Math 109: Calculus 1

Spring 2016

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class webpage:	`bit.ly/FandM2016`
class meetings:	11:00 AM–12:05 PM MWF in STA 105
office hours:	12:15 PM–1:15 PM MW in STA 231
textbook:	*Calculus, Concepts and Contexts 4E*, by James Stewart

Why Calculus?

For the purposes of this class, assume our universe runs on a computer with finite memory. One way this could work is for both space and time to be *discrete*; that is, there is a smallest possible distance Δd between any two objects and there is a smallest unit of time Δt. Let's work with a simple model where the universe is broken up into little cubes with side length Δd. Objects (or parts of objects) must be located within some cube, there is no in between and in one time step an object can only move to an adjacent cube.

Ok, so that's our universe. Say you throw a rock straight up and want to know when it will come back down so you can look up from your phone and catch it. If you threw the rock up with speed v (in units of Δd per Δt) and gravity increases its downward speed at a rate of a (in units of Δd per Δt per Δt), then with a little work we can compute the equation for its height above the ground at time t as:

$$h(t) = vt - \frac{a}{2}t^2 + \frac{a}{2}t\Delta t.$$

Setting $h(t)$ to whatever height you want to catch the rock at and solving for t will give you your answer. But your answer will contain Δt. There are a few of problems with this:

1. we don't know the value of Δt,
2. if we want to compute more complicated things like planetary orbits and rocket trajectories, these extra terms with Δt will proliferate making a giant complicated mess,
3. often the mess in (2) will lead to equations that we cannot solve exactly.

But, we really want a usable way to compute rocket trajectories, so what can we do? Well, fortunately we appear to live in a universe where Δt is very small, so we can get very accurate approximations by replacing all Δt's with some small value like a nanosecond. That solves problem (1). To solve problems (2) and (3), we need to completely get rid of the Δt terms. In the 17th century, this problem was solved by the inventors of Calculus by using *infinitesimals* which are new numbers that are bigger than zero but smaller than every positive real number. While these seemed to work, they were not completely understood which led to mistakes in their application. It wasn't until the 20th century that mathematicians gave a complete account of infinitesimals. In the intervening years the concept of a *limit* was introduced to replace the use of infinitesimals in getting rid of the Δt terms. Using limits we get an approximation to our function h that solves (2) and (3):

$$h(t) = vt - \frac{a}{2}t^2 + \frac{a}{2}t\Delta t \approx vt - \frac{a}{2}t^2.$$

In effect, we have taken Δt down to zero and we are modeling our discrete universe by a *continuous* universe. Calculus is the collection of tools we need to work with these continuous models.

Homework

I can only show you the door. You're the one that has to walk through it.

To achieve fluency in this subject, you will need to immerse yourself in the material. Working tons of problems is a great way to do this. How many problems? My recommendation is to work problems of a given type until they become easy for you.

I will put a list of practice problems for each class period on the class webpage. To encourage you to make working problems a regular activity, you will need to maintain a journal containing your practice work. These journals will be turned in periodically for inspection. There are many ways you could structure such a journal, we will go over some basic guidelines in class.

Each Thursday, I will select a couple of the more interesting problems and assign them—due the following Thursday. These will be graded both for correctness and clarity of exposition.

Quizzes

Pop quiz, hotshot.

There will be tiny quizzes at random times throughout the course. I will set the random number generator so that the expected number of quizzes is 10. Quizzes are intended to reinforce basic concepts as well as encourage attendance. Unlike exams, quizzes will be closed-book. Your lowest quiz score will be dropped.

Computing devices

We will be doing a lot of estimation, so you will need a graphing calculator. This should be a separate device from your phone/tablet since you will not be allowed to use any device on exams that is capable of wireless communication.

Exams

There will be two in-class exams and then a final exam during finals week. The purpose of the exams is to test your understanding of, and ability to reason about, the mathematical concepts. Since you can use your textbook as well as any other written material, no memorization is required; however, these exams occur in a finite time period, so rapid recall of facts will serve you well.

Graded work breakdown

what	%	when
journal	10	TBA
graded homework	10	weekly
quizzes	10	random times
in-class exam #1	15	Wednesday, February 10$^{\text{th}}$
in-class exam #2	25	Wednesday, March 9$^{\text{th}}$
final exam	30	TBA, in finals week

Help

If you need help or just want to know more about something, please come to my scheduled office hours or set up another time to meet. In addition to my office hours, there are several undergraduate mathematics teaching assistants who hold regular hours.

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.

Tentative Schedule

Monday	Wednesday	Friday
Jan 11th	13th **1** introduction	15th **2** 1.1, 1.2, 1.3 review
18th **3** 2.1 tangents and velocity	20th **4** 2.2 limits	22nd **5** 2.3 limit laws
25th **6** 2.4 continuity	27th **7** 2.5 infinite limits	29th **8** 2.6 rates of change
Feb 1st **9** 2.7 derivatives	3rd **10** 2.8 what does the derivative tell us?	5th **11** exam #1 review
8th **12** exam #1 review	10th **13** **in-class exam #1**	12th **14** 3.1 derivatives of polynomials
15th **15** 3.2 product and quotient rule	17th **16** Taylor series, imaginary numbers, and magic	19th **17** 1.5, 3.1 derivatives of exponentials
22nd **18** 3.3, Appendix C derivatives of trig functions	24th **19** 3.4 chain rule	26th **20** 3.5 implicit differentiation
29th **21** 1.6, 3.6 derivatives of inverse trig functions	Mar 2nd **22** 3.7 derivatives of logarithms	4th **23** exam #2 review
7th **24** exam #2 review	9th **25** **in-class exam #2**	11th Spring Break
14th Spring Break	16th Spring Break	18th Spring Break
21st **26** 4.2, 4.3 max and min values	23rd **27** 4.2, 4.3 max and min values	25th **28** 4.2, 4.3 max and min values

Monday	Wednesday	Friday
28th **29** 4.6 optimization	30th **30** 4.6 optimization	Apr 1st **31** automatic differentiation
4th **32** 4.8 antiderivatives	6th **33** 5.1 areas and distances	8th **34** 5.2 definite integrals
11th **35** 5.2 definite integrals	13th **36** 5.3 evaluating definite integrals	15th **37** 5.3 evaluating definite integrals
18th **38** final exam review	20th **39** final exam review	22nd Reading Day
25th Reading Day	27th Final Exam Week	29th Final Exam Week