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Carleton College
Northfield, MN 55057

The newsletter for the Carleton mathematics and statistics community

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## What's the Math and Stats Department Teaching Spring Term?

Have you checked your regestration time yet? Made a list of classes you're hoping to take next term? Let the course descriptions below guide you into an adventurous new term with the Carleton Department of Mathematics and Statistics! There's something for everyone, from applied regression to number theory.

## Stats Classes

**Stat 220:** Introduction to Data Science

**Instructor:** Deepak Bastola

**Time:** 4a

**Prerequisites:** Stat 120, and Stat 230 or 250

Are you passionate about uncovering the stories hidden in data? This course is for you! We will explore the computational side of data analysis and learn how to use powerful tools to make sense of unstructured and messy data. You'll learn how to clean, process, and visualize data with date, time, or geolocation variables, text processing, and regular expressions, as well as web scraping. We'll also cover modern classification and predictive models, and how to effectively communicate statistical results. We'll use the statistical software R to bring your data to life and tell its story. Don't miss out on this exciting journey – join us and unlock the power of data!

**Stat 230:** Applied Regression Analysis

**Instructor:** Laura Chihara

**Time:** 3a

**Prerequisites:** Stat 120 (AP Statistics 4/5) or Stat 250

On the night of January 27, 1986, engineers at Morton Thiokol teleconference with engineers and managers at the Marshall Space Flight Center and Kennedy Space Center to determine whether it was too cold (31 F) to launch the space shuttle Challenger. Data from previous flights seemed to suggest that temperature had an effect on the integrity of the O-rin seals on the booster rockets, but the final recommendation was to launch the Challenger on schedule. Could a statistical analysis of the preaccident data predicted the catastrophic failure of the shuttle? In this class, we will investigate the Challenger data and in general, learn statistical model building and model checking techniques. We will use the software package R to aid in the modeling.

**Stat 250:** Introduction to Statistical Inference

**Instructor:** Andy Poppick

**Time:** 4a

**Prerequisites:** Math 240

Statistics is the discipline concerned with how data are used to make inferences about populations or processes exhibiting variability, and how to quantify uncertainty in those inferences. In this course, we develop tools to evaluate what we know and don't know about the observed world. We will introduce some of the theory behind inferential methods, using the language of probability, and we'll also learn to apply these methods in realistic settings. An additional emphasis will be placed on computational tools for data analysis, using R.

**Stat 310:** Spatial Statistics

**Instructor:** Claire Kelling

**Time:** 5a

**Prerequisites:** Stat 230 and Stat 250

Spatial data is becoming increasingly available in a wide range of disciplines, including social sciences such as political science and criminology, as well as natural sciences such as geosciences and ecology. This course will introduce methods for exploring and analyzing spatial data. We will cover statistical methods and computational techniques in R. Students will work on a significant class research project, locating their own spatial dataset and developing original analyses and writing a research paper. These projects have proven to provide influential results in public policy, public health, and in environmental applications. Feel free to contact Claire Kelling with any questions.

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# Math Classes

**Math 236**: Mathematical Structures

**Instructor:** Claudio Gómez-Gonzáles, Sunrose Shrestha

**Times:** 3a, 4a

**Prerequisites:** Math 232, and Math 210 or Math 211, or instructor permission

As mathematicians, how do we know what we know? You may have seen examples of proofs, but this class is meant to explore their nature as epistemic devices. In other words, you'll be learning how to communicate in the style of professional mathematicians! Along the way, we'll cover concepts including set theory, formal logic, different "sizes" of infinity, and the fundamental nature of different number systems. We'll look at statements that we've taken for granted in previous classes (e.g. the square root of 2 is irrational, there are infinitely many primes, the intermediate value theorem, etc.) and work out robust frameworks that allow us to write convincing proofs of them. We will find comfort in definitions and push ourselves by formalizing intuitions, then bring to bear these powerful frameworks on concepts new and old.

Because of its focus on communicating ideas, you should expect to do a lot of writing and revisions in this class; on the other hand, expect to do less calculating than you are used to in math contexts. Ultimately, this course is a lot of fun and should challenge you to think about mathematics in new ways. Plus, Structures is a prerequisite for many of our upper-level math courses!

**Math 241:** Ordinary Differential Equations

**Instructor:** Rob Thompson

**Time:** 5a

**Prerequisites:** Math 232 or instructor permission

Differential equations are a fundamental language used by mathematicians, scientists and engineers to understand and describe processes involving continuous change. In this course we will study differential equations from both a practical and theoretical point of view. Our focus will be on developing differential equation models from natural laws and exploring the mathematical ideas that arise within these models.

We'll study examples like mechanical vibrations, lasers, insect outbreaks, competition and cooperation of species, language coexistence, superconducting circuits, and much more! The science will stay at an elementary level; our focus will be the mathematical ideas that arise in these models. Feel free to contact Rob (rthompson) with any questions!

**Math 261:** Functions of a Complex Variable

**Instructor:** Paul Zorn

**Time:** 4a

**Prerequisites:** Math 210 or 211

Introductory calculus is about real-valued functions (polynomial, trigonometric, and exponential functions are favorites) of real variables. We study such functions through by-now familiar lenses, like limits, derivatives, differential equations, integrals, and power series. Ordinary graphs of these functions are usually curves, sometimes wiggly, in a two-dimensional plane; these curves' shapes and behavior nicely reflect analytic properties of the functions.

Complex analysis is essentially the calculus of complex-valued functions of complex variables, including surprising analogues of all your old calculus friends. How do familiar calculus objects---limits, derivatives, integrals, series, etc.---look and behave in this new setting? What do graphs or plots of complex functions even look like? How can technology aid visualization? Math 261 considers such questions. Some answers are surprising: Scary name notwithstanding, complex functions often behave better, not worse, than their real cousins.

**Math 331:** Real Analysis II

**Instructor:** Rafe Jones

**Time:** 5a

**Prerequisites:** Math 321 or instructor permission

What happens when the power and depth of real analysis collide with the broad reach of linear algebra? You get the field of functional analysis, which in addition to its mathematical beauty has major applications to partial differential equations and other areas of mathematics. We will build a theory of special kinds of infinite-dimensional vector spaces, whose elements are typically functions. In such large vector spaces we must consider what happens when we take an infinite linear combination of elements, and that's where the analysis comes in — we have to tackle questions of convergence, completeness, and compactness. We must also answer questions about what the appropriate generalizations are of bases and linear transformations, and when we have some kind of "nice" collection of eigenvalues for a linear transformation. We'll use these ideas to construct tons of solutions to any of an entire family of classic partial differential equations.

The course will cover Banach spaces (complete normed vector spaces), Hilbert spaces (complete normed vector spaces whose norm comes from an inner product), and applications. Students will do a final project involving an oral presentation. If there is a possibility that you are headed for graduate school in mathematics or a related field, this course comes highly recommended. Open to students who have previously taken Math 331 when it focused on measure theory and Lebesgue integration, but no knowledge of those topics is assumed.

**Math 341:** Partial Differential Equations

**Instructor:** Joseph Johnson

**Time:** 3a

**Prerequisites:** Math 241 or instructor permission

Ordinary differential equations are useful to understand and describe processes involving continuous change in response to one factor, usually time. The one issue is that sometimes the system changes in response to many factors (e.g. heat in a room varies in time AND space). Partial differential equations gives us the ability to examine systems whose change is due to multiple variables. Our focus will be on analyzing a handful of quintessential partial differential equations and putting forth various solution methods for these archetypal equations. The equations that we study in this course can be used to model heat conduction, propagation of sound waves, traffic flow, and more! The science will stay at an elementary level, only motivating the development of the equation in question.

**Math 342:** Abstract Algebra

**Instructor:** MurphyKate Montee

**Time:** 2a

**Prerequisites:** Mathematics 236 or instructor permission

Algebra is a pillar of modern mathematics concerned, broadly, with the study of structure and symmetry. As such, algebraic problems arise across mathematics, the physical sciences, art, and everyday labor: from particle physics to quantum chemistry to textile production. In this course, we will start by studying symmetries to gain a deeper understanding of polynomials, permutations, matrices, polygons, and more. Along the way we'll see how a few simple assumptions can give rise to a remarkably rich theory and a zoo of fascinating structures, including groups, rings, and fields. While all of this sounds pretty abstract, the systems and theorems developed in this course will appear throughout mathematics; once you start seeing groups, they're everywhere!

**Math 395:** Introduction to Analytic Number Theory

**Instructor:** Caroline Turnage-Butterbaugh

**Time:** 4-5c

**Prerequisites:** Math 282 or Math 342 or instructor permission

Euclid proved that there are infinitely many primes. If N is a large number, how many primes are there less than or equal to N? Can we describe this count asymptotically, as N grows arbitrarily large? The theorem that describes this behavior, the Prime Number Theorem, was eventually proved in 1896 using techniques from complex analysis. Well before this proof (and without using complex analytic techniques) much progress was made towards this endeavor. In this class, we'll explore tools and techniques which are analytic in nature to solve problems related to the integers and, more specifically, the primes. Without any experience in (real or complex) analysis assumed, we will prove results towards the Prime Number Theorem and culminate the course in a proof of Dirichlet's Theorem on Primes in Arithmetic Progressions.

This course is open to students who have taken Math 282 (Elementary Theory of Numbers) or Math 342 (Abstract Algebra I); contact me if you are interested in the course but have not taken either of these courses. If you have taken more advanced courses (such as real analysis, complex analysis, Galois theory, and/or representation theory), you will have the opportunity to apply such experience via personalized final projects.

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## Comps Talks

Come support your classmates and friends at their comps talks next week! Independent comps talks will take place in **CMC 206 on Tuesday, February 21**. Take a look at what they'll be speaking about below, then be sure to stop by and support them while they show what they've learned; you're likely to learn a thing or two as well!

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## Tuesday, February 21 - CMC 206

**Title:** Manus's Freiheitsatz: A Lively Introduction to Combinatorial Group Theory

**Speaker:** Bowen Li

**Time:** 3:30-4pm

**Abstract:** In mathematics, we often study the structures of objects. While we often prefer objects with "more" structures, we sometimes want objects with "lesser" structures such as free groups. Manus's Freiheitsatz (freedom theorem) tells us certain subgroups of one-relator subgroups are free. Although the theorem itself is illuminating, the proof technique is even more surprising; When Magnus presented this proof to Dehn, he replied "Da sind Sie also blind gegangen (So you proceeded with a blindfold over your eyes)." The proof idea then becomes one of the fundamental ideas in the development of Combinatorial Group Theory. At the end of the presentation, I will shed light on how Manus's Freiheitsatz relates to the famous "Solvable Word Problem."

**Title:** The Effect of Elevated Carbon Dioxide Levels on Plant Mass: A Meta-Analysis

**Speaker:** Lane Maitland

**Time:** 4-4:30pm

**Abstract:** We are experiencing a massive increase in the amount and accessibility of published research. Between 2008 and 2020, the volume of data grew by more than 40 zettabytes. However, more data does not inherently imply stronger evidence or advanced methods. In this presentation, we show how meta-analysis integrates the results from multiple studies and the multiple experiments within them to produce a single estimate of an effect. We focus on quantifying and interpreting both the raw and standardized mean differences. We implement a random-effects model to account for sampling error and between-study heterogeneity, and we assess this variability with different measures, including the heterogeneity standard deviation, Cochran's *Q;* the $I^2$ statistic, and the $H^2$ statistic. We find evidence that elevated levels of carbon dioxide give rise to woody plants with a greater average mass than ambient levels, and we reveal the presence of high between-study heterogeneity. Our meta-analysis demonstrates an innovative way to obtain better estimates and utilize the quickly growing volume of available data.

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## Office Assistant Needed in the Math and Stats Department Spring Term

The Mathematics and Statistics Department is looking for an Office Assistant for 4 hours per week spring term.

**Skills/Qualifications:** Word, Excel, and willingness to learn Canva and Publisher. Previous office experience preferred. We are seeking someone who is friendly, reliable, detail-oriented, and has the ability to work independently, be creative, and have good written and oral skills.

Responsibilities include general office duties, creating spreadsheets and posters, running errands, copying and scanning, and other duties as needed.

Contact Sue Jandro for an application if you are interested.

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## Jobs, Internships and Other Opportunities

**Jobs**

Thrive Scholars Summer TA Position, Amherst, MA. Contact Steve Scheirer (sscheirer@carleton.edu) with questions, apply by March 3.

**Internships**

R&D Research Intern, Cardiac Rhythm Management, Boston Scientific, apply by April 7.

**Other**

DRUMS Summer Research Program, North Carolina State University, rolling admissions (application review began February 15).

Mathematical Modeling of Malaria Workshop, Minnesota State University, Mankato, apply by March 1.

Big Data Summer Institute, University of Michigan, apply by March 15.

For more information and opportunities, visit the Carleton Career Center!

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## Upcoming Events

**Week 7**

Friday, February 17, 3:30-4:30pm, Leighton 305
Tour of Mathemarics Talk, Sunrose Shrestha: "A dynamical systems approach to some classical algebraic and number theoretic results"

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