

Math 603, Fall 2011

Matrix Analysis

- Instructor:** John Zweck
- Office:** MP 424
- Email:** zweck@umbc.edu
- Webpage:** I will maintain a web page for the course, linked from my web page www.math.umbc.edu/~zweck. (I do *not* use Blackboard.) I will also communicate with you using a class email list.
- Phone:** (410) 455 2424
- Fax:** (410) 455 1066
- Lectures:** TuTh 4:00-5:15 (MP012)
- Problem Sessions:** (Optional, Tentative, Room TBD) Sep 9 – Oct 14: Fri 11-12; Oct 21 – Dec 9: Fri 3-4:30. During these sessions, students will solve problems at the blackboard with feedback from other students and the instructor.
- Text:** “Matrix Analysis and Applied Linear Algebra”, by Carl Meyer
- Other Books:** You may also find the following excellent books useful, though I will not explicitly rely on them.
1. “Applied Linear Algebra”, by Peter J. Olver and Chehrzad Shakiban Prentice-Hall, Upper Saddle River, N.J., 2005
 2. “Linear Algebra and Its Applications”, by Gilbert Strang
 3. “Applied Linear Algebra”, by Lorenzo Sadun
 4. “Matrix Mathematics”, by Daniel Bernstein
 5. Appendix on Matrix Theory in “An Introduction to Multivariate Statistical Analysis”, 3rd edition, by T.W. Anderson
 6. “Linear Algebra and its Applications”, by David C. Lay (This is the Math 221 book)
 7. “Matrix Computations”, by G. Golub and C.F. Van Loan
- Online Resources:** MIT’s OpenCourseWare project. Linear Algebra courses are numbered 18.06 and 18.07¹

¹<http://ocw.mit.edu/courses/mathematics/>

Prerequisites: Math 221, Math 251 and Math 301 or permission of instructor. **Note that you will be expected to do some proofs and we will discuss proofs a lot in class.**

Your Review: I will assume that by Tues Sept 6th you have reviewed the following sections from Meyer's book: 1.2, 1.3, 2.1-2.5, 3.2. The material is basically the same as that covered in Sections 1.1-1.8, 2.1-2.3 of Lay's book (the Math 221 text). We will use this review material extensively in our course, but I will not discuss it in class. I will assign homework on this material.

Material Covered: In class we will cover the following sections of Meyer's book: Chapters 3.2-3.7, 4.1-4.8, 5.3-5.6, 5.9, 5.11, 6.1, 6.2, 7.1-7.6, 5.10, 7.7, 7.8.

Office Hours: M 1:00-2:00, Tu 2:30-3:45 *and by appointment*. If you cannot come to my office hours *please* contact me in class or by email to set up a time to meet. Also, you are encouraged to ask me questions by email. I rarely check my phone messages.

Course Summary and Learning Goals

In this course we study some of the basic techniques from linear algebra that undergird the analysis and simulation of a large and diverse collection of applications in science and engineering. The equations used to model these applications typically involve many variables. Even when the underlying equations are nonlinear, solution techniques—both analytical and numerical—often involve exploiting the geometric and algebraic structure of linear transformations on finite dimensional vector spaces. Since every such linear transformation is given by matrix multiplication, this involves analyzing the structure of matrices.

The main themes of the course are: (1) Matrix algebra (akin to vector algebra in Multivariable calculus); (2) Linear transformations, focusing on the rank-and-nullity and change-of-basis theorems; (3) Linear transformations that preserve the inner product between vectors; (4) A careful development of the theory and meanings of determinants; (5) Eigensystems with a focus on the spectral theorem for normal matrices, functions of matrices and with applications to systems of ordinary differential equations; (6) Some general decomposition theorems for matrices; (7) Calculations involving block matrices.

The course is designed to serve the needs of incoming graduate students in Mathematics. The course material is widely used in pure and applied mathematics and statistics, and in applications fields. Applications include solutions of systems of linear ordinary differential equations, methods to solve large linear systems—and therefore linear and nonlinear partial differential equations—on a computer (see Math 630), multivariate probability and statistics,

signal and image processing, quantum mechanics, Hilbert space theory (see Math 611) and differential geometry (see Math 673).

Homework and exams will emphasize calculations for specific examples based on the theory discussed in class, as well as some more abstract proofs based on similar sorts of calculations to the ones performed in class. Exams will also test your understanding of definitions and theorems covered in class.

Students wishing to master the course material will be guided by the following **learning goals**.

1. Students will master the definitions, examples, calculations, theorems and proofs discussed in class and covered on homework.
2. Students will organize their understanding of the course material using the seven themes discussed above, and identify interconnections between them.
3. Students will become proficient at setting up and performing matrix algebra calculations to study the structure of matrices, and apply these techniques throughout the course.
4. Students will understand and be able to use the algebraic and geometric structures of special classes of matrices and linear transformations, including matrices that are square, diagonal, symmetric, block, orthogonal, unitary, diagonalizable, normal, positive definite, or in Jordan form.
5. Students will use the experience gained in this course to prepare them for higher level mathematics courses, for research, and for professional work involving mathematics. Specifically, they will learn how mathematics involves gaining mathematical and scientific knowledge by integrating concepts from a wide variety of subjects. For example, they will see how matrix analysis integrates ideas from linear algebra, calculus, the geometry of vectors and vector subspaces, differential equations, analysis and physics. In particular, students will learn to identify the abstract mathematical principles that are encoded into matrix analysis and which unite apparently disparate examples and applications.
6. Finally, students will be encouraged to develop an appreciation for the many applications of matrix analysis.

Academic Misconduct

I will not tolerate cheating in any form. All instances of cheating I discover will be reported to UMBC's academic integrity committee. (See <http://www.umbc.edu/integrity/>) In particular, in this course, giving or receiving aid on exams will result in a grade of zero for that

exam. Copying of homework solutions from other students in the class, from students who have previously taken this or an equivalent course, from a solutions manual, or from the web will be treated as a serious offense. At a minimum this will result in a grade of zero for that homework (which will not be counted as one of the two lowest homeworks I drop when calculating your overall homework grade). For flagrant cheating on homework I reserve the right to give a grade of zero for the homework on which the student was found to have cheated as well as on all homeworks that were turned in prior to the discovery of the offense. Also see comments below in the subsection on Homework.

Here is a summary of UMBC's official policy on academic misconduct, which I fully endorse:

By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the *UMBC Student Handbook*, the *Faculty Handbook*, or the UMBC Policies section of the *UMBC Directory*.

Grading

Grades: Homework 30%, Two Midterm Exams 20% each, Final 30%

Homework: The homework problems will be posted on the course web page for each day of class. Problems assigned on a Tuesday and Thursday will be due at the *start* of class the following **Thursday**. At least some of them will be graded. Make sure your homework paper is *stapled*. *No late homework will be accepted!* Your lowest two homework grades will be dropped. You may ask me questions about the homework and you may collaborate with another student in the class. In fact you are encouraged to do so! However the final write up is your own – *two (almost) identical solutions may both be given zero*. I do not encourage large groups of people to work together on homework. Do not miss class to complete a homework. *I will not accept homework that is handed in after the first few minutes of class.*

Midterm Exams: There will be two midterm exams.

- Midterm 1: Tuesday October 11th.
- Midterm 2: Tuesday November 8th.

Final Exam: **Tuesday December 20th, 3:30-5:30pm in MP012. The final will be based on the whole course.** Some questions may be more difficult than those on the midterms.

Make up exams: If you miss one of the midterms you *may* be given the chance to take a make up exam. To request a make up you should speak with me **no later than 48 hours after** the exam time. Generally speaking, you will be offered a make up if you are sick or if a close relative or friend is gravely injured/sick or dies. However I will listen to all reasonable requests. Be prepared to bring appropriate evidence in support of your request. There will be no make ups for the final exam.

How I assign final grades

For each exam I work out how many points I expect a student who has a solid understanding of the material to get. I tend to put the bottom B near this score. Then I work out where to place the bottom A,C,D using the grade distribution and by looking at individual exams. I also work out the bottom A,B,C,D for the homework, and project(s). Then I take an imaginary student who got the bottom B (say) for each component of the course and calculate their score. If your score is higher than the imaginary student's you get a B. If it is a little less than the imaginary student's score I look carefully at your work to decide whether you deserve a B or a C. Most importantly I look at your final exam. In particular, students on the borderline between two grades and who show mastery of the material on the final are more likely to receive the higher grade. *However, students who do very poorly on the final might find that their course grade is lower than they had expected!* In short I reward "strong finishers" who can show me they have a solid understanding of the entire course.

You can calculate your current overall grade from the cut-offs I will provide after each exam and project.

Study Tips

1. See the *Study Habits* survey of past students in my classes and the *Guidelines for Math/Stat Course Study Groups* information on my web page.
2. On the course web page I will post the sections that we will cover each day. **You are expected to read the section ahead of time**, so as to be familiar with the material.
3. It is very important to keep the main definitions, statements of theorems, and simpler examples on the forefront of your minds throughout the course, since we will refer back to them many times. You will need to digest the material several times to master it — before class, in class, reading through material after class, rederiving for yourself without any aid results discussed in class, and doing the assigned problems.
4. This is a fast paced course. Do not get behind. Do not miss class. Ask for help well before you are totally lost.

5. **Ask questions.** If you are dazed and confused your class mates will be too!
6. In class I call on people by name to answer questions mostly to help me find out whether you are understanding what's going on. **If you do not feel comfortable being called on in class, please come and talk with me.**
7. Come and talk with me in my office. Talk math with your fellow students, don't work in isolation.
8. Learn the art of taking good notes. My lectures will often present a somewhat complementary perspective on the subject to that in the textbook.
9. Do *all* the hwk problems. Work out what your mistakes are on the graded hwk and learn from them.

Advice for Homework

1. Never start your homework the day before it is due!!
2. Begin each hwk assignment *the same day* that we cover the material in class.
3. Write up your homework so that you'll easily understand it in a month's time when you're studying for the exam!
4. The only way to learn math is to do it: Struggle to solve problems for yourself.
5. However, if you get stuck on a problem for too long get help and get it before you waste too much time!! Here are some places you can go for help.
 - Carefully read your notes from lectures and the book (again!).
 - Draw a schematic picture to help you think about the problem.
 - Ask me for help by email or in person.
 - Ask a fellow class member – often two heads are better than one! **I encourage you to find a study partner for this class.** First attempt the hwk yourself, then discuss them with your study partner, and finally carefully write the solutions up in your own words.
 - Sleep on it. Some of my best ideas come when I wake up in the morning.
6. Some of the homework problems will be harder than others. Don't expect to solve them all on the first try!

Advice for Exams

Study in small groups for exams and learn from each other. Presenting material to someone else is often the best way to work out whether you really know it yourself.