Department of Mathematics

April 27, 2026

UNDERGRADUATE MATH SEMINAR

Professor Karl Zimmermann

The next seminar of the winter term will be

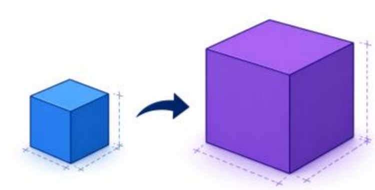
DATE: **THURSDAY, April 30**

Time & **12:30 –** Refreshments in **Bailey 204**

Location: **12:50 – 1:45** Seminar in **Bailey 207**

In this seminar, Union College **Professor Emeritus Karl Zimmermann,** a number theorist, will present the following talk.

Title: Doubling the Cube with Straightedge and Compass



(Image produced by ChatGPT)

Abstract: The ancient Greeks were interested in constructing geometric objects using only a straightedge (ruler without markings) and a compass. In particular, they constructed figures using the points of intersection of the lines and circles that they drew using these tools. We'll begin by looking at some elementary constructions and then move on to the problem of doubling the cube, i.e., given a cube, using straightedge and compass to construct a cube twice the volume of the original. Greek mathematicians started working on this problem during the 5th Century BCE and were never able to solve it. In fact, it wasn't until 1837 that Pierre Wantzel showed that doubling the cube is impossible - using only straightedge and compass. To develop the ideas necessary to understand why doubling the cube is impossible and sketch a proof, we'll look at how to turn this geometric question into a problem involving the real numbers.

Pieces from Thesis: Hunter Gould

*Hunter wrote his thesis this past fall and winter under the guidance of **Professor Phanuel Mariano.***

For my thesis, I studied what remains in stock returns after removing the main sources of common movement using a statistical factor model. Many stocks move together because of the same root causes, so I investigated what the “leftover” part of returns looks like after removing those common components. I wanted to understand whether or not it behaves like pure noise or if it still contains meaningful structure.

In order to study this, I used daily equity return data and built a statistical factor decomposition in a walk-forward manner. The model uses a two-stage, heteroskedasticity-adjusted, exponentially weighted procedure so that more recent data receives greater emphasis and very volatile assets do not skew factor estimates. This involved ideas from linear factor models, principal component analysis, singular value decomposition, covariance estimation, weighted least squares, and other mathematical concepts. This project gave me a lot of insight into the depth that goes into defining what should count as systematic and what should count as idiosyncratic.

After estimating the factors, I analyzed the residual returns in several ways. First, I looked at the cross-sectional distribution. I found that the decomposition was very effective at removing average linear dependence across stocks. However, the residuals did not become perfectly Gaussian or featureless. Their skewness and kurtosis still changed over time, so the idiosyncratic returns still retained higher-order distributional structure even after the main common factors had been removed.

I then examined whether these residuals still showed any time-series dependence. I found that residual portfolio returns were much closer to noise than to a strongly predictable process. However, the second moments behaved very differently. Squared residual returns exhibited clear volatility clustering, and

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using both EWMA and GARCH methods I was able to forecast residual variance out of sample. This demonstrates that the common factor does not contain all meaningful dynamics.

I also tested whether lagged residual returns could be used to predict future residual returns in the cross-section. I compared reversal and momentum-style signals based only on past returns. There was some modest evidence for overall predictability, and short-horizon momentum signals performed the best out of the candidate signals. However, these were not strong enough to support the claim that the residual space contains large or robust predictability.

Overall, I enjoyed this thesis because it let me combine theoretical mathematics, statistics and financial modeling in a way that was rigorous and applicable to a real world scenario. I particularly appreciated the connections between linear algebra and probability theory and their applicability to financial markets. I would recommend underclassmen choose a topic that they find genuinely interesting since you will spend a lot of time working with both the mathematics and the writing. The more interested you find yourself with the topic, the easier it will be to immerse yourself and enjoy your thesis experience.

Summer REU Research Leads to Published Article for Ricky Farina et al.

This past summer, **Ricky Farina '27**, a Math and Economics double major, participated in a Research Experience for Undergraduates (REU) at Marist University. Ultimately the work by Ricky, his REU cohort, and their supervising professor led to a paper, *"Excessive daytime sleepiness prevention using causality network driven by score-based Bayesian network structure learning algorithms*," that was published recently in Smart Health 40 (2026) - CONGRATULATIONS! The paper's abstract follows.

Objectives: Excessive Daytime Sleepiness (EDS) is a primary symptom of several sleep disorders, many of which exacerbate cardiovascular complications. While knowledge of factors associated with EDS has expanded due to extensive research in recent decades, its causal chain remains largely unknown. By establishing a clear cause-and-effect relationship, medical professionals and public health officials can intervene effectively to prevent or mitigate future harm caused by EDS.

Methods: This study uncovers etiologic factors leading to EDS by score-based Bayesian network structure learning algorithms. The likelihood of various contributing factors to EDS is examined by the causal chains produced by network models. The causality networks and conditional probabilities are constructed based on clinical and biomedical data of 1881 participants in the Stanford Technology Analytics and Genomics in Sleep study. It should be noted that this dataset contains uneven demographic distributions, particularly regarding ethnic distribution, that may have an effect on the generalizability of the causal network.

Results: The Bayesian Network constructed by Tabu algorithm performed the best with goodness of fit measures, yielding a BIC score of − 64844.62 versus scores of − 63921.19 and − 64526.64 for Hill-Climb and Max-Min Hill-Climb, respectively. Causalities of EDS produced by the graphical model include age, smoking, hypercholesterolemia, sex, psychiatric/mental health problems, depression, fatigue, and alcohol consumption, in addition to/in tandem with known causalities such as number of people in household, street/recreational drug use, insomnia, sleep duration, narcolepsy, exercise, body mass index, and apnea.

Conclusion: The Causality Bayesian network we developed offers a tool for examining EDS risk factors in contexts ranging from public health and policy to diagnosis, prevention, and research. The results from our model demonstrate the capability of learning Bayesian network structure methodology to serve as a template for researchers designing clinical studies evaluating the effectiveness of medical interventions.