Department of Mathematics

Spring 2016

GRADUATE COURSE SPRING 2016 - (01/19/16–05/16/16)

SENIOR UNDERGRADUATE COURSES

Course	Sec #	Course Title	Course Day & Time	Rm #	Instructor
Math 4309	16653	Mathematical Biology	MWF, 10-11 a.m.	SEC 201	Z. Kilpatrick
Math 4332/6313	12556/14457	Introduction to Real Analysis	TuTh, 2:30-4 p.m.	F 154	B. Bodmann
Math 4335	20432	Partial Differential Equations	TuTh, 4-5:30 p.m.	AH 301	Y. Gorb
Math 4364	22165	Numerical Analysis in Scientific Computing	MW, 4-5:30 p.m.	SEC 203	T. Pan
Math 4365	18961	Numerical Differential Equations	MW, 1-2:30 p.m.	TBA	R. Hoppe
Math 4377/6308	15306/14458	Advanced Linear Algebra I	TuTh, 10-11:30 a.m.	SEC 201	A. Torok
Math 4377/6308	20437/20438	Advanced Linear Algebra I (online)	Online	Online	J. Morgan
Math 4378/6309	12557/14459	Advanced Linear Algebra II	TuTh, 11:30-1 p.m.	F 154	D. Wagner
Math 4380	12558	A Mathematical Introduction to Options	MW, 1-2:30 p.m.	CBB 214	I. Timofeyev
Math 4389	12559	Survey of Undergraduate Mathematics	Online	Online	M. Almus
Math 4397	22166	Numerical Linear Algebra	MW, 1-2:30 p.m.	SW 102	Y. Kuznetsov

GRADUATE ONLINE COURSES

Course	Section	Course Title	Course Day & Time	Instructor
Math 5330	14251	Abstract Algebra	Arrange (online course)	K. Kaiser
Math 5332	12585	Differential Equations	Arrange (online course)	G. Etgen
Math 5333	18436	Analysis	Arrange (online course)	S. Ji
Math 5386	16176	Regression and Linear Models	Arrange (online course)	C. Peters

GRADUATE COURSES

Course	Section	Course Title	Course Day & Time	Rm #	Instructor
Math 6303	12592	Modern Algebra II	MW, 1-2:30 p.m.	MH 138	G. Heier
Math 6304	22169	Theory of Matrices	TuTh, 10-11:30 a.m.	MH 113	B. Bodmann
Math 6308	14458	Advanced Linear Algebra I	TuTh, 10-11:30 a.m.	SEC 201	A. Torok
Math 6308	20438	Advanced Linear Algebra I (online)	Online	Online	J. Morgan
Math 6309	14459	Advanced Linear Algebra II	TuTh, 11:30-1 p.m.	F 154	D. Wagner
Math 6313	14457	Introduction to Real Analysis	TuTh, 2:30-4 p.m.	F 154	B. Bodmann
Math 6321	12609	Theory of Functions of a Real Variable	MWF, 10-11 a.m.	AH 9	V. Climenhaga

Math 6323	22172	Theory of Functions of a Complex Variable	MWF, 11 a.m.-12 p.m.	AH 301	S. Ji
Math 6327	22174	Partial Differential Equations	TuTh, 4-5:30 p.m.	AH 301	M. Perepelitsa
Math 6361	14461	Applicable Analysis	MW, 4-5:30 p.m.	C 108	D. Onofrei
Math 6367	12610	Optimization and Variational Methods	TuTh, 11:30 a.m.-1 p.m.	M 104	J. He
Math 6371	12611	Numerical Analysis	TuTh, 4-5:30 p.m.	C 113	A. Quaini
Math 6378	19049	Basic Scientific Computing	TuTh, 1-2:30 p.m.	CAM 105	R. Sanders
Math 6383	12612	Probability Models and Mathematical Statistics	TuTh, 10-11:30 a.m.	MH 120	W. Fu
Math 6385	12613	Continuous-Time Models in Finance	TuTh, 2:30-4 p.m.	M 104	E. Kao
Math 6395	25733	C*-Algebras Associated with Dynamical Systems	TuTh, 4-5:30 p.m.	AH 2	M. Tomforde
Math 6397	22179	Hyperbolic Conservation Laws and Numerical Solutions	TuTh, 2:30-4 p.m.	AH 7	J. Qiu
Math 6397	22180	Stochastic Processes	MW, 4-5:30 p.m.	AH 301	I. Timofeyev
Math 6397	22187	Research Directions in Dynamical Systems and Related Fields	TuTh, 1-2:30 p.m.	SW 423	W. Ott
Math 6397	22190	Data Mining and Machine Learning	TuTh, 8:30-10:00 a.m.	SEC 203	R. Azencott
Math 7350	12672	Geometry of Manifolds	MW, 5:30-7 p.m.	AH 301	G. Heier
Math 7397	22195	Financial and Energy Time Series Analysis	TuTh, 10:00-11:30 a.m.	SW 219	E. Kao

--Course Details---

SENIOR UNDERGRADUATE COURSES

Math 4309 - Mathematical Biology

Prerequisites:	MATH 3331 and BIOL 3306 or consent of instructor. **Instructor's Prerequisite Notes**: Linear Algebra (MATH 2331) and Differential Equations (MATH 3321 or MATH 3331)
Text(s):	Mathematical Models in Biology by Leah Edelstein-Keshet (2005); ISBN-13:978-0898715545
Description:	Topics in mathematical biology, epidemiology, population models, models of genetics and evolution, network theory, pattern formation, and neuroscience. Students may not receive credit for both MATH 4309 and BIOL 4309. **Additional Instructor's notes:** This course introduces and analyzes a variety of mathematical models of biological systems at the molecular, cellular, and population levels. Applications to enzyme kinetics, population dynamics, gene expression, epidemiology, and neuroscience will all be discussed. Studying these systems will require mathematical techniques for dynamical systems, stochastic processes, pattern formation, and matrix analysis.

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Math 4332 - Introduction to Real Analysis II

Prerequisites:	MATH 4331 or consent of instructor
Text(s):	Real Analysis with Real Applications | Edition: 1; Allan P. Donsig, Allan P. Donsig; ISBN: 9780130416476

Description:	Further development and applications of concepts from MATH 4331. Topics may vary depending on the instructor's choice. Possibilities include: Fourier series, point-set topology, measure theory, function spaces, and/or dynamical systems.

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Math 4335 - Partial Differential Equations I

Prerequisites:	MATH 3331 or equivalent, and three additional hours of 3000–4000 level Mathematics.
Text(s):	Partial Differential Equations: An Introduction | Edition: 2; Walter A. Strauss ;ISBN: 9780470054567
Description:	Initial and boundary value problems, waves and diffusions, reflections, boundary values, Fourier series. **Additional Notes:** A partial differential equation (PDE) is an equation that states a relationship between a function of two or more independent variables and the partial derivatives of this function with respect to these independent variables. PDEs arise in all fields of engineering and science. Most physical processes are governed by PDEs. In this one-semester introductory course for PDEs we will consider three basic classes (elliptic, parabolic and hyperbolic) of PDEs and discuss two types of physical problem (equilibrium and propagation ones). Topics covered in class will include but not limited to the following: initial and boundary value problems; waves and diffusions; separations of variables; Dirichlet, Neumann and Robin boundary conditions; Fourier series; harmonic functions.

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Math 4364 - Numerical Analysis in Scientific Computing

Prerequisites:	MATH 3331 and COSC 1410 or equivalent or consent of instructor. **Instructor's Prerequisite Notes:** 1. MATH 2331, In depth knowledge of Math 3331 (Differential Equations) or Math 3321 (Engineering Mathematics) 2. 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, ISBN: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 4365 - Numerical Methods for Differential Equations

Prerequisites: MATH 3331, or equivalent, and three additional hours of 3000–4000 level Mathematics.

Text(s): TBA

Description: Numerical differentiation and integration, multi-step and Runge-Kutta methods for ODEs, finite difference and finite element methods for PDEs, iterative methods for linear algebraic systems and eigenvalue computation.

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Math 4377 - Advanced Linear Algebra I

Prerequisites: MATH 2331 or equivalent, and three additional hours of 3000–4000 level Mathematics.

Text(s): Linear Algebra | Edition: 4; Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence; ISBN: 9780130084514

Description: Linear systems of equations, matrices, determinants, vector spaces and linear transformations, eigenvalues and eigenvectors.

Additional Notes: This is a proof-based course. It will cover Chapters 1-4 and the first two sections of Chapter 5. Topics include systems of linear equations, vector spaces and linear transformations (developed axiomatically), matrices, determinants, eigenvectors and diagonalization.

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Math 4377 - Advanced Linear Algebra I *(Online)*

Prerequisites: MATH 2331 or equivalent, and six additional hours of 3000–4000 level Mathematics.

Text(s): Linear Algebra | Edition: 4; Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence; ISBN: 9780130084514

Description: Linear systems of equations, matrices, determinants, vector spaces and linear transformations, eigenvalues and eigenvectors.

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Math 4378 - Advanced Linear Algebra II

Prerequisites: MATH 4377

Text(s): TBA

Description: Similarity of matrices, diagonalization, Hermitian and positive definite matrices, normal matrices, and canonical forms, with applications..

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Math 4380 - A Mathematical Introduction to Options

Prerequisites: MATH 2433 and MATH 3338.

Text(s): An Introduction to Financial Option Valuation: Mathematics, Stochastics and Computation | Edition: 1; Desmond Higham; 9780521547574

Description: Arbitrage-free pricing, stock price dynamics, call-put parity, Black-Scholes formula, hedging, pricing of European and American options.

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Math 4389 - Survey of Undergraduate Mathematics

Prerequisites: MATH 3330, MATH 3331, MATH 3333, and three hours of 4000-level Mathematics.

Text(s): Instructor will use her own notes

Description: A review of some of the most important topics in the undergraduate mathematics curriculum.

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Math 4397 - Selected Topics in Mathematics *(Numerical Linear Algebra)*

Prerequisites: MATH 3333, MATH 3334, or MATH 3330 and consent of instructor.

Text(s): TBA

Description: TBA

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ONLINE GRADUATE COURSES

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MATH 5330 - Abstract Algebra

Prerequisites: Graduate standing.

Text(s): *Abstract Algebra , A First Course* by Dan Saracino. Waveland Press, Inc. ISBN 0-88133-665-3 (You can use the first edition. The second edition contains additional chapters that cannot be covered in this course.)

Description: Groups, rings and fields; algebra of polynomials, Euclidean rings and principal ideal domains. Does not apply toward the Master of Science in Mathematics or Applied Mathematics.

Other Notes: This course is meant for students who wish to pursue a Master of Arts in Mathematics (MAM). Please contact me in order to find out whether this course is suitable for you and/or your degree plan. *Notice that this course **cannot** be used for MATH 3330, Abstract Algebra.*

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MATH 5332 - Differential Equations

Prerequisites: Graduate standing. MATH 5331 or consent of instructor.

Text(s): TBA

Description: Linear and nonlinear systems of ordinary differential equations; existence, uniqueness and stability of solutions; initial value problems; higher dimensional systems; Laplace transforms. Theory and applications illustrated by computer assignments and projects. Applies toward the Master of Arts in Mathematics degree; does not apply toward the Master of Science in Mathematics or the Master of Science in Applied Mathematics degrees.

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MATH 5333 - Analysis

Prerequisites: Graduate standing. Two semesters of calculus or consent of instructor.

Text(s): Analysis with an Introduction to Proof | Edition:5; Lay; ISBN: 9780321747471; Pearson

Description:	A survey of the concepts of limit, continuity, differentiation and integration for functions of one variable and functions of several variables; selected applications. Applies toward the Master of Arts in Mathematics degree; does not apply towards the Master of Science in Mathematics or the Master of Science in Applied Mathematics degrees. **Additional Notes:** This course is an introduction to Analysis. It will cover limit, continuity, differentiation and integration for functions of one variable and functions of several variables, and some selected applications. More precisely, it will cover the textbook from the chapter 3 to the chapter 7 (skip the section 15 and the section 24). On-line course is taught through Blackboard Learn, visit https://accessuh.uh.edu/login.php for information on obtaining ID and password. Homework: Homework will be submitted through Blackboard Learn by pdf file. The deadline for each homework assignment can be found in Blackboard Learn. No late homework assignments accepted. Exams: There are two exams. The mid-term exam, and the comprehensive final exam. The dates are to be dertermined

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MATH 5386 - Regression and Linear Models

Prerequisites:	Graduate standing. Two semesters of calculus, one semester of linear algebra, and MATH 5385, or consent of instructor.
Text(s):	Introduction to Linear Regression Analysis | Edition:5; Montgomery, Peck, Vining; ISBN: 9780470542811; Wiley
Description:	Simple and multiple linear regression, linear models, inferences from the normal error model, regression diagnostics and robust regression, computing assignments with appropriate software. Applies toward Master of Arts in Mathematics degree; does not apply toward the Master of Science in Mathematics or the Master of Science in Applied Mathematics degrees. **Note**: This course is VEE approved for the regression component only. Approval Code: 4458-11008. For more information on VEE approved courses, click here.

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MATH 5397 - Applied Linear Algebra by Numerical Methods- **Cancelled**

Prerequisites:	N/A
Text(s):	N/A
Description:	N/A

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MATH 6303 - Modern Algebra II

Prerequisites:	Graduate standing. MATH 4378 or consent of instructor.
Text(s):	TBA
Description:	Topics from the theory of groups, rings, fields, and modules with special emphasis on universal constructions.

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MATH 6304 - Theory of Matrices

Prerequisites: Graduate standing. Consent of instructor

Text(s): TBA

Description: Emphasis on canonical forms and finite dimensional spectral theory.

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MATH 6308:14458 - Advanced Linear Algebra I

Prerequisites: Graduate standing. MATH 2331 or equivalent, and three additional hours of 3000–4000 level Mathematics.

Text(s): Linear Algebra | Edition: 4; Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence; ISBN: 9780130084514

Description: Transformations, eigenvalues and eigenvectors.

Additional Notes: This is a proof-based course. It will cover Chapters 1-4 and the first two sections of Chapter 5. Topics include systems of linear equations, vector spaces and linear transformations (developed axiomatically), matrices, determinants, eigenvectors and diagonalization.

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MATH 6308:20438 - Advanced Linear Algebra I *(online)*

Prerequisites: Graduate standing. MATH 2331 or equivalent, and six additional hours of 3000–4000 level Mathematics.

Text(s): Linear Algebra | Edition: 4; Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence; ISBN: 9780130084514

Description: Transformations, eigenvalues and eigenvectors. An expository paper or talk on a subject related to the course content is required

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MATH 6309 - Advanced Linear Algebra II

Prerequisites: Graduate standing and MATH 6308

Text(s): TBA

Description: Similarity of matrices, diagonalization, hermitian and positive definite matrices, canonical forms, normal matrices, applications. An expository paper or talk on a subject related to the course content is required.

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MATH 6313 - Introduction to Real Analysis II

Prerequisites: Graduate standing and MATH 6312 or consent of instructor.

Text(s): TBA

Description: Properties of continuous functions, partial differentiation, line integrals, improper integrals, infinite series, and Stieltjes integrals. An expository paper or talk on a subject related to the course content is required.

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MATH 6321 - Theory of Functions of a Real Variable

Prerequisites:	Graduate standing. MATH 4332 or consent of instructor. **Instructor's Prerequisite Notes:** MATH 6320
Text(s):	Primary (Required): Real Analysis: Modern Techniques and Their Applications, Gerald Folland (2nd edition); ISBN: 9780471317166 Supplementary (Recommended): Real Analysis for Graduate Students, Richard F. Bass, (2nd edition); ISBN: 9781481869140
Description:	Lebesque measure and integration, differentiation of real functions, functions of bounded variation, absolute continuity, the classical Lp spaces, general measure theory, and elementary topics in functional analysis. **Instructor's Additional Notes:** Math 6321 is the second course in a two-semester sequence intended to introduce the theory and techniques of modern analysis. The core of the course covers elements of functional analysis, Radon measures, elements of harmonic analysis, the Fourier transform, distribution theory, and Sobolev spaces. Additonal topics will be drawn from potential theory, ergodic theory, and the calculus of variations.

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MATH 6323 - Theory of Functions of a Complex Variable

Prerequisites:	Graduate standing. MATH 4331 or consent of instructor. **Instructor's Prerequisite Notes:** Math 6322 or consent of instructor.
Text(s):	No textbook required. Lecture notes provided.
Description:	Geometry of the complex plane, mappings of the complex plane, integration, singularities, spaces of analytic functions, special function, analytic continuation, and Riemann surfaces. **Additional Notes:** This course is an introduction to complex analysis. This two semester course will cover the theory of holomorphic functions, residue theorem, harmonic and subharmonic functions, Schwarz's lemma, Riemann mapping theorem, Casorati-Weterstrass theorem, infinite product, Weierstrass' (factorization) theorem, little and big Picard Theorems and compact Riemann surfaces theory.

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MATH 6327 - Partial Differential Equations

Prerequisites:	Graduate standing. MATH 4331 or consent of instructor.
Text(s):	TBA
Description:	Existence and uniqueness theory in partial differential equations; generalized solutions and convergence of approximate solutions to partial differential systems.

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MATH 6361 - Applicable Analysis

Prerequisites:	Graduate standing and consent of instructor
Text(s):	TBA
Description:	Solvability of finite dimensional, integral, differential, and operator equations, contraction mapping principle, theory of integration, Hilbert and Banach spaces, and calculus of variations.

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MATH 6367- Optimization and Variational Methods

Prerequisites:	Graduate standing. MATH 4331 and MATH 4377, or consent of instructor.
Text(s):	TBA
Description:	Constrained and unconstrained finite dimensional nonlinear programming, optimization and Euler-Lagrange equations, duality, and numerical methods. Optimization in Hilbert spaces and variational problems. Euler-Lagrange equations and theory of the second variation. Application to integral and differential equations.

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MATH 6371 - Numerical Analysis

Prerequisites:	Graduate standing and consent of instructor
Text(s):	TBA
Description:	Ability to do computer assignments. Topics selected from numerical linear algebra, nonlinear equations and optimization, interpolation and approximation, numerical differentiation and integration, numerical solution of ordinary and partial differential equations.

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MATH 6378 - Basic Scientific Computing

Prerequisites:	Graduate standing. MATH 4364 and MATH 4365 or equivalent, and either COSC 1304 or COSC 2101 or equivalents, or consent of instructor.
Text(s):	TBA
Description:	A project-oriented course in fundamental techniques for high performance scientific computation. Hardware architecture and floating point performance, code design, data structures and storage techniques related to scientific computing, parallel programming techniques, applications to the numerical solution of problems such as algebraic systems, differential equations and optimization. Data visualization.

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MATH 6383 - Probability Models and Mathematical Statistics

Prerequisites:	Graduate standing. MATH 3334, MATH 3338 and MATH 4378, or consent of instructor. ***Instructor's Prerequisites:*** Two years of Calculus, Math 6308 Advanced Linear Algebra I, Math 5386 Regression and Linear Models, andMath 6382 Probability and Statistics or equivalent.
Text(s):	**Recommended Text**: John A. Rice : Mathematical Statistics and Data Analysis, 3rd editionBrooks / Cole, 2007. ISBN-13: 978-0-534-39942-9. **Reference Texts:** -P. MuCullagh and J.A. Nelder: Generealized Linear Models, 2nd ed. 1999 Chapman Hall/CRC -Raymond H. Myers, Douglas C. Montgomery, G. Geoffrey Vining, Timothy J. Robinson, Generalized Linear Models: with Applications in Engineering and the Sciences, 2nd ed. Wiley, 2010. ISBN: 978-0-470-45463-3.

Description:	A survey of probability theory, probability models, and statistical inference. Includes basic probability theory, stochastic processes, parametric and nonparametric methods of statistics. **Instructor's 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 theory and techniques in modelling data of various types, including continuous, binary, counts and others. The selected topics will include basic probability distributions, likelihood function and parameter estimation, hypothesis testing, regression models for continuous and categorical response variables, variable selection methods, model selection, large sample theory, shrinkage models, ANOVA and some recent advances.

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MATH 6385 - Continuous-Time Models in Finance

Prerequisites:	Graduate standing. MATH 6384 or consent of instructor.
Text(s):	"Arbitrage Theory in Continuous Time" (3rd Edition), Tomas Björk, Oxford University Press, 2009. ISBN: 9780199574742 "Stochastic Calculus for Finance II: Continuous-Time Models," Steven Shreve, Springer, 2004. ISBN: 9780387401010
Description:	Stochastic calculus, Brownian motion, change of measures, Martingale representation theorem, pricing financial derivatives whose underlying assets are equities, foreign exchanges, and fixed income securities, single-factor and multi-factor HJM models, and models involving jump diffusion and mean reversion.

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MATH 6395:25733 - C*-Algebras Associated with Dynamical Systems

Prerequisites:	Graduate standing and consent of instructor
Text(s):	No textbook. Course notes will be distributed.
Description:	We will discuss various classes of C*-algebras constructed from dynamical systems, and examine the interplay that exists between the analysis, algebra, and dynamics. The course will start with an introduction to symbolic dynamics and discrete dynamical systems, and afterward we will construct classes of C*-algebras (e.g., Cuntz-Krieger algebras, graph C*-algebras, crossed products by the integers) that are intimately related to the dynamical systems.

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MATH 6397:22179 - Hyperbolic Conservation Laws and Numerical Solutions

Prerequisites:	Graduate standing and consent of instructor. **Instructor's Prerequisite Notes:** MATH 4360 or 6370. Basic knowledge in numerical analysis and scientific computing.

Text(s):	Numerical Methods for Conservation Laws, by Randall LeVeque; ISBN: 9783764327231
Description:	The first part of the course is to introduce mathematical theory for hyperbolic conservation laws that arise in many applications such as traffic flow, gas dynamics and fluid dynamics. The second part of the course is on advanced numerical methods for solving hyperbolic equations.

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MATH 6397:22180 - Stochastic Processes

Prerequisites:	Graduate standing and consent of instructor
Text(s):	**Recommended:** -Handbook of Stochastic Methods: For Physics, Chemistry and Natural Sciences, C.W. Gardiner -Interacting Particle Systems (Classics in Mathematics), Thomas M. Liggett -Multiscale Methods: Averaging and Homogenization (Texts in Applied Mathematics), G.A. Pavliotis & Andrew Stuart
Description:	This course will cover a wide range of topics in stochastic processesand applied probability. Main emphasis will be on applied topics incontinuous-time stochastic processes and stochastic differential equations (SDEs).The following topics will be covered - continuous time Markov chains,averaging of fastsub-system in Markov chains, estimation of transition probability matrix from data, application of Markov chains to particle systems and cellular automata, multiscale SDEs, avergaing and homogenization for multiscale SDEs.

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MATH 6397:22187 - Research Directions in Dynamical Systems and Related Fields

Prerequisites:	Graduate standing and consent of instructor. **Additional Prerequisite Notes:**It is strongly encouraged that students have a background in Linear Algebra and Real Analysis. Prior knowledge of Matlab is not required but the course will require writing simple routines in Matlab or an equivalent language.
Text(s):	- A basis theory primer, by C. Heil, 2011 - A wavelet tour of signal processing, by S. Mallat, Third edition, 2009 - A First Course on Wavelets , by E. Hernandez and G. Weiss, 1996. - (papers and notes)

We live in a data-intensive age which is bringing significant changes in the process of scientific discovery. During the last decade, sparsity has emerged as a leading theme in connection with the goal to produce faster and simpler algorithms for a wide range of signal processing applications. By enabling to accurately approximate data/functions in a certain class using a relatively small number of nonzero coefficients, sparse representations have the power to reveal the essential information we are looking for in the data. Therefore, sparsity implies not only data compression. Understanding the sparsity of a given data type entails a precise knowledge of the modelling and approximation of that data type. This knowledge is essential to design highly efficient algorithms for a tasks such as classification, denoising, interpolation, and segmentation. Multiscale techniques based on wavelets and their generalizations have emerged in the last decade as the most successful approach for sparse signal representations, as testified, for example, by their use in the new FBI fingerprint database and in JPEG2000, the new standard for image compression. Multiscale techniques were also extended beyond the traditional setting of physical spaces allowing for the efficient analysis of general structures, such as manifolds, graphs and point clouds in Euclidean space.

Description:

The aim of this course is to provide the mathematical tools to understand multiscale representations starting from the setting of traditional wavelets up to more advanced and emerging constructions such as curvelets, shearlets and diffusion wavelets. Several applications of these ideas will be presented.

Tentative list of topics:

- Orthonormal bases and frames. A basic problem in mathematics and engineering is to represent a function or a signal as superposition of elementary components. I will introduce the theory of frames and show that it provides the general framework to address this problem. Orthonormal bases are a special example of frames.

- Elements of Fourier analysis: I will briefly review Fourier analysis, including Fourier series and Fourier transforms.

- Wavelet construction and Multiresolution Analysis: The first wavelet basis, the Haar basis, was discovered in 1909 before wavelet theory was born. Unfortunately, the elements of this basis are not continuous. The success of the wavelet theory is due to the ability to construct a variety of wavelet bases with very nice mathematical properties such as smoothness, compact support, vanish moments, etc. Multiresolution analysis is a general method for constructing wavelet bases with prescribed properties.

- Sparse compression and approximation theory: One striking feature of wavelets is their ability to represent function with discontinuities. I will introduce linear and nonlinear approximations and discuss the approximation properties of wavelets and their generalizations (curvelets, shearlets, bandlets).

- Multiscale analysis on high-dimensional data: Multiscale analysis of random walks on graphs and applications to analysis of high-dimensional data sets.

- Modern signal processing: Multiscale methods and wavelets appear today in state-of-the-art signal processing applications, including analysis and diagnostics, quantization and compression, transmission and storage, noise reduction and removal. I will present some applications to data/image analysis. Additional applications will be further explored by the students as individual or group projects.

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MATH 6397:22190 - Data Mining and Machine Learning

Prerequisites:	Graduate Standing and consent of instructor. **Additional Prerequisite Notes:** Students should have previous familiarity (at the undergraduate level) with random variables and probability distributions
Text(s):	No single textbook. Reading assignments will be a small set of specific chapters extracted from the following reference texts: "The Elements of Statistical Learning, Data Mining", Friedman, Hastie,Tibshirani; ISBN: 978-0387848570 "Kernel Methods in Computational Biology", B. Schölkopf, K. Tsuda, J.-P. Vert; ISBN:978-0262195096 "Introduction to Support Vector Machines", N. Cristianini, J. Shawe-Taylor; ISBN: 978-0521780193
Description:	Automatic Learning of unknown functional relationships Y = F(X) between an output Y and high-dimensional inputs X , involves algorithms dedicated to the intensive analysis of large "training sets" of N "examples" of inputs/outputs pairs (Xn,Yn), with n= 1?N to discover efficient "blackboxes" approximating the unknown function F(X). Automatic learning was first applied to emulate intelligent tasks involving complex patterns identification, in artificial vision, face recognition, sounds identification, speech understanding, handwriting recognition, texts classification and retrieval, etc. Automatic learning has now been widely extended to the analysis of high dimensional biological data sets in proteomics and genes interactions networks, as well as to smart mining of massive data sets gathered on the Internet. The course will study major machine learning algorithms derived from Positive Definite Kernels and their associated Self-Reproducing Hilbert spaces. We will study the implementation, performances, and drawbacks of Support Vector Machines classifiers, Kernel based Non Linear Clustering, Kernel based Non Linear Regression, Kernel PCA. We will explore connections between these techniques and Dictionary Learning as well as Artificial Neural Nets with emphasis on key conceptual features such as generalisation capacity. We will present classes of Positive Definite Kernels designed to handle the very long "string descriptions" of proteins involved in genomics and proteomics. Emphasis will be on understanding key concepts and their mathematical formalization, with a strong focus on algorithmic implementation and testing on actual data sets. Homework assignments will involve implementation and reports on several applied projects. Students will be assumed to be able to use either Matlab or equivalent scientific softwares. Final exam will involve the in depth reading of one scientific paper and giving a public lecture on the paper.

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MATH 7350 - Geometry of Manifolds

Prerequisites:	Graduate Standing. MATH 3431 and MATH 3333, or consent of instructor.
Text(s):	TBA

Description:	Manifolds and tangent bundles, submanifolds and imbeddings, integral manifolds, triangulation of manifolds, connections and holonomy; Riemannian geometry, surface theory, Morse theory, and G-structures.

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MATH 7397 - Financial and Energy Time Series Analysis

Prerequisites:	Graduate Standing and consent of the instructor
Text(s):	1.) An Introduction to Analysis of Financial Data with R, by Ruey S. Tsay, 2012, ISBN: 9780470890813 2.) Multivariate Time Series Analysis: With R and Financial Applications, by Ruey S. Tsay, 2013, Wiley, ISBN: 9781118617908
Description:	The course is about time series analysis with special emphasizes onfinancial and erergydata. The course covers ARIMA models, ARCH/GARCH models, seasonal andtrend dataanalysis, high frequency data analysis, parmaters estimation for diffusionprocesses andlevy processes, multiple tiem series, heavy-tailed distributions, andstate space models.Various packages of R are expected to be employed in carrying out thestudy.

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