Linear Algebra and Differential Equations
The Syllabus

January 15, 2009

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Book Peterson and Sochacki, *Linear Algebra and Differential Equations*.

Even though the catalog calls this course "Linear Algebra and Differential Equations", and even though our book uses exactly the same title, a better title for this semester would include a verb and (since Crannell is teaching the course) an extra noun as well:

> Linear Algebra illuminates fractals and differential equations.

The title would start with *Linear Algebra* because that subject is incredibly useful in mathematics and because Linear Algebra will inform everything we do in this course. The verb that follows tells us that Linear Algebra is a subject of action: we'll use words like "transform", "rotate", "translate", "span" to describe much of what the mathematics does. *Fractals* and *Differential Equations* are two subjects that are nearly completely different from each other. The former one joins the course so that we can have a little fun; the latter subject is vast and important: it informs much of how we have understood our universe during the past four or five centuries. The thread that connects these two disparate subjects of fractals and differential equations—or more properly, the foundation that undergirds them both—is Linear Algebra.

So what *is* Linear Algebra? It's a subject that describes many of the kinds of mathematics you have already studied. Real numbers, Complex numbers, vectors, functions, and many other collections of mathematical objects have an underlying linear structure, and Linear Algebra explains the structure that all these collections have in common. Even more, Linear Algebra tells us how we can manipulate and work with these structures in ways that helps us to use the same kind of solution

techniques on very different kinds of problems. Most colleges teach Linear Algebra as a course all by itself. That's how important it is.

Why do we combine this with other subjects, then? Linear Algebra is a powerful tool. If we're going to teach you about the hammer, we want to give you some nails to hit. The computational aspects of Linear Algebra—matrix multiplication, determinants, eigenvalues, inverse operations—are like teaching you about the parts of hammer, and fractals and differential equations are the nails and the two-by-fours.

The Structure of this Class
Because of the diverse goals of this course, there will be several kinds of activities that you will be expected to participate in. I will expect you to prepare for class and to participate in class discussions; to hand in various homeworks which you write excellently; to solve complicated problems and write your solutions up elegantly; and to demonstrate your knowledge of the material through examinations.

Grade Percentages
Your grade in this class will be determined along the following percentages:
15% Daily Homework
15% Weekly Homework (Wednesdays)
10% Fractal Project (March 13)
25% Midterm Exam (April 3)
30% Final Exam (scheduled by the Registrar)

You will notice that this sums to only 95%—that's the bad news. The good news is that you can get up to 15% additional points via extra-credit. I explain all of the activities we'll be doing in class in greater detail below.

Attendance
Please be advised that Math Department and F&M policy state that penalties (including grade reduction and/or dismissal from the course) may be assessed for excessive, unexcused absences. Please bring your textbooks and notes to class.

Homework
There are two types of activities: daily exercises to do on your own, and weekly problems to write up formally. I will assign most of your homework from the book (all of these are listed on a separate web page), and I will supplement the book exercises with occasional fractal problems that I will give you in class.

Your "Daily Homework" grade will be based on your willingness and ability to put to put solutions to the daily assignments on the board during the first 5 minutes of class (I will randomly assign students to problems). You may "pass" twice during the semester.

Your weekly homework will be due at the beginning of class on Wednesday of each week. You may, if you like, choose a classmate as a partner with whom to work on problems—if you do so, you should choose a person whose ability is comparable to yours. As a team, you are to submit one solution to each problem, and both members of the team will receive the same grade. On these

assignments, I will pay attention both to the mathematics and the exposition of the solution.

Student Fractal Presentations
On the second day of class, you will "adopt" a fractal. On the Friday before Spring Break, you will show me an IFS version of your fractal and present the answers to the following questions: How many affine transformations generate the fractal? What are the formulas for these transformations? What are the ratios of the areas of the images to the original object? Are there well-defined angles of rotation? What is the Hausdorff dimension of your fractal? Is there anything else that is interesting about your fractal?

Extra Credit Activities
You may earn extra credit in this class in three different ways: attending talks, giving a talk, or TEXing your homework.

Attending and writing a summary of a professional math talk.
(1% each time) You may do this up to 5 times for credit (that is, you may earn up to 5% extra credit points this way), but of course, you may attend as many talks as you like!

How, you ask, do you find a professional math talk? There are several ways. This semester, the department will interview candidates, and each one will give a talk that is open to students. We'd love to have you come (student feedback really helps us). There are other opportunities to see real mathematicians give real talks; see "Public Presentations" below.

Public Presentations
(5%) Two possibilities for giving a mathematical talk in a public venue are at conferences I'm planning to attend:

- the Moravian College Student Mathematics Conference, Saturday, February 21.
  Advantages: looks great on your resume, and you only embarrass yourself in front of strangers, get it over with quickly.
  Caution: The deadline for registering is very early in the semester. Stay tuned!
- the EPADEL MAA Conference, Saturday, March 28, at Gettysburg College.
  Advantages: looks great on your resume, and you only embarrass yourself in front of strangers.
  Disadvantages: This is an all-day event during a busy time of the semester.

Both of the above meetings are ways to see real live mathematicians in action. In addition, F&M and Millersville hold colloquium talks on Thursdays at 4:00.

Other venues for attending and giving talks might present themselves during the semester; please check with me to make sure that these venues are appropriate.

Submitting a homework assignment typeset (correctly) in TEX.
(1% each time) You may do this up to 5 times for credit (that is, you may earn up to 5% extra credit points this way), but of course, you may TeX up as many homeworks as you like!

To write something like $\int \frac{1}{1+x^2}\,dx$ or

$$T(\mathbf{x}) = \begin{pmatrix} 1 & \pi \\ 0 & \frac{1}{2} \end{pmatrix} \mathbf{x},$$

you either have to write it by hand, use Microsoft Equation Editor, or use a professional typesetting software. Serious mathematicians use software called "TEX". It takes a lot of work to set it up and learn it, but it makes for really beautiful looking papers! You can learn how to download the software at http://edisk.fandm.edu/michael.mccooey/TeXsetup.html

Dr. McCooey writes, "If students try it and anything is confusing, I'd like to hear about it so I can clarify things."