Student Project

Math 133 - Section 201

June 27, 2019

In order to give you an opportunity to learn about something mathematical that you find interesting, I've included a project as part of your grade for this class. If you really enjoy something that's somewhat mathematical, or you can find a way to connect something you really enjoy to something mathematical, then this project is an opportunity for you to geek out over that thing, and do some critical thinking using math while doing it.

Each student will submit a proposal for a project, and the follow through on the project. Since it will look different for each student, the description on this page is going to be somewhat vague. However, every project has to include the following elements.

1. A first draft proposal, submitted via printed document or email.
2. A revised/2nd draft proposal, refined after feedback on first draft.
3. Final submitted project. Almost certainly this will involve a cleanly handwritten or typed document. If you would rather present something during class, we can discuss that as an option as well.
4. Included in the final project, a description of sources consulted, in lieu of a bibliography. Summarize the sources you consulted, and what you learned from each. About 2-3 sentences per source is enough.

A project can include other elements too. For example, the submitted project may require more than just text. It might involve some mathematical equations or problem solving, or graphs of functions or other mathematical drawings.

Proposal

The first draft of the proposal should be a typed document, at least three paragraphs, but definitely shorter than a page. The writing style can be casual, but punctuation and capitalization are still expected.

The proposal should include several questions which you would like to learn more about. The proposal should mention and describe at least two sources where you plan to get information from. Examples of reasonable sources include:

1. The textbook (if you include this, be specific about which chapters)
2. Reputable websites. Wikipedia is a very reputable source for most mathematical topics.
3. Mathematical magazines, library books, etc.

In order to have an idea about how reasonable your project is, you will probably need to do some skimming of your proposed sources, to have an idea of what there is to learn. After you submit your proposals, I will give feedback. Depending on the type of feedback, you may or may not need to submit a second draft of your proposal.

Ideas for projects

1. Write up a proof of some theorem from the textbook. Example theorems include
   - $e = \lim_{n\to\infty} \left(1 + \frac{1}{n}\right)^n$
   - Divergence of the harmonic series
   - L'hospital's rule
2. A "Project" page from the textbook.
3. Exploring a topic, such as
   - One-to-one and onto functions
   - The game of Nim
   - Imaginary numbers
   - Partial fractions
   - Something in probability
   - Predator-prey differential equation
   - The Fibonnaci sequence
   - A mathematical question related to a board game or video game
4. Learn to use some Latex and write up some notes or example problems from class.
5. Exploring a connection between math and another subject, such as economics or biology.

Example proposal 1

I'm curious about how computers and calculators compute things like trigonometric functions and logarithms. They can't just have a massive table stored inside them, and look things up. That would just take up too much space. At the same time, all calculators can really do is addition, at some level. I can see how they'd get multiplication out of that, and also exponential functions. But you can't write something like $\sin\left(\frac{\pi}{5}\right)$ in terms of just addition, right?

After doing a little bit of reading about this, apparently what calculators do is use something called "Taylor series" to approximate trigonometric functions. If that's right, then why don't we just learn about those Taylor series instead of trig functions? Maybe they're pretty complicated. Also, why would they have to approximate? Why can't they just compute it exactly?

To learn more about this, I play to read sections 11.8, 11.9, and 11.10 of the textbook, and the webpage `https://www.homeschoolmath.net/teaching/sine_calculator.php`. My final project will mostly consist of a written paper.

Example proposal 2

I want to learn more about the connections between math and music, especially how scales might be described using math. I've played cello since I was young, and always enjoyed the analytical aspects of music. Is it possible to describe musical pitch using mathematics? Is it possible to describe the relationship between notes in a musical scale, or in a chord, using mathematics? Does mathematics say anything about how or why particular combinations of notes sound good together? I'd really like to better understand why particular pairs of notes sound good together, and perhaps math is one way to understand that.

I know that when you shorten the length of a vibrating string, you get a higher pitched note. This is how stringed instruments like the cello change pitch, and how pianos makes differently pitched notes. The difference is that on a piano, the strings don't change lengths, but there are just a lot of different strings of different lengths. What is the mathematical relationship between shortening the length of a vibrating string, and the change in pitch? I know that when you cut the length of the string in half, you get a note which is one octave higher. What has to happen to make a perfect fifth?

To learn more about this, I plan to read the New York Times article, "Math and Music: The Deeper Links" available at `https://www.nytimes.com/1982/08/29/arts/math-and-music-the-deeper-links.html`, and the Wikipedia pages titled "Scale (Music)" and "Music and mathematics." I also plan to watch the videos availble on the American Mathematical Society society webpage `http://www.ams.org/publicoutreach/math-and-music`. My final project will mostly consist of a written paper.

Example proposal 3

I found it really interesting when we learned about solids of revolution in class, so for my project I will do the "discovery project" on page 575 of the textbook. The topic is rotating regions about slant lines, which are lines not parallel to the axes. This seems like it would be a lot harder than rotating something around one of the axes, or a line parallel to one of the axes. What variable do you even integrate with respect to?

The main part of my submitted project will be neatly handwritten solutions to the problems on page 576 of the textbook. The main source will be pages 575 and 576 in the textbook, but also the rest of sections 5.2, 5.3 and 8.2 of the textbook. I will also need a computer algebra system for some steps, so I will use WolframAlpha when necessary. I will probably have to meet with the professor a few times to figure things out when I get suck.

If there is an opportunity, I would be willing to present my part or all of my solutions in class instead of submitted a written project. This would involve me presenting for about 30 minutes.

Example proposal 4

I really love games, so I want to learn more about the game of mathematical game of Nim. To learn about it, I plan to try playing against the computer a lot at this website, `https://www.goobix.com/games/nim/`, and see if I can get better just by playing. Then if I just keep losing, I'll try and find some other websites to learn better strategy.

Once I get better, I'll try to understand the strategy enough to describe how to play well. For my project, I plan to submit a short write up of the rules of Nim, how to play, and what the good strategies are, but for the main part of my project, I want to spend some time teaching the rest of the class how to play Nim. This would probably take about 30-45 minutes of class time. I would teach everyone how to play, then let everyone try a game. Then I would talk about how to mathematicall model the game, and play a strategy which wins more, or maybe even every time.