Lecture Notes**

Week 2:
1. 1/20: MLK Day (No class)
2. 1/22: **Classwork, Homework #1 Due**
3. 1/24: Modular arithmetic/fields

Week 3:
1. 1/27: Vector spaces, **Ch 1: Section 2, Quiz #1**
2. 1/29: Subspaces, **Ch 1: Section 2, Homework #2 Due**
3. 1/31: Span, independence, basis and dimension, **Ch 1: Section 2,**

Week 4:
1. 2/03: Coordinate vectors, matrix of linear transformations, **Ch 1: Section 3, Quiz #2**
2. 2/05: Changing basis, **Ch 1: Section 3, Homework #3 Due**
3. 2/07: Eigenvalues and eigenvectors, **Ch 1: Section 4**

Week 5:
1. 2/10: Conditions for diagonalization, **Ch 1: Section 5, Quiz #3**
2. 2/12: Inner product spaces, **Ch 2: Sections 1-2, Homework #4 Due**
3. 2/14: Inner product spaces/orthogonality, **Ch 2: Section 1-2**

Inner Products, Spectral Theorems, SVD, Least Squares

Week 6:
1. 2/17: **Summative Assessment #1**
2. 2/19: Projections and Gram-Schmidt orthogonalization, **Ch2: Section 3**
3. 2/21: Projections and application to Fourier series, **Lecture Notes**

Week 7:
1. 2/24: Unitary matrices and Schur decomposition, **Ch 2: Section 4, Quiz #4**
2. 2/26: Hermitian matrices and rank 1 matrices, **Ch 2: Section 4, Homework #5 Due**
3. 2/28: Spectral theorem for Hermitian matrices, **Ch 2: Section 4**

Week 8:
1. 3/03: Normal matrices and the spectral theorem, **Ch 4: Section 3, Quiz #5**
2. 3/05: Algebraic construction of SVD I, **Ch 3, Homework #6 Due**
3. 3/07: Algebraic construction of SVD II, **Ch 3**

Spring Break 3/08-3/16

Week 9:
1. 3/17: Geometric interpretation of SVD, **Ch 3, Quiz #6**
2. 3/19: Low rank approximations and applications of SVD, **Lecture Notes, Homework #7 Due**
3. 3/21: Least square approximations and normal equations, **Ch 4: Section 5**

Week 10:
1. 3/24: Pseudoinverse, **Ch 4: Section 5, Quiz #7**
2. 3/26: Pseudoinverse and optimal least squares, **Ch 4: Section 6, Homework #8 Due**
3. 3/28: Catch up day

Square Roots, Exponentials, Polar Decomposition, Iterations

Week 11:
1. 4/01: **Summative Assessment #2**
2. 4/02: Positive semidefinite matrices and their square roots, **Ch 4: Section 1**
3. 4/04: Matrix exponential, **Ch 4: Section 4**

Week 12:
1. 4/07: Application to linear differential equations, **Lecture Notes, Quiz #8**
2. 4/09: Polar decomposition, **Ch 4: Section 2, Homework #9 Due**
3. 4/11: Gershgorin's circle theorem I, **Ch 5**

Week 13:
1. 4/14: Gershgorin's circle theorem II, **Ch 5, Quiz #9**
2. 4/16: Markov chains I, **Ch 6: Section 1, Homework #10 Due**
3. 4/18: Markov chains II, **Ch 6: Section 2**

Week 14:
1. 4/21: Power Method, **Lecture Notes, Quiz #10**
2. 4/23: Perron Frobenius and ranking things I, **Homework #11 Due**
3. 4/25: Perron Frobenius and ranking things II

Week 15:
1. 4/28: **Classwork, Quiz #11**

Final Exam: May 5, 9:00 AM

SUCCESS

Attend class **Participate constantly** **Invest time**

Concentrate on concepts in addition to calculations **Seek help when needed** **Eliminate Virtual Distractions**