Information Sheet

Math 485 Section 1: Differential Geometry with Applications to General Relativity, Spring 2014, Professor Rebecca Field

MW 4:40–5:55pm, Roop G105

Required Text: *Differential Geometry and Its Applications*
Second edition by John Oprea
Exam dates: Friday, September 28 (Big Quiz)
Week of October 26 (Midterm)
Friday, November 30 (Big Quiz)

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Supplemental textbook with Mathematica aplets and many examples: *Curves and surfaces* by Matthias Weber available at http://php.indiana.edu/∼matweber/IU/Textbooks.html

Supplemental physics textbook for math majors: *Gravity: An Introduction to Einstein's General Relativity* by James B. Hartle.

Office Hours: Tuesday 5:00–6:00pm, Wednesday 6:00–7:00pm, Friday 12:00-1:00pm (subject to change), and by appointment. I am usually not available on Thursdays.
You can always make an appointment to see me!

GOALS: The goal of this offering of Math 485 is to provide an introduction to one of the main things that research mathematicians mean when they say Geometry and to motivate one of its nicest applications, General Relativity.

Pure mathematics both historically and currently can be broken into roughly three fields (with loads of overlap). These fields are Algebra, Analysis and Geometry. The high school curriculum sees these three fields (in a very limited sense) by way of algebra/algebra 2, calculus/precalculus, and geometry. However, as anyone who has taken math 430 knows, what mathematicians mean by Algebra is very different from the high school class (abstract algebra is a *generalization* of algebra and arithmetic). In contrast, analysis and calculus are relatively closely linked: essentially analysis is calculus with *all* of the details (your high school calculus teacher was sweeping elephants under the rug). As for geometry, what modern mathematicians mean when they say geometry is not even the same species as the high school version! They are connected under the loose heading of potentially being visual, and every once in a while, concepts from Euclidean or non-Euclidean geometry will be touched upon, but its probably better to think of the connection between classical geometry and modern geometry as historical rather than literal. Differential geometry really lies at the boarders of geometry and analysis (as opposed to, say Algebraic Geometry or Geometric Group Theory which both lie in the boarder of Geometry and Algebra - though in completely different ways).

When mathematicians say Geometry, *this class* is what they mean, not Math 475!

Differential geometry is the study of spaces that live inside $\mathbb{R}^n$. The most general version of this that we will be talking about is called a *manifold* which are subsets of $\mathbb{R}^n$ that are built out of pieces of $\mathbb{R}^m$ for $m < n$. Building all of this up rigorously will take some time, so we will run into smaller examples in the form of curves in $\mathbb{R}^3$ (which are built out of pieces of $\mathbb{R}^1$) sooner. We will be studying several aspects of such spaces, including how they are built, how they are curved and the idea of what is the version of a 'straight line' in such spaces (they are called *geodesics*). This last concept is especially important when we talk about General Relativity because objects in a gravational field travel along such curves in the four dimensional manifold of spacetime.

Ideally, this class will change the way you think about the world, so you need to give the class the time and energy it deserves.

ADVICE: Here is my most important piece of advise about this course: DO NOT FALL BEHIND!! This includes things like DO NOT MISS CLASS!! (If you must miss a class, get notes from one of your classmates *and read them* before the next class.) It also includes things like DO YOUR HOMEWORK!! It is not possible to actually learn this material without doing problems. You might be able to convince yourself you understand, but if you can't do problems, you aren't at the level of understanding required to pass the class. In fact, if the class seems too easy at any point, do extra problems!

Here is the secret to doing well in a hard math class (lecture style).

1. The night before class, read the next section of the book, take note of where you found the book confusing and make sure you understand those sections when they are covered in class (ask questions in class if you don't).
2. In the morning before class, re-read your notes from the previous class.
3. Either take notes in class (if you can think and write at the same time) or co-operate with someone who

takes notes. If you co-operate, copy the notes after class and review with your note-taking group. Non-note takers contribute what they learned by listening closely instead of writing.
4. Read through the notes *and* the relevant sections of the book after class to make sure it all made sense. If something isn't clear, ask about it at the start of the next class or in office hours.
5. Repeat.

SCHEDULE: There will be two Big Quizzes and a midterm along with the final and short self scheduled quizzes roughly weekly. There will also be weekly homework usually due on Fridays. I will also attempt to find an acceptable time to have a weekly "Problem Session" in case that is needed. The best way to get feedback on the homework is to go over it with me, either in class (if it is a problem many people had trouble with) or in my office. The quizzes will be your main source of weekly feedback.

GRADES: Your grade for this course will be determined by the midterms and large quiz (50% total), the final exam (30%), and by your written work (20%). This written work includes weekly quizzes and homework. Class participation is very important and will be counted with your written work.

THE EXAMS: Mark these dates and times on your calendar now. The midterm will take place during a two hour period on a mutually agreed upon time the week of ??????. If you have an unavoidable conflict with one of the exam dates, let me know *as soon as possible* to arrange a makeup exam. Except in cases of sudden emergency, I will not arrange a makeup exam unless I know at least a week in advance.

If you have any special needs, please see me in the first three weeks of the term.

HOMEWORK may be worked on in groups, but *must* be written up independently *in your own words*. Cooperation is encouraged and we may sometimes spend the last 20 minutes of the class divided into small groups to discuss the more difficult homework problems. Typically, I will assign homework weekly, and I will let you know at the time I assign written work when it is due.

WEEKLY PROBLEMS TIME will (hopefully) be on Tuesday, exact time TBA. This is a time I will be available, by request, at a campus coffee facility for group and individual discussion of homework problems. I highly recommend you attend as many of these as are scheduled, as well as work on the homework on your own *before* Tuesday.

TOPICS: I am planning on covering
1. The Geometry of Curves
2. Surfaces
3. Curvatures
4. Geodesics, Metrics and Isometries
5. A Glimpse at Higher Dimensions
6. General Relativity

ATTENDANCE and participation will be an important requirement of this course. If you must miss a class, be sure to get notes.

HONOR CODE: I take the honor code very seriously, and so should you. Any instances of suspected cheating or academic dishonesty will be referred to the JMU Honor Board for investigation.