Mathematics 89S: The Magic of Numbers

Fall 2016 Wednesdays, Fridays 3:05–4:20pm Physics building 205

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Course web site: All important information (homework, handouts, etc.) will be posted on Sakai, http://sakai.duke.edu/. There is also a rudimentary web site at www.math.duke.edu/~ng/math89S/, but I don't expect to use this except as a placeholder.

Textbook: *The Magic of Numbers* by B. Gross and J. Harris (Pearson Prentice Hall, 2004). This is the official required text for the course. The book is **out of print**, but you can buy a coursepack version of the book at the Duke Textbook Store; there are also used copies floating around online.

Office hours: TBA, and by appointment (please e-mail me for appointments, and it's best if you give me a reasonable amount of advanced warning).

Course synopsis: This course will explore some of the intriguing and beautiful mathematics that underlies the arts, technology, and everyday life. No technical background is required beyond standard high school algebra and geometry; instead, we will emphasize how to discover and analyze patterns using mathematical reasoning.

We will explore a selection of elegant and accessible subjects that will expose us to a broad variety of mathematical disciplines, from combinatorics (the mathematics of counting) to geometry (the mathematics of shapes) to number theory (the mathematics of whole numbers). We'll see how the golden ratio and a number sequence called the Fibonacci numbers appear throughout nature, music, and other "non-mathematical" areas; how games of chance can be understood through probability and some simple counting arguments; how the ancient Greeks found order and symmetry in three-dimensional shapes; and how factoring whole numbers leads to "unbreakable" codes like the ones that underlie internet security. Emphasis will be placed on appreciating ways in which mathematical patterns can be applied to society and the natural world.

Please note that this is a rigorous mathematics course, and you will be graded partly on your ability to understand and craft precise mathematical arguments. Although we won't assume familiarity with calculus or other advanced methods, an advanced mathematical background may be helpful, not directly for the material you may have learned in calculus, etc., but indirectly for past exposure to mathematical lines of reasoning.

Assignments: There will be weekly homework sets due on Fridays, as well as two midterm exams. You are allowed and encouraged to work with fellow students on the homework; however, each student must write up their problem sets on their own.

As the culmination of this course, each of you will research a topic that builds on one of the subjects covered in the class, specifically exploring the mathematics underlying some aspect of nature, technology, or everyday life. This topic will be chosen in consultation with me. You will write a 10–15 page paper on your research topic and give an in-class presentation.

Your grade will be based on a weighted average of your grades in the various graded components: homework 15%, each midterm 25%, final project 35%.

Prerequisites: No precise prerequisites. You should be interested in, and willing to learn, mathematical methods of analytical thinking.

Topics to be covered: Here is a tentative list of topics, time permitting. Note that some of these are not in the text, so it's important that you keep up with the lectures. I'm also happy to take requests for topics (within reason).

- Number patterns and sequences; the Fibonacci numbers and the golden ratio in nature
- Counting problems: how to count things in a systematic way
- Probability and games of change; how likely is it that two people in a room share the same birthday?
- Modular arithmetic and prime numbers, and applications to technology, communications codes, and cryptography
- Math in music: rhythms, tones/scales
- Platonic solids and the math of shapes