Thinking and Problem Solving: Math in the Real World

Chloe Urbanski Wawrzyniak
ceu11@math.rutgers.edu

Course Description

In this course, students will develop their problem-solving skills by working through a few of the many applications of Mathematics in the real world. Topics include

- Graph Theory
- Combinatorics and Probability
- Biology
- Game Theory
- Finance
- Cryptography

For a more detailed breakdown of the topics and schedule, see below.

Presentations

Students will choose an application of Mathematics which is either not discussed in the course or is only briefly mentioned to present about to their classmates. Examples include Alpha Go and other automated game-playing machines, map-making, error-correcting codes, special effects in movies, and data compression. No two students may present the same topic. Students will receive a list of possible topics to choose from but may choose a topic not on the list with approval from the instructor. More details on this assignment are provided in a second document.

Other Homework

Students will be assigned homework each night. Their solutions are to be handed in at the start of the next day's morning session. On some days, the homework will entail practice of that day's topics. On some days, however, the homework will be preparation for the next day's topics. Therefore, it is imperative that students complete the homework on time. If not, you will not be prepared for the next topic and will have difficulty getting the full benefit from the planned activities.

There is no assigned textbook for this course, so any assignments or notes will be provided by the instructor to the students. In most cases, the instructor will provide the students will printed copies. Students may also find all material posted to the instructor's website: http://www.math.rutgers.edu/~ceu11

Museum of Mathematics

In the afternoon of Thursday, July 26, we will be taking a field trip to the Museum of Mathematics in New York City. More details will be provided separately.

Schedule

Day	Morning	Afternoon
1 7/17	**Graph Theory: Paths** • Ice Breaker • Seven Bridges of Königsberg • What is a graph	**Graph Theory: Proofs** • Induction • Parity and Cycles • Classification of Eulerian Circuits
2 7/18	**Graph Theory: Spanning Trees** • Algorithms for finding minimizing spanning trees • Applications to Utilities Companies	**Graph Theory: Spanning Tree Algorithms** • Traveling Salesman Problem
3 7/19	**Graph Theory: Matrices** • What is a matrix • Matrix arithmetic • Transition Matrices	**Graph Theory: Markov Chains** • Passing Beans Game • Markov Chains as a Matrix
4 7/20	**Graph Theory: Matching and Bipartite Graphs** • Matching Algorithms • Bipartite Graphs	**Graph Theory: Matching, and Matrices** • Matching algorithms on weighted graphs • Matrix interpretation
5 7/23	**Combinatorics: Counting Methods** • Combinations • Permutations	**Combinatorics: Counting Methods** • Binomial Coefficients • Pascal's Triangle
6 7/24	**Probability: Introduction** • Equally likely events • Discrete Probability Distributions • Discrete Random Variables	**Probability: Expected Value** • Venn Diagrams • Expected Value • Law of Large Numbers
7 7/25	**Probability: Conditional Probability and Independent Events** • Conditional Probability • Bayes Theorem • Independent Events	**Probability: Applications** • Games • False Positives • Monty Hall • The Birthday Problem
8 7/26	**Computer Lab Day** • Working on Presentations	**MoMath**
9 7/27	**Biology: Population Growth** • Exponential Growth • Carrying Capacity • Logistic Growth	**Biology: Shapes of Nature** • Surface Area to Volume Ratios • Fractals in Nature
10 7/30	**Finance: Stocks and Investments** • What's My Interest? Activity	**Finance: Loans** • Amortization tables in Excel Note: This class will be in a computer lab
11 7/31	**Game Theory: Introduction** • Midday Lecture Series (Ayas) 11:10-12 • Debrief lecture	**Game Theory: Nash Equilibrium** • Finding Nash Equilibrium • Prisoner's Dilemma
12 8/1	**Cryptography: Basic Cyphers** • Transposition Cyphers • Substitution Cyphers	**Number Theory: Introduction** • Modular Arithmetic • Fast Modular Exponentiation
13 8/2	**Number Theory: Introduction** • Review Fast Modular Exponentiation • Totient Function	**Cryptography: RSA and Public Key Encryption** • Sending Messages using Public Key Encryption
14 8/3	**Presentations**	**Presentations**