Department of Mathematics

Fall 2019

*(**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**.)*

GRADUATE COURSES - FALL 2019

SENIOR UNDERGRADUATE COURSES

Course	Section	Course Title	Course Day & Time	Rm #	Instructor
Math 4310	26074	Biostatistics	TuTh, 1—2:30pm	MH 140	D. Labate
Math 4320	16736	Intro to Stochastic Processes	MWF, 10—11am	SEC 103	I. Timofeyev
Math 4322	27531	Introduction to Data Science and Machine Learning	MWF, 11am—Noon	SEC 102	C. Poliak / W. Wang
Math 4331	19930	Introduction to Real Analysis I	TuTh, 8:30—10am	F 154	B. Bodmann
Math 4335	22583	Partial Differential Equations I	MWF, 9—10am	CBB 214	G. Jaramillo
Math 4339	28362	Multivariate Statistics	(online)	(online)	J. Morgan
Math 4339	28373	Multivariate Statistics	TuTh, 1—2:30pm	ARC 402	C. Poliak
Math 4364	20801	Introduction to Numerical Analysis in Scientific Computing	MW, 4—5:30pm	SEC 104	T-W. Pan
Math 4366	21616	Numerical Linear Algebra	TuTh, 11:30am-1pm	SW 229	J. He
Math 4377	19933	Advanced Linear Algebra I	TuTh, 10—11:30am	F 154	A. Vershynina
Math 4383	25435	Number Theory and Cryptopgraphy	MW, 1—2:30pm	AH 12	M. Ru
Math 4388	18566	History of Mathematics	(online)	(online)	S. Ji
Math 4389	17781	Survey of Undergraduate Mathematics	MW, 1-2:30pm	SEC 202	M. Almus
Math 4397	27370	Mathematical Methods for Physics	MW, 2:30—4pm	CBB 124	L. Wood

GRADUATE ONLINE COURSES

Course	Section	Course Title	Course Day & Time	Instructor
Math 5331	18067	Linear Algebra with Applications	Arrange (online course)	K. Kaiser
Math 5333	18856	Analysis	Arrange (online course)	G. Etgen
Math 5383	25706	Number Theory	Arrange (online course)	M. Ru
Math 5385	17472	Statistics	Arrange (online course)	J. Morgan

GRADUATE COURSES

Course	Section	Course Title	Course Day & Time	Rm #	Instructor

Math 6302	16741	Modern Algebra I	TuTh, 11:30am—1pm	SW 2019	M. Kalantar
Math 6308	19935	Advanced Linear Algebra I	TuTh, 8:30am—10am	F 154	A. Vershynina
Math 6308	TBA	Advanced Linear Algebra I	TBA	TBA	TBA
Math 6312	19931	Introduction to Real Analysis	TuTh, 8:30—10am	F 154	B. Bodmann
Math 6320	16770	Theory of Functions of a Real Variable	TuTH, 1—2:30pm	CAM 101	W. Ott
Math 6326	28709	Partial Differential Equations	TuTh, 11:30am—1pm	SEC 105	G. Auchmuty
Math 6342	16771	Topology	MWF, 10—11am	CBB 214	D. Blecher
Math 6360	17453	Applicable Analysis	TuTh, 2:30—4pm	AH 208	A. Mamonov
Math 6366	16772	Optimization Theory	MWF, Noon—1pm	AH 301	A. Mang
Math 6370	16773	Numerical Analysis	MW, 4—5:30pm	CBB 214	M. Olshanskiy
Math 6382	22891	Probability and Statistics	TuTh, 10—11:30am	AH 301	M. Nicol
Math 6384	22588	Discrete Time Model in Finance	TuTh, 2:30-4pm	SW 423	E. Kao
Math 6395	25708	Spectral & Operator Theory	MWF, 9—10am	CBB 120	A. Czuron
Math 7326	25412	Dynamical Systems	MWF, Noon—1pm	AH 202	V. Climenhaga
Math 7396	25411	Preconditioned Iterative Methods for Large Scale Problems	MW, 1—2:30pm	CBB 214	Y. Kuznetsov

MSDS Courses *(MSDS Students Only)*

Course	Section	Course Title	Course Day & Time	Rm #	Instructor
Math 6350	26102	Statistical Learning and Data Mining	MW, 1—2:30pm	CBB 214	R. Azencott
Math 6357	28361	Linear Models & Design of Experiments	MW, 4—5:30pm	SEC 202	W. Wang / W. Fu
Math 6358	23164	Probability Models and Statistical Computing	Fr, 1—3:00pm	AH 301	C. Poliak
Math 6380	29420	Programming Foundation for Data Analytics	Fr, 3—5pm	SEC 202	D. Shastri
Math 6397	26096	Topics in Financial Machine Learning/Analytics in Commodity & Financial Markets	W, 5:30—8:30pm	AH 204	D. Zimmerman

--Course Details---

SENIOR UNDERGRADUATE COURSES

Math 4310 - Biostatistics

Prerequisites: **MATH 3339** and **BIOL 3306**

Text(s): "Biostatistics: A Foundation for Analysis in the Health Sciences, Eleventh Edition, by Wayne W. Daniel, Chad L. Cross. **ISBN**: 9781119496700

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.

<< back to top >>

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.

<< back to top >>

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

Description:

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.

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

<< back to top >>

Math 4331 - Introduction to Real Analysis

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.

<< back to top >>

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.

<< back to top >>

Math 4339 (28362) - Multivariate Statistics

Prerequisites:	**MATH 3349**
Text(s):	• Applied Multivariate Statistical Analysis (6th Edition), Pearson. Richard A. Johnson, Dean W. Wichern. **ISBN**: 978-0131877153 (**Required**) • An Introduction to Statistical Learning, with Applications in R. by G. James, D. Witten, T. Hastie and R. Tibshirani, Springer. **ISBN**: 978-1461471370 *(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. Course Objectives: • 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 Course Topics: • 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)

<< back to top >>

Math 4339 (28373) - 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.

Course Objectives:

- 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

Course Topics:

- 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)

<< back to top >>

Math 4364 (20801) - 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.

<< back to top >>

<< back to top >>

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

<< back to top >>

Math 4377 (19933) - 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.

<< back to top >>

Math 4383 (25435) - Number Theory and Cryptography

Prerequisites:	MATH 3330 or MATH 3336
Text(s):	Instructor Notes. ***Recommended texts***: • “Beginning Number Theory” Edition: 2, by Neville Robbins. **ISBN**: 9780763737689; Jones & Bartlett Learning • "Elementary Number Theory" Edition 7, by David Burton. **ISBN**: 9780073383149; McGraw-Hill Higher Education
Description:	**Catalog Description**: Divisibility theory, primes and their distribution, theory of congruences and application in security, integer representations, Fermat’s Little Theorem and Euler’s Theorem, primitive roots, quadratic reciprocity, and introduction to cryptography

<< back to top >>

<< back to top >>

Math 4388 - History of Mathematics

Prerequisites:	**MATH 3333**
Text(s):	*No textbook is required. Instructor notes will be provided*

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.

Description:

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.

<< back to top >>

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.

<< back to top >>

Math 4397 (27370) - Mathematical Methods for Physics

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.

<< back to top >>

ONLINE GRADUATE COURSES

<< back to top >>

MATH 5331 - 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.

Description:	**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. **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%

<< back to top >>

MATH 5333 - 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.

<< back to top >>

TBD

Prerequisites:	**TBD**
Text(s):	TBD
Description:	TBD

<< back to top >>

MATH 5383 - Number Theory

Prerequisites:	**Graduate standing**
Text(s):	Instructor's lecture notes. The reference book will be "Beginning Number Theory" by Neville Robbins, second Edition.
Description:	Number theory is a subject that has interested people for thousand of years. This course is a one-semester long graduate course on number theory. Topics to be covered include divisibility and factorization, linear Diophantine equations, congruences, applications of congruences, solving linear congruences, primes of special forms, the Chinese Remainder Theorem, multiplicative orders, the Euler function, primitive roots, quadratic congruences, and introduction to cryptography . There'll be no specific prerequisites beyond basic algebra and some ability in reading and writing mathematical proofs.

<< back to top >>

MATH 5385 - Statistics (17472)

Prerequisites:	**Graduate standing**.
Text(s):	• Applied Multivariate Statistical Analysis (6th Edition), Pearson. Richard A. Johnson, Dean W. Wichern. **ISBN**: 978-0131877153 (**Required**) • An Introduction to Statistical Learning, with Applications in R. by G. James, D. Witten, T. Hastie and R. Tibshirani, Springer. **ISBN**: 978-1461471370 *(Recommended)*
Description:	Data collection and types of data, descriptive statistics, probability, estimation, model assessment, regression, analysis of categorical data, analysis of variance. Computing assignments using a prescribed software package (e.g., EXCEL, Minitab) will be given.

<< back to top >>

GRADUATE COURSES

<< back to top >>

MATH 6302 - 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.

<< back to top >>

MATH 6308 (19935)- 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.

<< back to top >>
<< back to top >>

MATH 6312- 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.

<< back to top >>

MATH 6320 - Theory Functions of a Real Variable

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.

<< back to top >>

MATH 6326 - Partial Differential Equations

Prerequisites: Graduate Standing and MATH 4331.

Text(s):

Required: The instructor will provide notes on much of the material for the course and there is no prescribed text.

Recommended Texts: The course will cover the material in the first three chapters of ”Hilbert Space Methods in Partial Differential Equations” by Ralph E. Showalter (Dover or free online) and some of the text ”Elliptic Equations: An Introductory Course”,by Michel Chipot, Birkhauser, 2009. The Universitext ”Functional Analysis, Sobolev Spaces and Partial Differential Equations” by Haim Brezis, Springer 2011 provides a thorough treatment of the functional analysis used. These three texts may be good reference texts for the material treated in the course.

Description:

Course Outline: This course will provide an introduction to the modern theory of elliptic partial differential equations using Sobolev space methods. The prerequisite is competence in multivariable calculus and real analysis. Ideally a student should have done well in M6320- 21 and having a working knowledge of Lebesgue integration and some Fourier analysis. The basic constructions of linear analysis in Hilbert and Banach spaces will be assumed known.

The first lectures will provide an introduction to boundary value problems for elliptic PDEs and describe the types of results that will be obtained. In particular weak formulations of various boundary problems and the background to finite element modeling of the problems will be described. Some results about the formulations typically used for numerical simulations will be treated in the course.

To do this the calculus of weak derivatives and the associated Sobolev function spaces needed for weak formulations of boundary value problems will be studied. Various results needed for the existence and properties of solutions of partial differential equations will be proved.

There will be an emphasis on important examples from applications involving equations posed on bounded subsets of RN with $1 \leq N \leq 3$.

<< back to top >>

<< back to top >>

MATH 6342 - 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.

<< back to top >>

MATH 6350 - 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.

<< back to top >>

MATH 6357 - Linear Models and Design of Experiments

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.

<< back to top >>

MATH 6358 - Probability Models and Statistical Computing

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.

<< back to top >>

MATH 6360 - 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

<< back to top >>

MATH 6366 - 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.

<< back to top >>

MATH 6370 - Numerical Analysis

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.

<< back to top >>

MATH 6380 - 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.

<< back to top >>

MATH 6382 - 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

<< back to top >>

MATH 6384 - Discrete Time Model in Finance

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.

<< back to top >>

MATH 6395 (25708) - Spectral & Operator Theory

Prerequisites: Graduate standing.

Text(s):

- "Banach spaces for Analysts", P. Wojtaszczyk

- "Functional Analysis", by W. Rudin

Description:

Instructor's description: The course is designed to give an introduction to various concepts of mathematical analysis. The course is divided onto two parts. First parts covers classical functional analysis and spectral theory. In the second part we focus on some specific topics in analysis.

Course Content:

- 3.1 First Part The topics in functional analysis will include: Open Mappin Theorem, Closed Graph Theorem, Banach-Steinhaus Theorem, Hahn-Banach Theorem, Riesz-Thorin Theorem, Marcinkiewicz Theorem, Kintchine's inequality, type and cotype inequalities, spectral theorem, functional calculus and other basic concepts in functional analysis.
- 3.2 Second Part In the second part we cover some topics in analysis. The following list contains some propositions of the topics. 1. Absolutely summing operators. 2. Bounded approximation property. 3. Bases in Banach spaces. 4. Expanders and non-linear spectral gap. 5. Coarse embeddings.

<< back to top >>

MATH 6397 (26096) - 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.

<< back to top >>

MATH 7326 (25412) - Dynamical Systems

Prerequisites: Graduate standing. **Instructor's prerequisite:** Undergraduate real analysis (Math 4331-4332 or equivalent) and undergraduate differential equations (Math 3331 or equivalent), or consent of instructor.Â Some background in measure theory and graduate level ODE would be helpful, but will not be assumed, and any relevant notions from these areas will be introduced as they appear.

Text(s):

There is no required textbook. Â The more in-depth arguments in the course will largely be drawn from the primary literature (references will be provided) or from the book "One-dimensional dynamics" by Wellington de Melo and Sebastian van Strien, which is out of print but available free in pdf form from the second author's website: http://wwwf.imperial.ac.uk/~svanstri/

Some of the history of the subject is discussed in "Chaos: Making a New Science" by James Gleick, **ISBN**: 9780143113454, and an undergraduate-level introduction to some of the topics is given in "Nonlinear Dynamics and Chaos" by Steven Strogatz **ISBN**: 9780813349107, so these books are worth looking at and I will draw from both to some extent, but neither is required for this course.

Description:

Catalog Description:

Instructor's Description: This course will introduce the qualitative study of dynamical systems via historically and scientifically important examples such as the three-body problem, nonlinear oscillators, the Lorenz system, and the logistic map.

These examples illustrate how systems evolving in time according simple deterministic rules can exhibit complicated "chaotic" behavior. Â Each of these systems depends on one or more parameters, and a central part of the course will be to study how the qualitative behavior of the system changes (or does not change) as the parameters vary.Â This will lead us to discuss topics such as KAM theory, phase locking, bifurcations, period-doubling cascades, renormalization, and parameter exclusion.

The topics to be covered in this course are largely distinct from the topics covered in previous edition of Math 7326 that I taught in Spring 2017, so students who took that class would benefit from taking this one as well.

<< back to top >>

TBD- TBD

Prerequisites: Graduate standing.

Text(s):

Description:

<< back to top >>

MATH 7396 - Preconditioned Iterative Methods for Large Scale Problems

Prerequisites: Graduate standing. **Instructor's Prerequisite**: Graduate Course on Numerical Analysis

Text(s): None

Description: **Instructor's Description**: Finite Element, Finite Volume, and Finite Difference discretizations of partial differential equations result in large scale systems of linear algebraic equations with sparse ill-conditioned matrices. Preconditioned iterative methods are the only way for efficient solution of such systems. The course consists in four major parts. In the first part, we recall basic information on preconditioned Conjugate Gradient and Generalized Minimal Residual methods. In the second part, we describe properties of matrices arising from discretizations of differential problems. The third part is devoted to several major approaches for designing of efficient preconditioners based on Domain Decomposition and Fictitious Domain algorithms. Finally, we consider applications of preconditioned Iterative methods for solving of steady-state and time-dependent diffusion and convection-diffusion problems.

<< back to top >>

<< back to top >>