

**Program**  
**2014 Governor's Institute in Mathematical Sciences**  
**June 22 - 27, 2014**

Descriptions of the class sessions for this year's Institute:

**Chaos, Fractals, and the Mathematics of Prediction**

"Chaotic" is a term used to describe mathematical behavior that appears random, but may in fact be produced by a very simple equation. The "butterfly effect," whereby a butterfly flaps its wings in Brazil and causes a tornado in Texas two weeks later, is a metaphor for the implications of chaos in the Earth's atmosphere. This course will introduce students to the difficulties associated with modeling chaotic physical phenomena using bifurcation diagrams and fractals, drawing upon examples from the fields of astronomy, biology, physics, and atmospheric science. This course is taught by Chris Danforth of the UVM Mathematics Department.

**Geometry and the Shape of Space**

We are three-dimensional people, living in a three-dimensional universe. Have you ever thought about what the shape of the universe is? Does it go on forever, or does it somehow curve back on itself? To make this easier to visualize, imagine you are a flat, two-dimensional person living in a two-dimensional universe. The analogous question would be: do you live on a plane that goes on forever and ever, or does your universe wrap back around on itself, like a sphere or a doughnut shape? Geometers study two- and three-dimensional shapes like these. In our time together, we'll learn some tricks for representing two-dimensional shapes and then use these tricks to begin to understand some possible shapes for our three-dimensional universe. This class is taught by Emily Proctor of the Middlebury College Department of Mathematics.

**Evolutionary Robotics**

Building a robot is hard work: it requires an understanding of physics, biology, math, mechanical and electrical engineering, and computer science. So rather than build a robot by hand, could we get a computer to build a robot for us? In this course we explore how we can use computer programs known as 'evolutionary algorithms' to create and compete virtual robots against one another, much like in Will Wright's 'Spore' computer game. Along the way, we'll learn much about biological evolution, computer simulation, and robotics. This class is taught by Josh Bongard of the UVM Computer Science Department.

**Estimating the Circumference of the Earth – Following in the Shadow of Eratosthenes**

The goal of this activity is to recreate to a certain degree the remarkable estimate of the circumference of the earth done by the Greek mathematician Eratosthenes over two millennia ago. Using the length of the sun's shadow at high noon ("sun transit") at two locations, groups will estimate the "sun" angle (the angle between the sun's rays and a vertical stick) at these two locations. Knowing the "sun" angle at two different locations will allow us to estimate the circumference of the earth. This class is taught by George Ashline of the St. Michael's College Mathematics Department.

**Unsolved**

Solving math problems is hard. Sometimes even the experts can't solve them. In this talk I'll introduce three simple, beautiful mathematics problems that are easy to state but which remain unsolved. Maybe someone in the audience will be the first to figure one of them out. This class is taught by Greg Warrington of the UVM Department of Mathematics & Statistics.

## **Synthetic Biology**

Did you know you can buy DNA on the internet? Scientists have used this synthetic DNA to build entire organisms. It can also be used to make simple “gene regulatory networks” that mimic systems that exist in nature. This talk will discuss recent advances in synthetic biology and what they mean for the future of biotechnology. This class is taught by Mary Dunlop of the UVM School of Engineering and Computer Science Department.

## **Sundials**

A whirlwind tour of the world of sundials: history, explanation, and demonstrations, many handmade by the speaker. This course is taught by Bill Gottesman of Precision Sundials, of Burlington, Vermont.

## **Where Have You Gone, Joe DiMaggio? Probability and Hitting Streaks**

In 1941, Joe DiMaggio reached safely by base hit in 56 consecutive games. This is the longest hitting streak in Major League Baseball history. In this talk, the different ways to estimate the probability of observing such a streak will be investigated. This class is taught by Phil Yates of the St. Michael's College Department of Mathematics.

## **How to Beat Your Friends at the Dots-and-Boxes Game**

One famous mathematician claims that the game Dots-and-Boxes is the "mathematically richest popular child's game in the world, by a substantial margin." We'll try to justify this statement and increase your game-playing ability. This class is taught by John Schmitt of the Middlebury College Department of Mathematics.

## **Filtering Out Spam with a Bayesian Classifier**

Everyone is familiar with email spam. It is easy to recognize when you see it, but comes in a variety of forms. Developing algorithms to effectively recognize spam and filter it out is an ongoing research area because spammers continually look for ways to evade existing software. This so-called "arms race" between spammers and anti-spam filter developers is not unlike the escape mutations used by viruses to evade the human immune response. We will look at how conditional probability and Bayes' rule can be used to develop a naive Bayesian classifier for email spam filtering. This class is taught by Richard Single of the UVM Department of Mathematics & Statistics.

## **To Be Announced!**

This mysterious class is taught by Jeff Dinitz of the UVM Department of Mathematics & Statistics.

## **Problem Solving Strategies**

This session is taught by Felix Wu, Senior at Harvard, and GIV Math Alumnus.