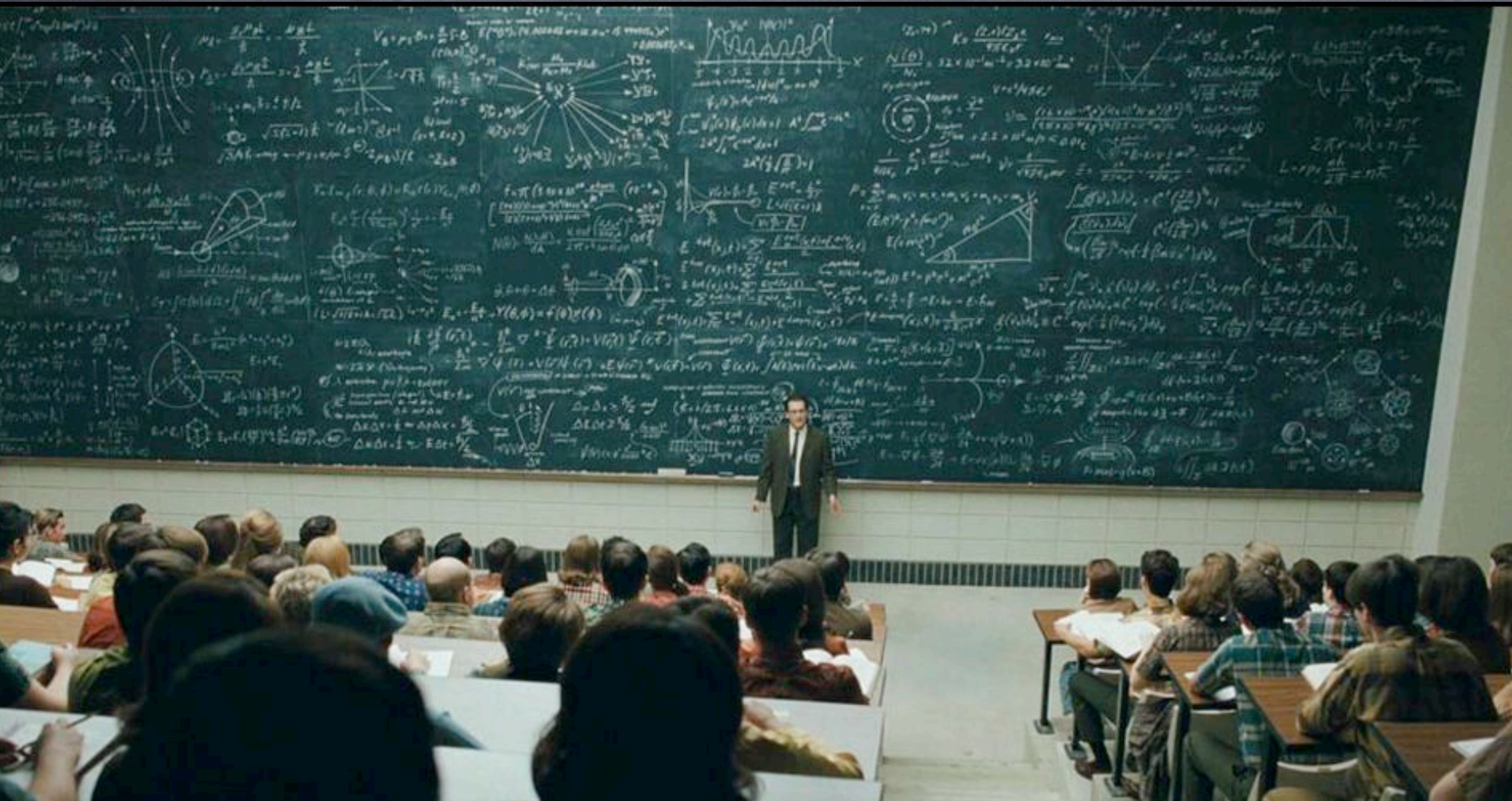
2015-2016 Mathematics and Statistics Course Fest



Fall Courses

MATH 467: Advanced Partial Differential Equations

- Instructor: Dr. Martial Agueh
- Term: Fall 2015

PDEs and Examples

- A partial differential equation (PDE) is an equation which involves the partial derivatives of some -unknown- function.
- PDEs are used to describe many phenomena in Physics, Biology, Engineering, Chemistry, etc; (they are called the mathematical models of these phenomena).

Examples of PDEs

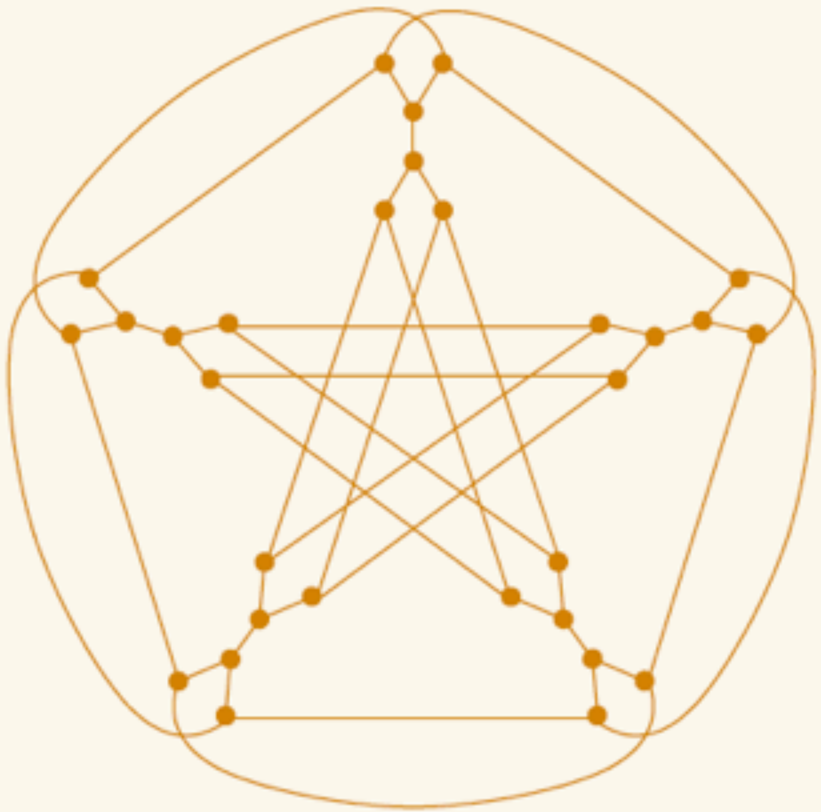
- **Heat equation (or diffusion equation)**: describes how a quantity (e.g., heat, a chemical) spreads in an environment. Used in Physics, Chemistry, Biology, and many other fields.
- **Aggregation equation**: describes how some material (which initially may be spread out) comes together as time evolves. Used to describe the social behaviour of animal populations.
- **Euler equation and Navier Stokes equations**: model the evolution of a moving fluid; (See *Math 492/550 (Fluids)*).
- **Monge-Ampère equation**: linked to Optimal Transport theory; used in Image Processing, Engineering and Physics.

MATH 423: Graph Theory

- Instructor: Dr. Kieka Mynhardt
- Term: Fall 2015

Why Graph Theory?

1. It's different
2. It's cool
3. It's visual
4. It's relevant
5. It's applicable
6. It's theoretical
7. It's taught by Gary, Jing or Kieka
8. **Prereq:** 222 + 1.5 units 300/400-level math; or **our permission**.



MATH 493: Functional Analysis

- Instructor: Dr. Ian Putnam
- Term: Fall 2015

Math 493/531 Functional Analysis

Prereq: Math 311 (Linear Algebra),
Math 365 (Topology)

- Math 311: Let V be a finite-dimensional vector space...

- $(x_1, x_2, \ldots) =$
$x_1(1, 0, \ldots) + x_2(0, 1, 0 \ldots) + \ldots$?

- Geometry/topology in infinite dimensions.

- $V =$ smooth functions.
Linear transformations:

$$X(f(x)) = xf(x), \qquad D(f(x)) = f'(x),$$

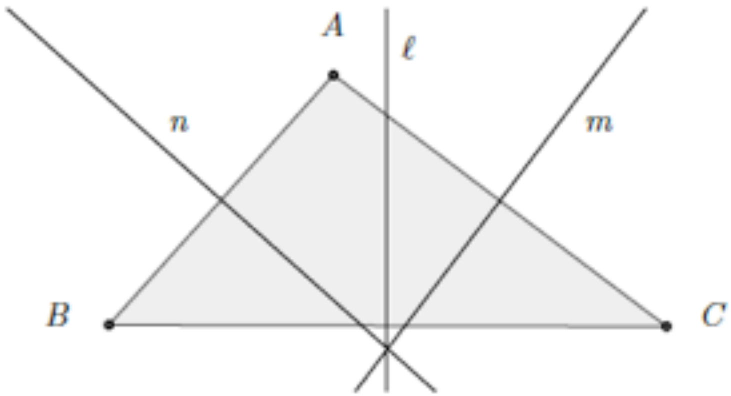
satisfy:

$$D \circ X - X \circ D = I.$$

MATH 366: Geometry

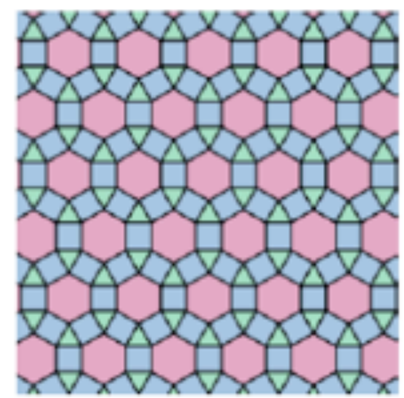
- Instructor: Dr. Peter Dukes
- Term: Fall 2015

Math 366: Geometry



$$\sigma_\ell \sigma_m \sigma_n(B) = B$$

$$z \mapsto 1/\overline{z}$$



$$\cos\frac{2\pi}{17} = \frac{\sqrt{17} - 1 + \sqrt{2}\sqrt{34 + 6\sqrt{17} + \sqrt{2}\left(\sqrt{17} - 1\right)\sqrt{17 - \sqrt{17}} - 8\sqrt{2}\sqrt{17 + \sqrt{17}}} + \sqrt{2}\sqrt{17 - \sqrt{17}}}{16}$$

MATH 452: Stochastic Processes

- Instructor: Dr. Junling Ma
- Term: Fall 2015

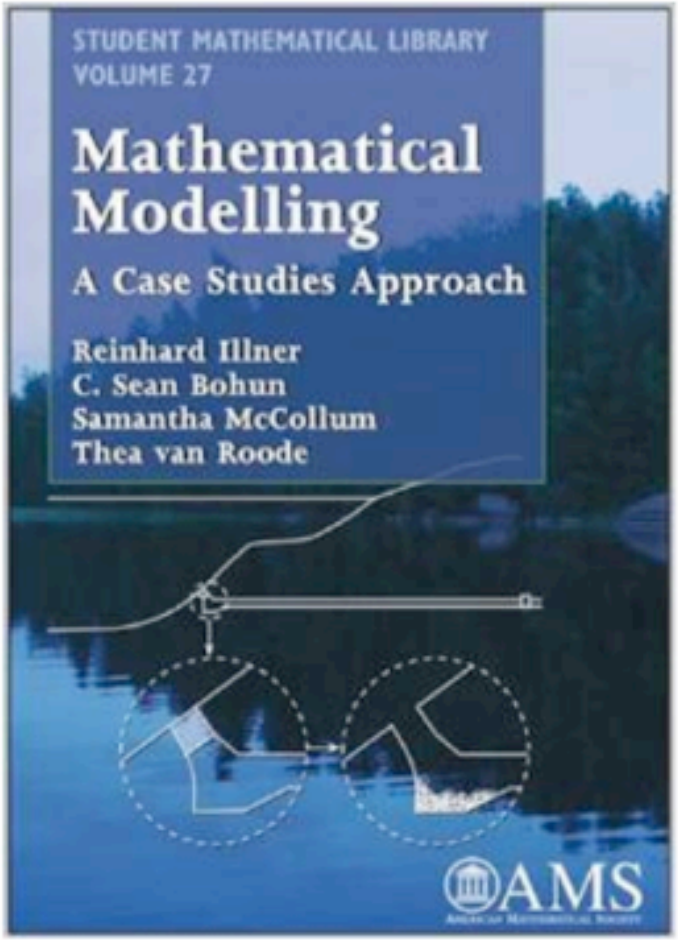
MATH 452 Stochastic Processes

- What:
  - Ex: how to characterize the arrival of events
  - Ex: how to model state changes
  - Random variables as functions of time, space, etc.
- Why:
  - Most real systems are stochastic in nature
  - Randomness may change the behavior of your beloved differential (difference) equation models
- Prerequisite: STAT 350

MATH 377: Mathematical Modelling

- Instructor: Dr. Roderick Edwards
- Term: Fall 2015

MATH 377 – Mathematical Modelling



Spherical Crystal growth – A problem from UVic Chemistry

How a BC Hydro engineer figured out whether the valve at the end of a tunnel from a mountain lake would hold when the water rushed in (air pressure model)

How to make money by guessing when people will die (pricing annuities)

How Sir G.I. Taylor estimated the energy of a Nuclear Bomb from a movie (dimensional analysis)

How Volterra figured out why fish stocks were depleted in the Adriatic despite lack of fishing during WWI

How density shocks propogate in traffic flow

How disease spreads on social contact networks

https://www.youtube.com/watch?v=a4VtJieJ-ug#!

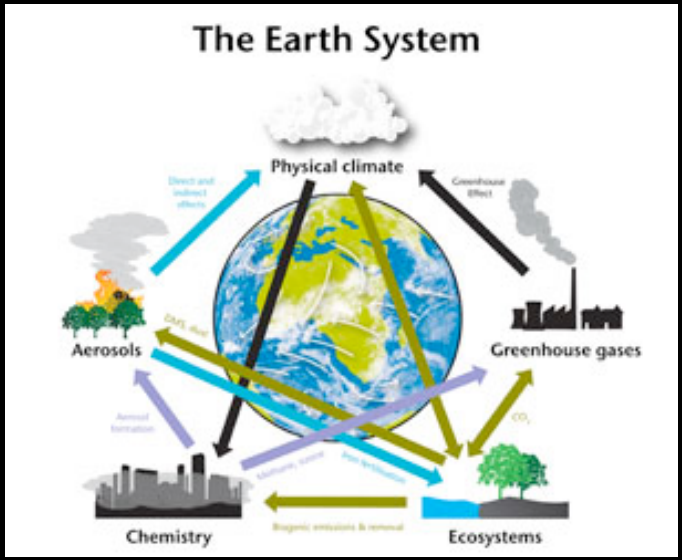
MATH 449: Scientific Computing

- Instructor: Dr. Boualem Khouider
- Term: Fall 2015

What is Scientific Computing?

The use computers to address problems in science and engineering.

Physical System



Modelling

Mathematical Model

$$F(x, y, z) = 0$$

$$\min F(u, v, w)$$

$$\dot{X} = F(X, t)$$

$$u_t + u \cdot \nabla u = \nu \Delta u$$

$$\ldots$$

Numerical Analysis

Computer Model

Data Analysis and Validation

Pre-req: M348 or CSC349A

MATH 401: Complex Analysis

- Instructor: Dr. Marcelo Laca
- Term: Fall 2015

$$
\begin{aligned}
f(z) &= \frac{1}{2\pi i}\int_{|\zeta|=r} \frac{f(\zeta)}{\zeta - z}\,d\zeta \\
&= \frac{1}{2\pi i}\int_{|\zeta|=r} \frac{f(\zeta)}{\zeta}\,\frac{1}{1-\frac{z}{\zeta}}\,d\zeta \\
&= \frac{1}{2\pi i}\int_{|\zeta|=r} \frac{f(\zeta)}{\zeta}\left(\sum_{n=0}^{\infty}\left(\frac{z}{\zeta}\right)^{n}\right)d\zeta \\
&= \frac{1}{2\pi i}\int_{|\zeta|=r} \left(\sum_{n=0}^{\infty}\frac{f(\zeta)}{\zeta}\left(\frac{z}{\zeta}\right)^{n}\right)d\zeta \\
&= \sum_{n=0}^{\infty}\left(\frac{1}{2\pi i}\int_{|\zeta|=r}\frac{f(\zeta)}{\zeta^{n+1}}\,d\zeta\right)z^{n} \\
&= \sum_{n=0}^{\infty} c_n z^n,
\end{aligned}
$$

where

$$
c_n = \frac{1}{2\pi i}\int_{|\zeta|=r}\frac{f(\zeta)}{\zeta^{n+1}}\,d\zeta
$$

Math 401: Complex Analysis

What? The course will start with an efficient and rigorous introduction to the theory of differentiable complex functions, highlighting its unsurpassed intrinsic elegance and cohesion, and pointing out the many unexpected and quite pleasant surprises that one encounters along the way.
This introduction will be followed by a development of several special topics selected from a wealth of possibilities, including applications of the residue theorem, winding number, conformal mappings, the Riemann mapping theorem, the maximum modulus principle, infinite products, Picard's theorem, normal families, Hp-spaces, approximation by rational functions, the Riemann zeta function, analytic continuation and Riemann surfaces.

Who? Any serious student of mathematics, either for its own sake or for its applications.

Why? The intrinsic beauty of the subject. Also a highly useful theory in other branches of mathematics, engineering and the physical sciences. (e.g. from the fundamental theorem of algebra to the control mechanisms in a modern airplane depend on this theory).

When? After a rigorous introduction to real analysis.

Where to? A better understanding of classical mathematics at its best, and an open door to the applications that follow.

MATH 435: Real Analysis II

- Instructor: Dr. Ahmed Sourour
- Term: Fall 2015

It is all real!

Math 435
REAL ANALYSIS
September 2015

- Covers the modern (20th century) theory of integration.
- Important for further studies in most areas of pure and applied mathematics including differential equations, Fourier analysis, probability and many others.

STAT456: Multivariate Statistics

- Instructor: Dr. Min Tsao
- Term: Fall 2015

Stat 456/553 Multivariate Analysis

In many cases, the data that we observe come naturally as vectors. For example, we may observe the height (h) and weight (w) of the same individual and have (h_i, w_i) data on a sample n randomly selected people $(i = 1, 2, \ldots, n)$. In such cases, we say that we have multivariate data and we wish to study probability and statistical properties of the underlying random vector. This course covers methods for analysing such multivariate data which closely parallel many methods that we have studies for analysing univariate data. Here are some highlights of the course:

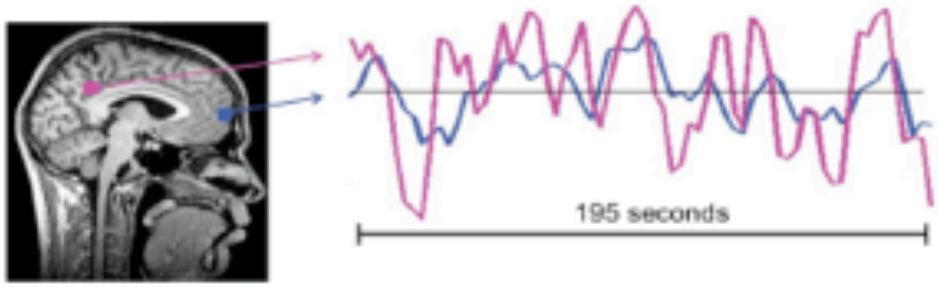
1. Multivariate normal distribution — the most useful multivariate model with many applications in analysing multivariate data.
2. Multivariate analysis of variance — this generalises the univariate analysis of variance and compares the vector means of several populations.
3. Multivariate regression analysis — where the response variable is a vector instead of a univariate response.
4. Discriminant analysis — studies methods to divide objects with multivariate measurements into different groups.

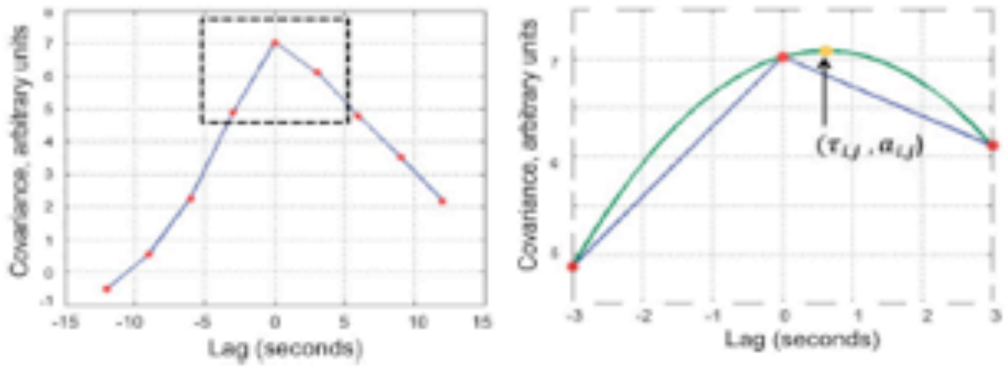
The course material have a lot of applications, highly recommended for people handling multivariate data.

STAT457: Time Series Analysis

- Instructor: Dr. Farouk Nathoo
- Term: Fall 2015

Stat 457/554 Time Series Analysis



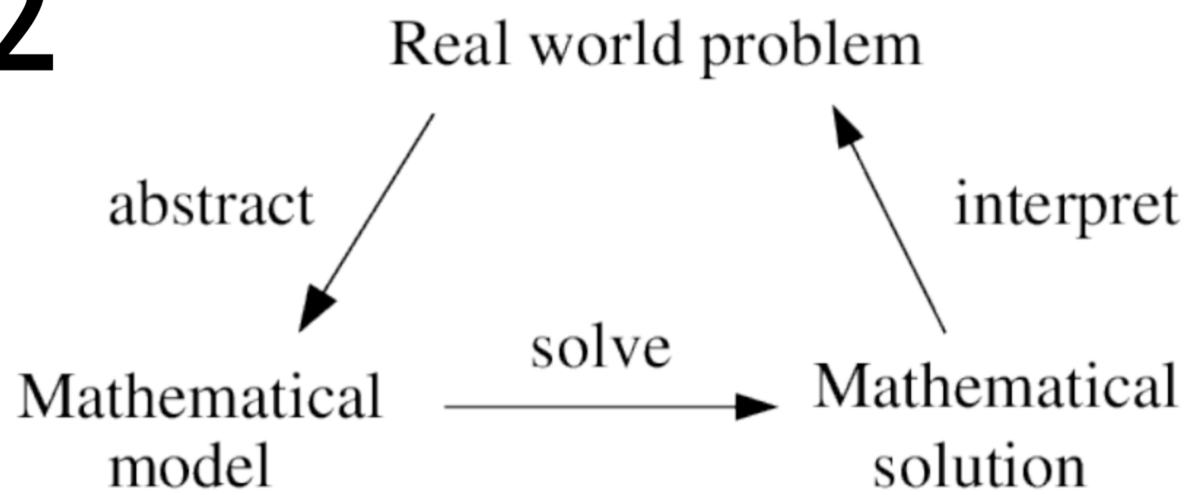


- **Time Series:** sequence of data points consisting of measurements taken over time
- Such data arise in a number of areas: finance, engineering, brain imaging, physics, environmental monitoring, among many others…
- This course will discuss: (i) basic stochastic process models for time series; (ii) estimation and inference in both time domain and frequency domain; (iii) forecasting
- Topics include: autoregressive and moving average models, seasonal models, smoothing, time series regression, spectral analysis, linear filters, non-Gaussian dynamics, multivariate time series
- Need at least one course in mathematical statistics (e.g. 350) and one course in regression (e.g. 353)
- Course involves a nice blend of statistical theory, computing, and real data analysis

MATH 442: Advanced ordinary differential Equations

- Instructor: Dr. Slim Ibrahim
- Term: Fall 2015

MATH 442



- The mathematical study of the properties of solutions of (nonlinear) ODEs without finding the solutions themselves.
- The foundations of the qualitative theory: regarding the solutions of systems of differential equations as curves in an appropriate space (Poincare)
- Special solutions: equilibrium & periodic solutions (construction, stability, linearization)
- Stability: by linearization and by direct methods (Lyapunov)
- Perturbation and bifurcation theory
- Applications: Hamiltonian systems(Birkhoff normal forms and KAM theory ????)

Spring Courses

MATH 492: Topics in Applied Math (Fluids)

- Instructor: Dr. Slim Ibrahim
- Term: Spring 2016

Introduction to Fluid Mechanics

- We are surrounded by fluids: from the air that we breath to the water that fills oceans and lakes,

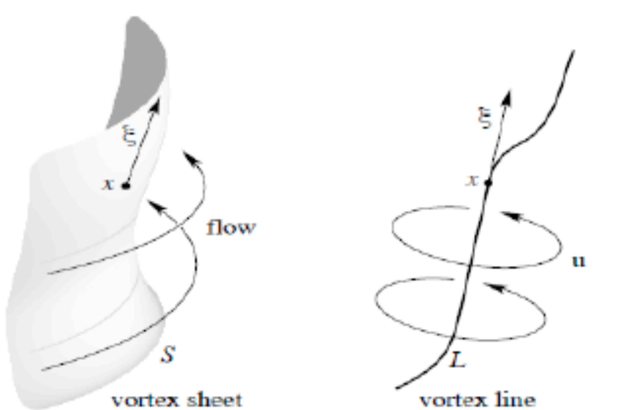


FIGURE 1.2.3. Vortex sheets and lines remain so under the flow.

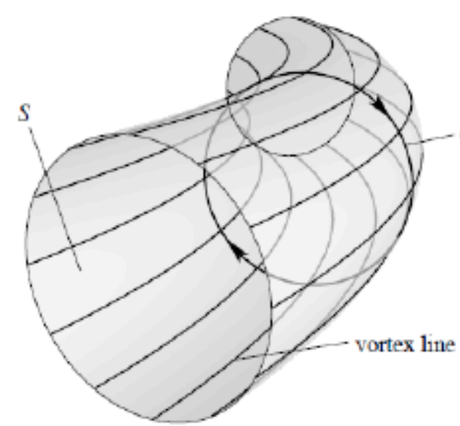


FIGURE 1.2.5. A vortex tube consists of vortex lines drawn through points of C.

STAT 453: Design and Analysis of Experiments

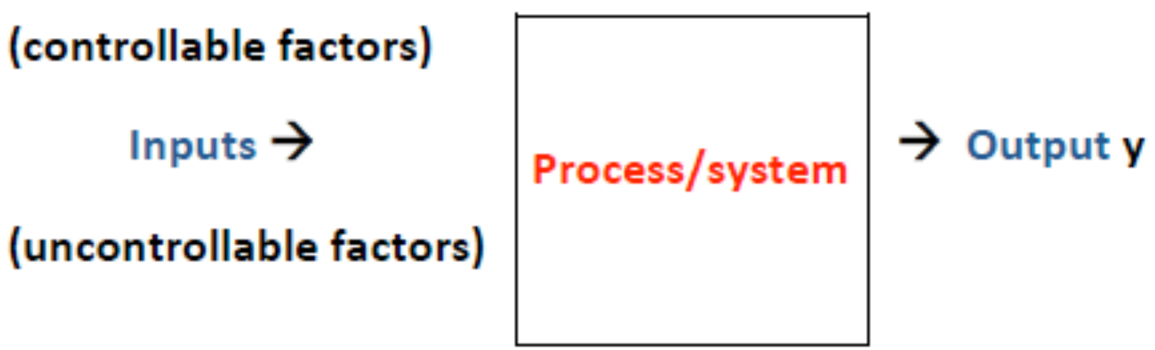
- Instructor: Dr. Julie Zhou
- Term: Spring 2016

Stat 453

Design and Analysis of experiments

Pre-requisites: Stat 353 -- Applied Regression Analysis

- Study the design of experiments
- Analyze the data after experiments
- Optimize a process or system



Factorial designs, Block designs, Randomized designs, Optimal designs, Efficient designs, ...

One-way ANOVA, two-way ANOVA, linear fixed effects models, random effects models, mixed effects models ...

STAT 354: Sampling Techniques

- Instructor: Dr. Laura Cowen
- Term: Spring 2016

Photo credit: AFSC, NOAA

STAT 354 Sampling

required for Major or Minor in Statistics
Pre-reqs: 2 second year stats courses
(255/256 or 260/261)

Answer questions like:

- How do I estimate the number of humpback whales in Alaska? -> aerial line transects
- How can I estimate the survival rates of ribbon seals?
- -> mark-recapture

Career path in statistics? Answer population based questions (human and otherwise), deal with finite populations, subject area anywhere from protein fragments, to health insurance, brain images, to whales- how cool is that!

MATH 412: Abstract Algebra II

- Instructor: Dr. Anthony Quas
- Term: Spring 2016

Math 412
Abstract Algebra II

What?	Study of fields, group theory, Galois theory
Why take it?	This is a course for the romantic! Galois died a slow death after a romantic duel. He spent his dying 2 days writing an account of his theory, which was only recognized 20 years after he died. This is really beautiful mathematics, connecting groups and solutions of equations in an amazing way. Also, everyone knows how to solve quadratic equations. You might know that quintic equations cannot be solved. This course explains why! Plus, an answer to a problem of the ancient Greeks: *can you trisect an angle using ruler and compass?* It can even be extended to calculus *(how can you prove that* $\exp(x^2)$ *doesn't have an elementary integral?*)
Prereqs:	MATH 311 (LinAlgII) and MATH 312 (Abstract Alg I).

MATH 477: Stochastic Financial Models

- Instructor: Dr. Anthony Quas
- Term: Spring 2016

MATH 477
Stochastic Financial Models

What?	Use probability to answer questions like: “what is the value of a contract giving you the right to buy a Microsoft share for $47 on June 1st?”
What's cool about it?	It's the only place in the undergrad math curriculum where you get up close and personal with Nobel-prizewinning work! Also if you're motivated by $$, people with these skills are in a lot of demand. You can get paid a lot for doing interesting stuff!
How do I sign up?	You should have taken MATH 452 (Probability Models) and STAT 350 (Mathematical Statistics I). A key feature of the course is that there are computer projects, where you get to use computers as a tool to compute option prices.

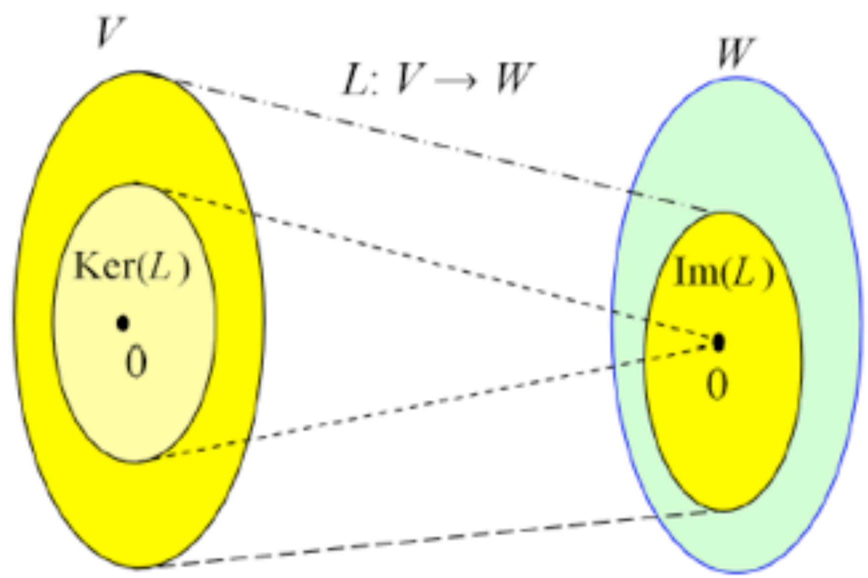
MATH 467: Differential Geometry

- Instructor: Dr. Ryan Budney
- Term: Spring 2016

MATH 311: Linear Algebra

- Instructor: Dr. Peter Dukes
- Term: Spring 2016

Math 311: Linear Algebra



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$$\begin{bmatrix} 5 & 4 & 2 & 1 \\ 0 & 1 & -1 & -1 \\ -1 & -1 & 3 & 0 \\ 1 & 1 & -1 & 2 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 4 & 1 \\ 0 & 0 & 0 & 4 \end{bmatrix}$$

MATH 462: Topics in Number Theory

- Instructor: Dr. Gary MacGillivray
- Term: Spring 2016

Math 462 Topics in Number Theory
Analytic Number Theory

A rare commodity -- Last offered in 2008!

Prerequisites: Math 362 and 236

Instructor: Gary MacGillivray

Course notes available (**no textbook to buy**)

Arithmetic functions, the distribution of primes, the Prime Number Theorem, and the geometry of numbers

There is no good reason to take this course … except that you can't be a mathematician and not love numbers

MATH 422: Combinatorial Mathematics

- Instructor: Dr. Jing Huang
- Term: Spring 2016

Combinatorial Mathematics - MATH 422 [Spring 2016]

- Counting is an art!
- Counting numbers: multinomial coefficients, Stirling numbers, Bell numbers, Catalan numbers, ...
- Techniques: bijection, pigeonhole principle, principle of inclusion and exclusion, generating function, Möbius inversion ...
- Nothing is totally irregular: Ramsey theory
- Combinatorial algebra: orbits, stabilizers and Polya's theorem
- Happy counting!

MATH 365: Intro to Topology

- Instructor: Dr. Heath Emerson
- Term: Spring 2016

Math 365 - an Introduction to Topology

Topology is the mathematics that describes what is invariant about a shape, or space (think of the sphere, or the surface of a donut) under continuous deformation of it – that is, what is preserved if one pulls and pushes the shape about without tearing or breaking it.

Topological ideas are ubiquitous in mathematics. For example infinite dimensional linear algebra often involves introducing subtle topologies on various vector spaces. Rather general compactness theorems from topology play a crucial role in many problems in all sorts of fields.

Math 365 introduces the definition of 'topological space' and gets you used to reasoning with the definition. The notions of compactness, connectedness, metrizability of spaces, are all covered as well.

The course is very problem-based, and is quite self-contained. If you enjoy puzzles and abstract reasoning, or like geometry and to visualize shapes, you should take it!

MATH 379: Chaos Theory

- Instructor: Dr. Chris Bose
- Term: Spring 2016

STAT450: Mathematical Statistics

- Instructor: Dr. Min Tsao
- Term: Spring 2016

Stat 450 Mathematical Statistics II

This course covers advanced material on the theory of statistical inference. It provides the theoretical foundation for many of the statistical methods that are taught in lower level statistics courses.

In lower courses, ideas/procedures such as point estimation, confidence interval estimation and hypothesis testing are used to handle many different types of problems but only their applications are discussed, not the theoretical underpinning, their mathematical validity. This course fills this important gap, and is highly recommended for students who are interested in learning not just how to use statistical methods and but also why they work.

STAT458: Generalized Linear Models

- Instructor: Dr. Min Tsao
- Term: Spring 2016

Stat 458/568 Generalized Linear Models

The linear models are simple and useful models. But they require very strong assumptions on the linear dependence of the response variable to the explanatory variables as well as normal assumption on the error distribution, which may fail in many applications. When the response variable is a count or a proportion, for example, such assumptions are often invalid and more sophisticated models are required to study the dependence of the response variable on the explanatory variables.

Generalized linear models are devised to handle situations where a linear combination of the explanatory variables is linked to the response variable through a link function. When this link function is the identity function, the generalized linear model reduces to the ordinary linear model. This course discusses selection of link functions and parameter estimation and inference for generalized linear models. The most well-known generalized linear models include the logistic regression model for proportions and log-linear models for counts. They are very useful for anyone doing modelling for non-normal data.