MATH 5524 · MATRIX THEORY · Spring 2017 · Virginia Tech

Lectures:	Monday/Wednesday/Friday, 12:20–1:10PM, McBryde 328
Web Site:	`http://www.math.vt.edu/people/embree/math5524`
Instructor:	Mark Embree (embree@vt.edu), McBryde 575, (540) 231-9592
Office Hours:	Monday 4:00–5:30PM, Thursday 1:30–3PM, or by appointment.
Piazza:	We will use Piazza as a venue for posting questions and extending class discussion. Please use this forum vigorously! Sign up at: `http://piazza.com/vt/spring2017/math5524`.

Prerequisites: Students should be comfortable with fundamental concepts from linear algebra, as covered in a solid undergraduate course, e.g., subspaces, the column space and null space of a matrix, invertibility, solution of linear equations, and basics of eigenvalues and eigenvectors. Some facility with MATLAB or a similar package will be helpful.

Grade Policy:
50% standard problem sets (approximately six during the semester; collaboration welcome)
35% pledged problem sets (two during the semester; no collaboration allowed)
15% end-of-semester project (due at 5:25pm on 6 May 2017)

Scores of at least 90, 80, 70, and 60 guarantee grades of at least A−, B−, C−, and D−.

Participation: Please contribute to the classroom environment by asking questions and participating in discussions. Your interaction (in class and/or Piazza) will be considered when assigning borderline grades, as will improving performance throughout the course of the semester.

Standard problem sets: Approximately six standard problem sets will be assigned. These exercises will require proofs of general results and analysis of illustrative examples. Mathematically rigorous solutions are expected; strive for clarity and elegance. Some problems will require a bit of MATLAB coding.

You are encouraged to collaborate on the standard problem sets, *but your write-up must be your independent work.* (A good rule of thumb: spend an hour on each problem by yourself, before consulting classmates.) Transcribed solutions and copied code are unacceptable. Specify your collaborators; credit outside sources you use (books, articles, websites).

Late policy: Your may submit two standard problem sets one class period late with no penalty. Subsequent late assignments will be penalized 25%. No work will be accepted more than one class period late without prior arrangement or a written excuse.

Pledged problem sets: Two assignments will be designated as *pledged problem sets.* These must be completed with only the aid of class notes and limited other specified resources. *You may not use outside sources:* other students, other books, the web, etc.

Pledged problem sets *may not* be turned in late without prior arrangement or written excuse.

Re-Grade Policy: If your work has been graded incorrectly, you may submit a re-grade request. Clearly explain the perceived error on a separate sheet of paper, staple it to the front of your graded paper, and give it to the instructor within one week of the paper's return.

Projects: Each student will complete a significant project that digests a research paper (or covers a similar scope). Students may propose a topic or choose from a provided list.

Honor Code: Virginia Tech's Honor Code applies to all work in this course. Students must uphold the highest ethical standards, abiding by our Honor Code: "As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do." From the Office for Undergraduate Academic Integrity: "Students enrolled in this course are responsible for abiding by the Honor Code. A student who has doubts about how the Honor Code applies to any assignment is responsible for obtaining specific guidance from the course instructor before submitting the assignment for evaluation. Ignorance of the rules does not exclude any member of the University community from the requirements and expectations of the Honor Code. For additional information about the Honor Code, please visit: www.honorsystem.vt.edu."

Any student with special needs or circumstances requiring accommodation in this course is encouraged to contact the instructor during the first week of class, as well as the Dean of Students. We will ensure that these needs are appropriately addressed.

Tentative Schedule

The course will roughly follow the schedule below. Topics will be added (and omitted) as time permits, guided by class interest. The problem sets will extend these topics. (The instructor will be traveling during four of the normal classes. Make-up lectures or alternative reading will be scheduled.)

1	Wed	Jan 18	1. Diagonalization
2	Fri	Jan 20	1. Resolvents, Schur factorization
3	Mon	Jan 13	1. Spectral theorem for Hermitian matrices
4	Wed	Jan 25	1. Example: eigenvalues, eigenvectors, and mechanics
5	Fri	Jan 27	1. Example: eigenvalue optimization for critical damping
6	Mon	Jan 30	1. Jordan form
7	Wed	Feb 1	1. Jordan form
8	Fri	Feb 3	1. Cayley–Hamilton, spectral representation
9	Mon	Feb 6	1. Spectral representation
10	Wed	Feb 8	1. Simultaneous diagonalization
11	Fri	Feb 10	2. Rayleigh quotients and extreme eigenvalues
12	Mon	Feb 13	2. Cauchy Interlacing Theorem
13	Wed	Feb 15	2. Courant–Fischer variational characterization
14	Fri	Feb 17	2. Eigenvalue inequalities for Hermitian matrices
15	Mon	Feb 20	2. Eigenvalue majorization
16	Wed	Feb 22	2. Sylvester's Law of Inertia
17	Fri	Feb 24	2. Example: Jacobi matrices
18	Mon	Feb 27	2. Eigenvalue avoidance
19	Wed	Mar 1	*ME at SIAM CSE meeting*
20	Fri	Mar 3	*ME at SIAM CSE meeting*
21	Mon	Mar 13	2. Example: KKT matrices in optimization and fluids
22	Wed	Mar 15	3. Singular value decomposition
23	Fri	Mar 17	3. Schatten matrix norms
24	Mon	Mar 20	3. The polar decomposition
25	Wed	Mar 22	3. Variational characterization of singular values
26	Fri	Mar 24	*ME traveling*
27	Mon	Mar 27	3. Singular value inequalities
28	Wed	Mar 29	3. Principal component analysis
29	Fri	Mar 30	4. Eigenvalue perturbation theory: asymptotics
30	Mon	Apr 3	4. Hoffmann–Wielandt theorem for normal matrices
31	Wed	Apr 5	4. Theorems on spectral variation
32	Fri	Apr 7	4. Theorems of Gerschgorin, Bauer–Fike, Bendixson
33	Mon	Apr 10	4. Numerical range (field of values)
34	Wed	Apr 12	4. Pseudospectra
35	Fri	Apr 14	4. Example: transient behavior of dynamical systems
36	Mon	Apr 17	5. Functions of matrices
37	Wed	Apr 19	5. Example: the exponential of a matrix
38	Fri	Apr 21	*ME traveling*
39	Mon	Apr 24	5. Examples: the sign function, logarithm, etc.
40	Wed	Apr 26	6. Positive matrices
41	Fri	Apr 28	6. Positive matrices
42	Mon	May 1	6. Nonnegative matrices
43	Wed	May 3	6. Example: Markov chains
	Sat	May 6	Projects due at 5:25pm