Department of Mathematics

Fall 2020

(*Disclaimer: Be advised that some information on this page may not be current due to course scheduling changes. Please view either the* ***UH Class Schedule*** *page or your Class schedule in* ***myUH*** *for the* ***most current/updated information****.)*

***NEW: UH plans to deliver classes this fall in the following three instructional modes:**

Hyflex: courses have a safe number of students face-to-face in a socially distanced classroom, with lectures being live-streamed to allow additional students to participate in the class remotely. Lectures are also recorded for viewing by students online later if necessary, with additional course materials posted online that can be accessed anytime. These courses are displayed with a **Meeting Time** in the class schedule.

Synchronous Online: courses have **NO Face-to-Face** classes but do meet at a particular day and time in a virtual classroom. All course materials are available online and virtual lectures may be recorded to provide additional flexibility for students to view them later. These courses are displayed as **"Online"** with a **Meeting Time** in the class schedule.

Asynchronous Online: courses have **NO Face-to-Face** classes or virtual meeting times. All course materials are available online anytime. These courses are displayed as **"Online"** with **NO Meeting Time** in the schedule.

GRADUATE COURSES - FALL 2020

SENIOR UNDERGRADUATE COURSES

Course	Section	Course Title	Course Day & Time	Rm #	Instructor
Math 4310	*19894*	*Biostatistics*	***Online***	***Online***	*A. Török*
Math 4320	13147	Intro to Stochastic Processes	TuTh, 2:30—4PM - **Online**	**Online**	W. Ott
Math 4322	20046	Introduction to Data Science and Machine Learning	TuTh, 11:30AM—1PM - **Online**	**Online**	C. Poliak
Math 4323	26382	Data Science and Statistical Learning	MWF, Noon—1PM - **Online**	**Online**	W. Wang
Math 4331	15671	Introduction to Real Analysis I	MWF, 11AM—Noon - **Online**	**Online**	A. Vershynina
Math 4335	*17727*	*Partial Differential Equations I*	***Online***	***Online***	*W. Fitzgibbon/J. Morgan*
Math 4339	20275	Multivariate Statistics	TuTh, 1—2:30PM - **Online**	**Online**	C. Poliak
Math 4350	21332	Differential Geometry I	MW, 1—2:30PM - **Online**	**Online**	M. Ru
Math 4364	16353	Introduction to Numerical Analysis in Scientific Computing	MW, 4—5:30PM - **Online**	**Online**	T-W. Pan
Math 4364	*21330*	*Introduction to Numerical Analysis in Scientific Computing*	***Online***	***Online***	*Y. Kuznetsov*
Math 4366	*17014*	*Numerical Linear Algebra*	***Online***	***Online***	*J. He*
Math 4377	15673	Advanced Linear Algebra I	MWF, Noon—1PM - **Online**	**Online**	A. Mamonov

Math 4388	*14603*	*History of Mathematics*	***Online***	***Online***	*S. Ji*
Math 4389	14031	Survey of Undergraduate Mathematics	MW, 1—2:30PM - **Online**	**Online**	M. Almus
Math 4397	21953	Math Methods for Physics	MW, 2:30—4PM - **Online**	**Online**	L. Wood

GRADUATE ONLINE COURSES

Course	Section	Course Title	Course Day & Time	Instructor
Math 5331	*14246*	*Linear Algebra with Applications*	***Online***	*K. Kaiser*
Math 5333	*14831*	*Analysis*	***Online***	*G. Etgen*
Math 5382	*21959*	*Probability*	***Online***	*I. Timofeyev*
Math 5397	*21333*	*Partial Differential Equations*	***Online***	*J. Morgan*

GRADUATE COURSES

Course	Section	Course Title	Course Day & Time	Rm #	Instructor
Math 6302	*13148*	*Modern Algebra I*	***Online***	***Online***	*G. Heier*
Math 6308	15674	Advanced Linear Algebra I	MWF, Noon—1PM - **Online**	**Online**	A. Mamonov
Math 6312	15672	Introduction to Real Analysis	MWF, 11AM—Noon - **Online**	**Online**	A. Vershynina
Math 6320	13175	Theory of Functions of a Real Variable	MWF, 11AM—Noon - **Online**	**Online**	D. Blecher
Math 6320	28138	Theory of Functions of a Real Variable	MWF, 11AM—Noon - **Hyflex**	SEC 204	D. Blecher
Math 6322	21335	Func. Complex Variable	MWF, 10—11AM - **Online**	**Online**	S. Ji
Math 6342	13176	Topology	MWF, 9—10AM - **Online**	**Online**	V. Climenhaga
Math 6360	13736	Applicable Analysis	MWF, 9—10AM - **Online**	**Online**	G. Jaramillo
Math 6366	13177	Optimization Theory	MWF, 10—11AM - **Online**	**Online**	A. Mang
Math 6370	13178	Numerical Analysis	TuTh, 8:30—10AM- **Online**	**Online**	A. Quaini
Math 6382	17936	Probability and Statistics	TuTh, 10—11:30AM - **Online**	**Online**	M. Nicol
Math 6384	17730	Discrete Time Model in Finance	TuTh, 2:30—4PM - **Online**	**Online**	E. Kao
Math 6397	21336	Stochastic Models in Biology	MW, 2:30—4PM - **Online**	**Online**	K. Josic
Math 6397	21337	Computational Inverse Problems	MW, 1—2:30PM - **Online**	**Online**	A. Mang
Math 6397	*21338*	*Statistical Computing*	***Online***	***Online***	*W. Fu*
Math 6397	21339	High Dimensional Measures & Geometry	TuTh, 10—11:30AM - **Online**	**Online**	B. Bodmann
Math 6397	*21960*	*Applied and Computational Probability*	***Online***	***Online***	*I. Timofeyev*
Math 6397	30076	Spatial Statistics	MW, 4—5:30PM - **Online**	**Online**	M. Jun
Math 7320	21334	Functional Analysis	TuTh, 1—2:30PM - **Online**	**Online**	M. Kalantar

MSDS Courses *(MSDS Students Only)*

Course	Section	Course Title	Course Day & Time	Rm #	Instructor

Math 6350	19912	Statistical Learning and Data Mining	MW, 1—2:30PM - **Online**	**Online**	R. Azencott
Math 6357	20271	Linear Models & Design of Experiments	MW, 4—5:30PM - **Online**	**Online**	W. Wang
Math 6357	28141	Linear Models & Design of Experiments	MW, 4—5:30PM - **Hyflex**	SEC 201	W. Wang
Math 6358	18147	Probability Models and Statistical Computing	Friday, 1—3PM - **Online**	**Online**	C. Poliak
Math 6358	28142	Probability Models and Statistical Computing	Friday, 1—3PM - **Hyflex**	SEC 101	C. Poliak
Math 6380	20633	Programming Foundation for Data Analytics	Friday, 3—5PM - **Online**	**Online**	D. Shastri
Math 6397	TBD	Topics in Financial Machine Learning/Analytics in Commodity & Financial Markets	TBD	TBD	TBD

---Course Details---

SENIOR UNDERGRADUATE COURSES

Math 4310 Biostatistics: 19894 (**Online**)

Prerequisites:	**MATH 3339** and **BIOL 3306**
Text(s):	"Biostatistics: A Foundation for Analysis in the Health Sciences, Edition (TBD), by Wayne W. Daniel, Chad L. Cross. **ISBN**: (TBD)
Description:	Statistics for biological and biomedical data, exploratory methods, generalized linear models, analysis of variance, cross-sectional studies, and nonparametric methods. Students may not receive credit for both MATH 4310 and BIOL 4310.

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Math 4320 - Intro to Stochastic Processes

Prerequisites:	**MATH 3338**
Text(s):	An Introduction to Stochastic Modeling" by Mark Pinsky, Samuel Karlin. Academic Press, Fourth Edition. ISBN-10: 9780123814166 ISBN-13: 978-0123814166
Description:	We study the theory and applications of stochastic processes. Topics include discrete-time and continuous-time Markov chains, Poisson process, branching process, Brownian motion. Considerable emphasis will be given to applications and examples.

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Math 4322 - Introduction to Data Science and Machine Learning

Prerequisites:	MATH 3339
Text(s):	While lecture notes will serve as the main source of material for the course, the following book constitutes a great reference: "An Introduction to Statistical Learning (with applications in R)" by James, Witten et al. ISBN: 978-1461471370 "Neural Networks with R" by G. Ciaburro. ISBN: 978-1788397872

Course will deal with theory and applications for such statistical learning techniques as linear and logistic regression, classification and regression trees, random forests, neural networks. Other topics might include: fit quality assessment, model validation, resampling methods. R Statistical programming will be used throughout the course.

Learning Objectives: By the end of the course a successful student should:

• Have a solid conceptual grasp on the described statistical learning methods.
• Be able to correctly identify the appropriate techniques to deal with particular data sets.
• Have a working knowledge of R programming software in order to apply those techniques and subsequently assess the quality of fitted models.
• Demonstrate the ability to clearly communicate the results of applying selected statistical learning methods to the data.

Description:

Software: Make sure to download R and RStudio (which can't be installed without R) before the course starts. Use the link https://www.rstudio.com/products/rstudio/download/ to download it from the mirror appropriate for your platform. Let me know via email in case you encounter difficulties.

Course Outline:
Introduction: What is Statistical Learning?

Supervised and unsupervised learning. Regression and classification.
Linear and Logistic Regression. Continuous response: simple and multiple linear regression. Binary response: logistic regression. Assessing quality of fit.
Model Validation. Validation set approach. Cross-validation.
Tree-based Models. Decision and regression trees: splitting algorithm, tree pruning. Random forests: bootstrap, bagging, random splitting.
Neural Networks. Single-layer perceptron: neuron model, learning weights. Multi-Layer Perceptron: backpropagation, multi-class discrimination

Math 4323 - Introduction to Data Science and Machine Learning

Prerequisites: MATH 3339

Text(s): TBA

Description: Theory and applications for such statistical learning techniques as maximal marginal classifiers, support vector machines, K-means and hierarchical clustering. Other topics might include: algorithm performance evaluation, cluster validation, data scaling, resampling methods. R Statistical programming will be used throughout the course.

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Math 4331 - Introduction to Real Analysis I

Prerequisites: **MATH 3333**. In depth knowledge of Math 3325 and Math 3333 is required.

Text(s): Real Analysis, by N. L. Carothers; Cambridge University Press (2000), ISBN 978-0521497565

Description:

This first course in the sequence Math 4331-4332 provides a solid introduction to deeper properties of the real numbers, continuous functions, differentiability and integration needed for advanced study in mathematics, science and engineering. It is assumed that the student is familiar with the material of Math 3333, including an introduction to the real numbers, basic properties of continuous and differentiable functions on the real line, and an ability to do epsilon-delta proofs.

Topics: Open and closed sets, compact and connected sets, convergence of sequences, Cauchy sequences and completeness, properties of continuous functions, fixed points and the contraction mapping principle, differentiation and integration.

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Math 4335 - Partial Differential Equations I

Prerequisites: **MATH 3331** or equivalent, and three additional hours of 3000-4000 level Mathematics. Previous exposure to Partial Differential Equations (Math 3363) is recommended.

Text(s): "Partial Differential Equations: An Introduction (second edition)," by Walter A. Strauss, published by Wiley, ISBN-13 978-0470-05456-7

Description: **Description**:Initial and boundary value problems, waves and diffusions, reflections, boundary values, Fourier series.

Instructor's Description: will cover the first 6 chapters of the textbook. See the departmental course description.

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Math 4339 (20275) - Multivariate Statistics

Prerequisites: **MATH 3349**

Text(s):

- Applied Multivariate Statistical Analysis (6th Edition), Pearson. Richard A. Johnson, Dean W. Wichern. **ISBN**: 978-0131877153 (Required)

- Using R With Multivariate Statistics (1st Edition). Schumacker, R. E. SAGE Publications. **ISBN**: 978-1483377964 (recommended)

Description:	Course Description: Multivariate analysis is a set of techniques used for analysis of data sets that contain more than one variable, and the techniques are especially valuable when working with correlated variables. The techniques provide a method for information extraction, regression, or classification. This includes applications of data sets using statistical software. <u>Course Objectives:</u> • Understand how to use R and R Markdown • Understand matrix algebra using R • Understand the geometry of a sample and random sampling • Understand the properties of multivariate normal distribution • Make inferences about a mean vector • Compare several multivariate means • Identify and interpret multivariate linear regression models <u>Course Topics:</u> • Introduction to R Markdown, Review of R commands (Notes) • Introduction to Multivariate Analysis (Ch.1) • Matrix Algebra, R Matrix Commands (Ch.2) • Sample Geometry and Random Sampling (Ch.3) • Multivariate Normal Distribution (Ch.4) • MANOVA (Ch.6) • Multiple Regression (Ch.7) • Logistic Regression (Notes) • Classification (Ch.11)

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Math 4350 (21332) - Differential Geometry I

Prerequisites:	MATH 2433 and six additional hours of 3000-4000 level Mathematics.
Text(s):	Instructor's notes will be provided
Description:	Curves in the plane and in space, global properties of curves and surfaces in three dimensions, the first fundamental form, curvature of surfaces, Gaussian curvature and the Gaussian map, geodesics, minimal surfaces, Gauss' Theorem Egregium, The Codazzi and Gauss Equations, Covariant Differentiation, Parallel Translation.

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Math 4364 (16353) - Introduction to Numerical Analysis in Scientific Computing

Prerequisites:	**MATH 3331** and COSC 1410 or equivalent. *(2017—2018 Catalog)* **MATH 3331** or **MATH 3321** or equivalent, and three additional hours of 3000-4000 level Mathematics *(2018—2019 Catalog)* *Ability to do computer assignments in FORTRAN, C, Matlab, Pascal, Mathematica or Maple.
Text(s):	Numerical Analysis (9th edition), by R.L. Burden and J.D. Faires, Brooks-Cole Publishers, 9780538733519

Description:	This is an one semester course which introduces core areas of numerical analysis and scientific computing along with basic themes such as solving nonlinear equations, interpolation and splines fitting, curve fitting, numerical differentiation and integration, initial value problems of ordinary differential equations, direct methods for solving linear systems of equations, and finite-difference approximation to a two-points boundary value problem. This is an introductory course and will be a mix of mathematics and computing.

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Math 4364 (21330) - Introduction to Numerical Analysis in Scientific Computing

Prerequisites:	**MATH 3331** and COSC 1410 or equivalent. *(2017—2018 Catalog)* **MATH 3331** or **MATH 3321** or equivalent, and three additional hours of 3000-4000 level Mathematics *(2018—2019 Catalog)* *Ability to do computer assignments in FORTRAN, C, Matlab, Pascal, Mathematica or Maple.
Text(s):	Numerical Analysis (9th edition), by R.L. Burden and J.D. Faires, Brooks-Cole Publishers, 9780538733519
Description:	This is an one semester course which introduces core areas of numerical analysis and scientific computing along with basic themes such as solving nonlinear equations, interpolation and splines fitting, curve fitting, numerical differentiation and integration, initial value problems of ordinary differential equations, direct methods for solving linear systems of equations, and finite-difference approximation to a two-points boundary value problem. This is an introductory course and will be a mix of mathematics and computing.

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Math 4366 - Numerical Linear Algebra

Prerequisites:	**MATH 2331**, or equivalent, and six additional hours of 3000-4000 level Mathematics.
Text(s):	Instructor will use his own notes.
Description:	Conditioning and stability of linear systems, matrix factorizations, direct and iterative methods for solving linear systesm, computing eigenvalues and eigenvectors, introduction to linear and nonlinear optimization

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Math 4377 (15673) - Advanced Linear Algebra I

Prerequisites:	MATH 2331, or equivalent, and a minimum of three semester hours of 3000-4000 level Mathematics.
Text(s):	Linear Algebra, 4th Edition, by S.H. Friedberg, A.J Insel, L.E. Spence,Prentice Hall, ISBN 0-13-008451-4
Description:	**Catalog Description**: Linear systems of equations, matrices, determinants, vector spaces and linear transformations, eigenvalues and eigenvectors. **Instructor's Description**: The course covers the following topics: vector spaces, subspaces, linear combinations,systems of linear equations, linear dependence and linear independence, bases and dimension,linear transformations, null spaces, ranges, matrix rank, matrix inverse and invertibility,determinants and their properties, eigenvalues and eigenvectors, diagonalizability.

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Math 4388 - History of Mathematics

Prerequisites:	**MATH 3333**
Text(s):	*No textbook is required. Instructor notes will be provided*
Description:	This course is designed to provide a college-level experience in history of mathematics. Students will understand some critical historical mathematics events, such as creation of classical Greek mathematics, and development of calculus; recognize notable mathematicians and the impact of their discoveries, such as Fermat, Descartes, Newton and Leibniz, Euler and Gauss; understand the development of certain mathematical topics, such as Pythagoras theorem, the real number theory and calculus. Aims of the course: To help students to understand the history of mathematics; to attain an orientation in the history and philosophy of mathematics; to gain an appreciation for our ancestor's effort and great contribution; to gain an appreciation for the current state of mathematics; to obtain inspiration for mathematical education, and to obtain inspiration for further development of mathematics. On-line course is taught through Blackboard Learn, visit http://www.uh.edu/webct/ for information on obtaining ID and password. The course will be based on my notes. Homework and Essays assignement are posted in Blackboard Learn. There are four submissions for homework and essays and each of them covers 10 lecture notes. The dates of submission will be announced. All homework and essays, handwriting or typed, should be turned into PDF files and be submitted through Blackboard Learn. Late homework is not acceptable. There is one final exam in multiple choice. Grading: 35% homework, 45% projects, 20 % Final exam.

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Math 4389 - Survey of Undergraduate Mathematics

Prerequisites:	**MATH 3331**, **MATH 3333**, and three hours of 4000-level Mathematics.
Text(s):	*No textbook is required. Instructor notes will be provided*
Description:	A review of some of the most important topics in the undergraduate mathematics curriculum.

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Math 4397 (21953) - Selected Topics in Mathematics

Prerequisites:	**Catalog Prerequisite:** MATH 3333 or consent of instructor.

Text(s):

- **Required Textbook**: Mathematical Methods in the Physical Sciences by Mary Boas, Third edition, Wiley. 9780471198260
- *Reference texts*:
  - Mathematics for Physicists, by Susan M. Lea, **ISBN**: 9780534379971; Cengage Learning
  - Advanced Engineering Mathematics, by Greenberg, **ISBN**: 9780133214314, Pearson
  - Mathematical Methods for Physics and Engineering by Riley, Hobson, and Bence: **ISBN**: 9780521679718, Cambridge University Press
  - Mathematical Physics; A Modern Introduction to Its Foundations by Sadri Hassani; **ISBN**: 9780387985794, Springer
  - An Introduction to Mathematical Methods of Physics by Lorella Jones; **ISBN**: 9780805351309, Benjamin-Cummings Publishing Company

**Any edition can be used for the reference texts*

- **Software**: You may use any mathematical assistant to check your work, but my recommendation is that you NEVER as a computer to do anything that you do not know how to do. You will have to do the work by hand on the examinations. UH recently purchased some licenses for Maple, and I recommend that you use it. You may purchase Maple at a 25% discount at the Maplesoft web store.

Description:

Course Content:

- A. Vector algebra review and vector calculus: Coordinate system construction, nonorthogonal coordinate systems, covariant and contravariant vector components, rotations, vector operators (divergence, curl, gradient, and Laplacian), integral theorems (Stokes' theorem and divergence theorem), line integrals and surface integrals, curvilinear coordinates, and dual vector spaces.
- B. Introduction to partial differential equations, boundary value problems, and special functions: Sturm-Liouville systems, boundary value problems, solutions to Laplace's equation, wave equation, Helmholtz equation, and Schrödinger equation in Cartesian, cylindrical coordinate systems, and spherical coordinate systems, sines and cosine functions and Legendre polynomials.
- C. Advanced techniques for solving partial differential equations, Bessel functions, modified Bessel functions, Hankel functions, spherical harmonics, Green functions, and applications of these topics to basic physics.

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ONLINE GRADUATE COURSES

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MATH 5331 (14246) - Linear Algebra with Applications

Prerequisites: **Graduate standing**.

Text(s): Linear Algebra Using MATLAB, Selected material from the text *Linear Algebra and Differential Equations Using Matlab* by Martin Golubitsky and Michael Dellnitz)
The text will made available to enrolled students free of charge.

Software: Scientific Note Book (SNB) 5.5 (available through MacKichan Software, http://www.mackichan.com/)

Syllabus: Chapter 1 (1.1, 1.3, 1.4), Chapter 2 (2.1-2.5), Chapter 3 (3.1-3.8), Chapter 4 (4.1-4.4), Chapter 5 (5.1-5.2, 5.4-5-6), Chapter 6 (6.1-6.4), Chapter 7 (7.1-7.4), Chapter 8 (8.1)

Project: Applications of linear algebra to demographics. To be completed by the end of the semester as part of the final.

Description:

Course Description: Solving Linear Systems of Equations, Linear Maps and Matrix Algebra, Determinants and Eigenvalues, Vector Spaces, Linear Maps, Orthogonality, Symmetric Matrices, Spectral Theorem

Students will also learn how to use the computer algebra portion of SNB for completing the project.

Homework: Weekly assignments to be emailed as SNB file.

There will be two tests and a Final.

Grading: Tests count for 90% (25+25+40), HW 10%

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MATH 5333 (14831) - Analysis

Prerequisites: **Graduate standing** and two semesters of Calculus.

Text(s): Analysis with an Introduction to Proof | Edition: 5, Steven R. Lay, 9780321747471

Description: A survey of the concepts of limit, continuity, differentiation and integration for functions of one variable and functions of several variables; selected applications.

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MATH 5382 (21959) - Probability

Prerequisites: **Graduate Standing. Instructor's prerequisite:** Calculus 3 (multi-dimensional integrals), very minimal background in Probability.

Text(s): Sheldon Ross, A First Course in Probability (10th Edition)

Description: This course is for students who would like to learn about Probability concepts; I'll assume very minimal background in probability. Calculus 3 (multi-dimensional integrals) is the only prerequisite for this class. This class will emphasize practical aspects, such as analytical calculations related to conditional probability and computational aspects of probability. No measure-theoretical concepts will be covered in this class. This is class is intended for students who want to learn more practical concepts in probability. This class is particularly suitable for Master students and non-math majors.

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MATH 5397 (21333) - Partial Differential Equations

Prerequisites: **Graduate standing**

Text(s):

Required Text: Walter A. Strauss, Partial Differential Equations: An Introduction, John Wiley & Sons

Course Site: This course will be hosted on Space (https://space.uh.edu). You will be able to go to this site and access the course on August 24, 2020.

Description:	**Course Material**: The primary goal of this course is to provide a conceptual introduction to the basic ideas encountered in partial differential equations, the techniques for analyzing these equations, and the ideas associated with the context of physical applications. The secondary goal is to expose students to Matlab methods for approximating the solutions to Partial Differential Equations. Students are not expected to have any previous experience with Matlab, and the software is free for all UH students. In addition to reading the text book, students will have access to weekly posted notes and videos associated with the course material. **Detailed Syllabus (PDF)**

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GRADUATE COURSES

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	MATH 6302 (13148) - Modern Algebra I
Prerequisites:	Graduate standing.
Text(s):	**Required Text**: Abstract Algebra by David S. Dummit and Richard M. Foote, ISBN: 9780471433347 This book is encyclopedic with good examples and it is one of the few books that includes material for all of the four main topics we will cover: groups, rings, field, and modules. While some students find it difficult to learn solely from this book, it does provide a nice resource to be used in parallel with class notes or other sources.
Description:	We will cover basic concepts from the theories of groups, rings, fields, and modules. These topics form a basic foundation in Modern Algebra that every working mathematician should know. The Math 6302--6303 sequence also prepares students for the department's Algebra Preliminary Exam.

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	MATH 6308 (15674)- Advanced Linear Algebra I
Prerequisites:	**Catalog Prerequisite**: Graduate standing, MATH 2331 and a minimum of 3 semester hours transformations, eigenvalues and eigenvectors. Instructor's Prerequisite: **MATH 2331**, or equivalent, and a minimum of three semester hours of 3000-4000 level Mathematics.
Text(s):	Linear Algebra, Fourth Edition, by S.H. Friedberg, A.J Insel, L.E. Spence,Prentice Hall, ISBN 0-13-008451-4
Description:	**Catalog Description**: An expository paper or talk on a subject related to the course content is required. **Instructor's Description:** The course covers the following topics: vector spaces, subspaces, linear combinations,systems of linear equations, linear dependence and linear independence, bases and dimension,linear transformations, null spaces, ranges, matrix rank, matrix inverse and invertibility,determinants and their properties, eigenvalues and eigenvectors, diagonalizability.

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	MATH 6312 (15672) - Introduction to Real Analysis
Prerequisites:	Graduate standing and **MATH 3334**. In depth knowledge of Math 3325 and Math 3333 is required.
Text(s):	Real Analysis, by N. L. Carothers; Cambridge University Press (2000), ISBN 978-0521497565

Description: This first course in the sequence Math 4331-4332 provides a solid introduction to deeper properties of the real numbers, continuous functions, differentiability and integration needed for advanced study in mathematics, science and engineering. It is assumed that the student is familiar with the material of Math 3333, including an introduction to the real numbers, basic properties of continuous and differentiable functions on the real line, and an ability to do epsilon-delta proofs.

Topics: Open and closed sets, compact and connected sets, convergence of sequences, Cauchy sequences and completeness, properties of continuous functions, fixed points and the contraction mapping principle, differentiation and integration.

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MATH 6320- Theory Functions of a Real Variable **[Hyflex]**: 13175 (**Online**) & 28138 (**Face-to-Face)**

Prerequisites: Graduate standing and Math 4332 (Introduction to real analysis).

Text(s): Real Analysis: Modern Techniques and Their Applications | Edition: 2, by: Gerald B. Folland, G. B. Folland. ISBN: 9780471317166

Description: Math 6320 / 6321 introduces students to modern real analysis. The core of the course will cover measure, Lebesgue integration, differentiation, absolute continuity, and L^p spaces. We will also study aspects of functional analysis, Radon measures, and Fourier analysis.

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MATH 6322 (21335) - Func. Complex Variable

Prerequisites: Graduate Standing. Math 3333 or consent of instructor.

Text(s): No textbook required. Lecture notes provided.

Description: This course is an introduction to complex analysis. It will cover the theory of holomorphic functions, Cauchy theorem and Cauchy integral formula, residue theorem, harmonic and subharmonic functions, and other topics

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MATH 6342 (13176) - Topology

Prerequisites: Graduate standing and **MATH 4331** and **MATH 4337**.

Text(s): (Required) Topology, A First Course, J. R. Munkres, Second Edition, Prentice-Hall Publishers.

link to text

Description:

Catalog Description: Point-set topology: compactness, connectedness, quotient spaces, separation properties, Tychonoff’s theorem, the Urysohn lemma, Tietze’s theorem, and the characterization of separable metric spaces

Instructor's Description: Topology is a foundational pillar supporting the study of advanced mathematics. It is an elegant subject with deep links to algebra and analysis. We will study general topology as well as elements of algebraic topology (the fundamental group and homology theories).

Though traditionally viewed as a pure subject, algebraic topology has experienced a renaissance in recent years with the emergence of applied algebraic topology. To wit, SIAM has recently launched a new journal on applied algebra and geometry.

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MATH 6350 (19912) - Statistical Learning and Data Mining

Prerequisites:

Graduate Standing and must be in the **MSDS Program.** Undergraduate Courses in basic Linear Algebra and basic descriptive Statistics

Text(s):

Recommended text: Reading assignments will be a set of selected chapters extracted from the following reference text:

- Introduction to Statistical Learning w/Applications in R, by James , Witten, Hastie, Tibshirani (This book is freely available online). **ISBN**: 9781461471370
- "Neural Networks with R” by G. Ciaburro. **ISBN**: 978-1788397872

Description:

Summary: A typical task of Machine Learning is to automatically classify observed "cases" or "individuals" into one of several "classes", on the basis of a fixed and possibly large number of features describing each "case". Machine Learning Algorithms (MLAs) implement computationally intensive algorithmic exploration of large set of observed cases. In supervised learning, adequate classification of cases is known for many training cases, and the MLA goal is to generate an accurate Automatic Classification of any new case. In unsupervised learning, no known classification of cases is provided, and the MLA goal is Automatic Clustering, which partitions the set of all cases into disjoint categories (discovered by the MLA).

Numerous MLAs have been developed and applied to images and faces identification, speech understanding, handwriting recognition, texts classification, stock prices anticipation, biomedical data in proteomics and genomics, Web traffic monitoring, etc.

This MSDSfall 2019 course will successively study :

1) Quick Review (Linear Algebra) : multi dimensional vectors, scalar products, matrices, matrix eigenvectors and eigenvalues, matrix diagonalization, positive definite matrices

2) Dimension Reduction for Data Features : Principal Components Analysis (PCA)

3) Automatic Clustering of Data Sets by K-means algorithmics

3) Quick Reviev (Empirical Statistics) : Histograms, Quantiles, Means, Covariance Matrices

4) Computation of Data Features Discriminative Power

5) Automatic Classification by Support Vector Machines (SVMs)

Emphasis will be on concrete algorithmic implementation and testing on actual data sets, as well as on understanding importants concepts.

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MATH 6357- Linear Models and Design of Experiments **[Hyflex]**: 20271 (**Online**) & 28141 (**Face-to-Face**)

Prerequisites:	**Graduate Standing** and must be in the **MSDS Program.** MATH 2433, MATH 3338, MATH 3339, and MATH 6308
Text(s):	Required Text: ”Neural Networks with R” by G. Ciaburro. **ISBN**: 9781788397872
Description:	Linear models with L-S estimation, interpretation of parameters, inference, model diagnostics, one-way and two-way ANOVA models, completely randomized design and randomized complete block designs.

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MATH 6358- Probability Models and Statistical Computing **[Hyflex]**: 18147 (**Online**) and 28142 (**Face-to-Face**)

Prerequisites: **Graduate Standing** and must be in the **MSDS Program.** MATH 3334, MATH 3338 and MATH 4378

Text(s):

- **Required:** Probability with Applications in Engineering, Science, and Technology, by Matthew A. Carlton and Jay L. Devore, 2014.
- *Recommended:* Introductory Statistics in R, Peter Dalgaard, 2nd ed., Springer, 2008
- *Recommended:* Introduction to Probability Models by Sheldon Axler 11th edition
- Lecture Notes

Description:

Course Description: Probability, independence, Markov property, Law of Large Numbers, major discrete and continuous distributions, joint distributions and conditional probability, models of convergence, and computational techniques based on the above.

Topics Covered:

- Probability spaces, random variables, axioms of probability.
- Combinatorial analysis (sampling with, without replacement etc)
- Independence and the Markov property. Markov chains- stochastic processes, Markov property, first step analysis, transition probability matrices. Longterm behavior of Markov chains: communicating classes, transience/recurrence, criteria for transience/recurrence, random walks on the integers.
- Distribution of a random variable, distribution functions, probability density function. Independence.
- Strong law of large numbers and the central limit theorem.
- Major discrete distributions- Bernoulli, Binomial, Poisson, Geometric. Modeling with the major discrete distributions.
- Important continuous distributions- Normal, Exponential. Beta and Gamma.
- Jointly distributed random variables, joint distribution function, joint probability density function, marginal distribution.
- Conditional probability- Bayes theorem. Discrete conditional distributions, continuous conditional distributions, conditional expectations and conditional probabilities. Applications of conditional probability.

Software Used:

- Make sure to download R and RStudio (which can't be installed without R) before the course starts. Use the link RStudio download to download it from the mirror appropriate for your platform.
- **New: Rstudio is in the cloud: RStudio.cloud.

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MATH 6360 (13736) - Applicable Analysis

Prerequisites:	**Graduate standing** and MATH 4331 or equivalent.
Text(s):	J.K. Hunter and B. Nachtergaele, Applied Analysis, World Scientific, (2005). ISBN: 9789812705433 A.W. Naylor and G.R. Sell, Linear Operator Theory in Engineering and Science, Springer. ISBN: 9780387950013
Description:	This course treats topics related to the solvability of various types of equations, and also of optimization and variational problems. The first half of the semester will concentrate on introductory material about norms, Banach and Hilbert spaces, etc. This will be used to obtain conditions for the solvability of linear equations, including the Fredholm alternative. The main focus will be on the theory for equations that typically arise in applications. In the second half of the course the contraction mapping theorem and its applications will be discussed. Also, topics to be covered may include finite dimensional implicit and inverse function theorems, and existence of solutions of initial value problems for ordinary differential equations and integral equations

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MATH 6366 (13177) - Optimization Theory

Prerequisites:	Graduate standing and **MATH 4331** and **MATH 4377** Students are expected to have a good grounding in basic real analysis and linear algebra.
Text(s):	"Convex Optimization", Stephen Boyd, Lieven Vandenberghe, Cambridge University Press, ISBN: 9780521833783 *(This text is available online. Speak to the instructor for more details)*
Description:	The focus is on key topics in optimization that are connected through the themes of convexity, Lagrange multipliers, and duality. The aim is to develop a analytical treatment of finite dimensional constrained optimization, duality, and saddle point theory, using a few of unifying principles that can be easily visualized and readily understood. The course is divided into three parts that deal with convex analysis, optimality conditions and duality, computational techniques. In Part I, the mathematical theory of convex sets and functions is developed, which allows an intuitive, geometrical approach to the subject of duality and saddle point theory. This theory is developed in detail in Part II and in parallel with other convex optimization topics. In Part III, a comprehensive and up-to-date description of the most effective algorithms is given along with convergence analysis.

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MATH 6370 - Numerical Analysis**:** 13178

Prerequisites:	**Graduate standing**. Students should have knowledge in Calculus and Linear Algebra.
Text(s):	Numerical Mathematics (Texts in Applied Mathematics), 2nd Ed., V.37, Springer, 2010. By A. Quarteroni, R. Sacco, F. Saleri. ISBN: 9783642071010
Description:	The course introduces to the methods of scientific computing and their application in analysis, linear algebra, approximation theory, optimization and differential equations. The purpose of the course to provide mathematical foundations of numerical methods, analyse their basic properties (stability, accuracy, computational complexity) and discuss performance of particular algorithms. This first part of the two-semester course spans over the following topics: (i) Principles of Numerical Mathematics (Numerical well-posedness, condition number of a problem, numerical stability, complexity); (ii) Direct methods for solving linear algebraic systems; (iii) Iterative methods for solving linear algebraic systems; (iv) numerical methods for solving eigenvalue problems; (v) non-linear equations and systems, optimization.

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MATH 6380 (20633) - Programming Foundation for Data Analytics

Prerequisites:	**Graduate Standing** and must be in the **MSDS Program.** **Instructor prerequisites:** The course is essentially self-contained. The necessary material from statistics and linear algebra is integrated into the course. Background in writing computer programs is preferred but not required.

Text(s):

- "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", by Wes McKinney, 2 edition, 2017, O'Reilly. (PD) Paper Book. **ISBN 13**: 9781491957660. *Available for free on **Safari** through **UH library**.*
- "Python for Everybody (Exploring Data in Python3)", by Dr. Charles Russell Severance, 2016, 1 edition, CreateSpace Independent Publishing Platform (PE) Paper Book. **ISBN 13**: 9781530051120

  Free online copy: https://books.trinket.io/pfe/index.html

Description:

Instructor's Description: The course provides essential foundations of Python programming language for developing powerful and reusable data analysis models. The students will get hands-on training on writing programs to facilitate discoveries from data. The topics include data import/export, data types, control statements, functions, basic data processing, and data visualization.

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MATH 6382 (17936) - Probability and Statistics

Prerequisites:

Graduate standing and **MATH 3334**, **MATH 3338** and **MATH 4378**.

Text(s):

Recommended Texts :
- A First Look at Rigorous Probability Theory, by Jeffrey Rosenthal, 2000. **ISBN**: 9789812703705
- An Intermediate Course in Probability Theory, by Allan Gut, Springer 2009 (any edition)

Review of Undergraduate Probability:
- A First Course in Probability, 6th Edit. by Sheldon Ross, 2002, Prentice Hall. **ISBN:** 9780321794772

Complementary Texts for further reading:
- Probability: Theory and Examples, 3rd Ed., Richard Durrett, Duxbury Press. **ISBN**: 9787506283403
- An Introduction to Probability Theory and Its Applications, Vol 1, by William Feller.
ISBN: 9780471257080
- Probability, by Leo Breiman, 1968, Addison-Wesley. **ISBN**: 9780898712964

Description:

General Background (A).
(1) Combinatorial analysis and axioms of probability
(2) Elementary random variables theory: expectation, variance, moments, distribution function, probability density functions, impact of change of variable on density functions
(3) Major discrete probability distributions: Bernoulli, Binomial, Poisson, Geometric
Major continuous probability distributions: Uniform, Normal, Exponential
(4) Basic Modelling Applications
(5) Conditional probability: Bayes formula, Independence, Conditional Expectation,
Conditional density function, Conditional Probability distribution, Independent identically distributed random variables
(6) Joint distributions, joint density functions, marginal distributions, marginal densities, covariances and correlation coefficients
(7) Moment generating functions, Characteristic functions,

Measure theory (B).
(1) Elementary measure theory : Boolean algebras, probability spaces , continuity of probabilities, Borel-Cantelli lemma, Chebychevs inequality,
(2) Convergence of random variables: Almost sure convergence, Convergence in distribution, Law of Large Numbers, Central Limit theorem

Markov chains and random walks (C).
Markov chain theory for finite or countable state spaces
(1) Markov property and Transition matrix, Irreducibility
(2) First hitting times, Transience, Recurrence ,
(3) Stationary distributions : existence theorems and computation
(4) Random walks on Z and Z2 as Markov chains; Gambler's ruin problem

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MATH 6384- Discrete Time Models in Finance: 17730

Prerequisites:	Graduate standing and **MATH 6382**.
Text(s):	Introduction to Mathematical Finance: Discrete-time Models, by Stanley Pliska, Blackwell, 1997. **ISBN**: 9781557869456
Description:	The course is an introduction to discrete-time models in finance. We start with single-period securities markets and discuss arbitrage, risk-neutral probabilities, complete and incomplete markets. We survey consumption investment problems, mean-variance portfolio analysis, and equilibrium models. These ideas are then explored in multiperiod settings. Valuation of options, futures, and other derivatives on equities, currencies, commodities, and fixed-income securities will be covered under discrete-time paradigms.

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MATH 6397 (21336) - Stochastic Models in Biology

Prerequisites:

Graduate standing. **Instructor's prerequisite**: Two semesters of calculus, undergraduate probability, some knowledge of differential equations and linear algebra

Text(s):

There is no required textbook, but the following will be useful as references:

- "An Introduction to Stochastic Modeling" by Howard M. Taylor and Samuel Karlin
- "Computational Cell Biology" edited by C. Fall,
- "Markov Processes: An Introduction for Physical Scientists" by D. Gillespie,
- "Stochastic Modeling for Systems Biology" by Darren Wilkinson, and
- "Stochastic Processes in Cell Biology" by P. Bressloff.

Description:

Instructor's description: In this course we will apply the theory of probability and stochastic processes to models of biological systems. Students taking the course should be comfortable with multivariate calculus, differential equations, linear algebra, as well as undergraduate level probability (I will not assume familiarity with measure theory).

Topics to be covered include: a review of probability, including numerical techniques for generating random samples, Markov processes with discrete and continuous space variables, diffusion processes, Wiener and Ornstein-Uhlenbeck processes, point processes, Gillespie’s algorithm and other algorithms for simulating stochastic processes and their application in biology. A portion of the course will be devoted to numerical simulations of stochastic systems using Python. For a more detailed overview of the course, see the lesson plan.

Computational component: Python There will be several computational challenges that will require the use of Python. There are numerous helpful tutorials to help you get started. I will also offer some suggestions in a separate note. Please use the Jupyter environment, as it makes the presentation a lot easier to follow.

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MATH 6397 (TBD) - Topics in Financial Machine Learning/Analytics in Commodity & Financial Markets

Prerequisites: **Graduate Standing** and must be in the **MSDS Program.**

Text(s):

Much of the material is drawn from these works:

- "An Introduction to Statistical Learning: with Applications in R", by James, Witten, Hastie, and Tibshirani
- "Advances in Financial Machine Learning" by Lopez de Prado
- "The Econometrics of Financial Markets", by Campbell, Lo, and MacKinlay
- "Data Analysis: A Bayesian Tutorial", by Sivia

Description:

This is an applied data analysis course focusing on financial and economic data. We will cover various kinds of analyses common in the field and, as much as possible, use multiple approaches to each case in order to demonstrate the strengths, weaknesses, and advantages of each technique. This is not intended to be a programming course. There are many examples done in R and you are welcome to use that language. If you are, or aspire to be a strong Python programmer, you are welcome to use that language also. Proficiency in basic probability and linear algebra is assumed. By the end of the course you may find your skills in those areas strengthened as well.

The goals for the course are to familiarize students with common types of economic and financial data, some of the statistical properties of this kind of data which usually involves time series, and to equip everyone with a thorough enough understanding of the techniques available for them to make the best decision on the approach to take in an analysis depending on the nature of the data and the specific purpose of the study.

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MATH 6397 (21337) - Computational Inverse Problems

Prerequisites:

Graduate standing. **Instructor's prerequisite:** Credit for or concurrent enrollment in MATH 4331 and MATH 4377/4378, or consent of instructor. Students are expected to have a good grounding in basic real analysis and linear algebra. Basic knowledge about optimization theory (MATH 6366/6367) is helpful but not required.

Text(s):

No particular textbook is required, but several good references for various topics related to inverse problems
(which go far beyond the material covered in class) include:

• Computational Methods for Inverse Problems by C. R. Vogel, SIAM 2002.
• Statistical and Computational Inverse Problems by J. Kaipio and E. Somersalo. Springer 2005.
• Discrete Inverse Problems: Insight and Algorithms by P. C. Hansen, SIAM 2010.
• An Introduction to the Mathematical Theory of Inverse Problems by A. Kirsch, Springer 2011.
• Optimization with PDE Constraints by M. Hinze, R. Pinnau, M. Ulbrich, and S. Ulbrich. Springer 2009.
• Perspectives in Flow Control and Optimization by M. D. Gunzburger. SIAM 2003.
• Convex Optimization by S. Boyd and L. Vandenberghe. Cambridge University Press 2004.
• Numerical Optimization by J. Nocedal and S. J. Wright. Springer 2006.

Description: **Instructor's Description**: Inverse problems are paramount importance and can be found in virtually all scientific disciplines with applications ranging from medicine, geophysics, to engineering. In many of these applications the forward or simulation problem, i.e., the solution of an underlying mathematical model to yield outputs given some inputs, is already a challenging task. Many applications require us to go beyond evaluating forward operators; we have to address what is often the ultimate goal: prediction and decision-making. This requires us to tackle mathematical challenges that comprise, and, therefore, are more difficult than the forward problem. One example is the solution of inverse problems. Here, we seek model inputs (or parameters) so that the output of the forward model matches observational data.

This course will introduce the theoretical foundations of inverse problems and strategies to their numerical solution. We will consider applications in data and physical sciences. Starting from first principles we will discuss how to design and analyze direct and iterative methods for efficiently solving different classes of inverse problems. Students will get to explore the design of computational strategies to solve these problems. Examples studied in the class will be selected from different areas of computational sciences and engineering, including deblurring, imaging, and continuum mechanics.

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MATH 6397 (21338) - Statistical Computing

Prerequisites: Graduate standing. **Instructor's prerequisite**: Two years of Calculus, Math 2331 Linear Algebra, and undergraduate probability and statistics (concepts), or equivalent, or approval by instructor.

Text(s): **Recommended books**:

Textbook: Maria Rizzo: Statistical Computing with R (Chapman & Hall/CRC The R Series) 2007. ISBN-13: 978-1584885450 ISBN-10: 1584885459 Edition: 1st

References:

- Efron, B and Tibshirani, R.: "An Introduction to the Bootstrap", Chapman Hall / CRC
- Trevor Hastie, Robert Tibshirani, Jerome Friedman: "The Elements of Statistical Learning", 2nd ed. Springer.
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani: "Introduction to Statistical Learning, with Applications" in R. Springer

Description: This course is designed for graduate students who have been exposed to basic probability and statistics and would like to learn more advanced statistical computing techniques in modeling data. The selected topics will include basic sampling techniques from known probability distributions, Monte Carlo estimation and testing, bootstrapping, permutation methods for testing, shrinkage model and variable selection with the Lasso, Tree-based methods and other statistical learning, such as the RandomForests, etc. The instructor reserves the right to exclude certain topics from the textbook and add other topics not covered in the textbook.

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MATH 6397 - High Dimensional Measures and Geometry: 21339

Prerequisites: Graduate standing. **Instructor's prerequisite**: A course on Probability and a graduate-level course on Analysis.

Texts (recomm.): The materials will be collected from the following recommended monographs.

- Roman Vershynin, High-Dimensional Probability: An Introduction with Applications in Data Science (Cambridge Series in Statistical and Probabilistic Mathematics), Cambridge University Press, 2018.
- Michel Ledoux, The Concentration of Measure Phenomenon, AMS, 2001.
- Holgert Rauhut and Simon Foucart, A Mathematical Introduction to Compressive Sensing, Birkh¨auser, 2013.

Topics papers:

Text(s):

- “An Elementary Proof of a Theorem of Johnson and Lindenstrauss” by Sanjouy Dasgupta and Anupam Gupta
- “A Simple Proof of the Restricted Isometry Property for Random Matrices” by Richard Baraniuk, Mark Davenport, Ronald DeVore, and Michael Wakin
- “Decoding by Linear Programming” by Emmanuel Cand`es and Terry Tao
- “The restricted isometry property and its implications for compressed sensing” by Emmanuel Cand`es,
- “Hastings’ additivity counterexample via Dvoretzky’s theorem” by Guillaume Aubrun, Stanislaw Szarek, and Elisabeth Werner

Description:

This course covers many aspects of the phenomenon that functions of small oscillation become nearly constant in high-dimensional spaces. This principle, developed by Milman for Banach spaces, has applications in geometry, probability and statistics, functional analysis, discrete mathematics and even in quantum information theory and complexity theory.

In an introductory part, some interesting features of Boolean cubes and Euclidean balls in high dimensions will be discussed. We will also see how integration with respect to a suitable Gaussian measure and with respect to the surface measure of the sphere are more and more indistinguishable in high dimensions.

The probabilistic aspects of the concentration of measure phenomenon start with the traditional laws of large numbers for independent random variables and random processes. When reformulated in a geometric fashion, this allows to find more general versions of this phenomenon. We will even establish a version of the central limit theorem for matrices! In the final part of the course, we will discuss applications ranging from compressed sensing and machine learning to quantum information theory.

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MATH 6397 - Applied and Computational Probability: 21960

Prerequisites: Graduate standing. Calculus 3 (multi-dimensional integrals), very minimal background in Probability.

Text(s): Sheldon Ross, A First Course in Probability (10th Edition)

Description: This course is for students who would like to learn about Probability concepts; I’ll assume very minimal background in probability. Calculus 3 (multi-dimensional integrals) is the only prerequisite for this class. This class will emphasize practical aspects, such as analytical calculations related to conditional probability and computational aspects of probability. No measure-theoretical concepts will be covered in this class. This is class is intended for students who want to learn more practical concepts in probability. This class is particularly suitable for Master students and non-math majors.

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MATH 6397 - Spatial Statistics: 30076

Prerequisites: Graduate standing and MATH 6382

Text(s):

Lectures will be based on lecture notes provided by the instructor.

Recommended Texts:

- "Statistical Methods for Spatial Data Analysis" by Schabenberger and Gotway, 2005; CRC Press
- "Statistics for Spatial Data" by Noel Cressie, revised edition, Wiley
- "Statistics for Spatio-temporal data" by Noel Cressie and Christopher K. Wikle, 1st edition, Wiley

Description:	This is a graduate level course (multidisciplinary, for Master as well as PhD students) that gives a general overview of the field of spatial and spatio-temporal statistics. Students will learn concepts and statistical methods for real data with spatial and temporal dependence. Course material will be applied in nature although some discussion on theory and technical contents will be given (will be kept at minimal level). Students will learn to analyze spatial and spatio-temporal data, mainly using R and thus some programming experience with R, or similar languages such as matlab is necessary. Various real data application examples will be given during lectures. Students will learn to make prediction in space and time based on the analysis results of spatial and spatio-temporal data. There will be a semester-long project (could be team or individual, depending on enrollment) on real applications, and they are welcome to work on data that come from their own graduate research (as long as they are appropriate for spatial or spatio-temporal analysis). Statistical Software: R (http://r-project.org)

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MATH 7320- Functional Analysis: 21334

Prerequisites:	Graduate standing. **Instructor's Prerequisite**: MATH 6308, Math 6320, and Math 6342, or the approval of the instructor. For this course, you need to have a strong background in real analysis and linear algebra, and a good background in measure theory and topology
Text(s):	A Course in Functional Analysis by John B. Conway, Second Edition.
Description:	**Instructor's Description**: Banach spaces, Hilbert spaces, linear operators on Hilbert spaces, weak topologies.

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