Department of Mathematics

2024 - Spring Semester

*(**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**.)*

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GRADUATE COURSES - SPRING 2024

This schedule is subject to changes. Please contact the Course Instructor for confirmation.

SENIOR UNDERGRADUATE COURSES

Course	Section	Course Title	Course Day/Time	Rm #	Instructor
Math 4309	12220	Mathematical Biology	MW, 2:30—4PM, (F2F)	S 101	R. Azevedo
Math 4322	15443	Introduction to Data Science and Machine Learning	TTh, 11:30AM—1PM, (F2F)	SEC 102	C. Poliak
Math 4323	14927	Data Science and Statistical Learning	MWF, 10—11AM, (F2F)	SEC 103	W. Wang
Math 4332/6313	11140	Introduction to Real Analysis II	TTh, 8:30—10AM, (F2F)	S 207	B. Bodmann
Math 4351	19769	Calculus on Manifolds	TTh, 2:30—4PM, (F2F)	F 162	Y. Wu
Math 4362	14344	Theory of Differential Equations and Nonlinear Dynamics	MWF, 9—10AM, (F2F)	SEC 201	G. Jaramillo
Math 4364-01	13069	Intro. to Numerical Analysis in Scientific Computing	MW, 4—5:30PM, (F2F)	SEC 105	T.W. Pan
Math 4364-02	17730	Intro. to Numerical Analysis in Scientific Computing	***Asynch.**/on-campus exams*	Online	J. Morgan
Math 4365	12608	Numerical Methods for Differential Equations	TTh, 10—11:30AM, (F2F)	SW 219	Min Wang
Math 4370	N/A	Mathematics for Physicists - cancelled	N/A	N/A	N/A
Math 4377/6308	12846	Advanced Linear Algebra I	TTh, 11:30AM—1PM, (F2F)	S 102	A. Quaini
Math 4378/6309	11141	Advanced Linear Algebra II	TTh, 11:30AM—1PM, (F2F)	CBB 106	A. Mamonov
Math 4380	11142	A Mathematical Introduction to Options	MW, 1—2:30PM, (F2F)	AH 301	M. Papadakis
Math 4389	11143	Survey of Undergraduate Mathematics	TTh, 1—2:30PM, (F2F)	F 154	D. Blecher

GRADUATE ONLINE COURSES

Course	Section	Course Title	Course Day & Time	Instructor
Math 5330	11601	*Abstract Algebra*	***(Asynch.**/on-campus exams)*	*A. Haynes*
Math 5332	11150	*Differential Equations*	***(Asynch.**/on-campus exams)*	*G. Etgen*
Math 5334	19701	*Complex Analysis*	***(Asynch.**/on-campus exams)*	*S. Ji*
Math 5344	19702	*Intro. to Scientific Computing*	***(Asynch.**/on-campus exams)*	*J. Morgan*

Math 5350	19703	*Intro. to Differential Geometry*	***(Asynch.**/on-campus exams)*	*M. Ru*
Math 5385	15455	*Statistics*	***(Asynch.**/on-campus exams)*	*TBD*

GRADUATE COURSES

Course	Section	Course Title	Course Day & Time	Rm #	Instructor
Math 6303	11151	Modern Algebra II	TTh, 1—2:30PM	S 101	M. Kalantar
Math 6308	12847	Advanced Linear Algebra I	TTh, 11:30AM—1PM	S 102	A. Quaini
Math 6309	11643	Advanced Linear Algebra II	TTh 11:30AM—1PM	CBB 106	A. Mamonov
Math 6313	11642	Introduction to Real Analysis	TTh, 10—11:30AM	F 162	B. Bodmann
Math 6321	11156	Theory of Functions of a Real Variable	MWF, 9—10AM	S 101	V. Climenhaga
Math 6361	20465	Applicable Analysis	TTh, 1—2:30PM	S 119	D. Onofrei
Math 6367	19704	Optimization Theory	TTh, 11:30AM—1PM	SEC 201	J. He
Math 6371	11157	Numerical Analysis	TTh, 10—11:30AM	S 102	L. Cappanera
Math 6377	19705	Mathematics of Machine Learning	TTh 1—2:30PM	AH 301	R. Azencott
Math 6383	11158	Statistics	MW, 4—5:30PM	S 102	M. Jun
Math 6397	19706	Computation & Math Methods in Data Science	MW, 4—5:30PM	F 162	A. Mang
Math 6397	19707	Applied & Computational Topology	TTh, 2:30—4PM	S 202	W. Ott
Math 6397	19708	Quantum Information and Computation	MWF, 11AM—Noon	F 154	A. Vershynina
Math 6397	19709	Stochastic Process	MW, 1—2:30PM	S 202	I. Timofeyev
Math 6397	20173	Bayesian Statistics	MW, 2:30—4PM	SEC 202	Y. Niu
Math 6397	25618	Image Processing Methods	MWF, 10—11AM	AH 204	N. Charon
Math 7321	18187	Functional Analysis	TBD	TBD	TBD
Math 7326	17738	Dynamical Systems	MWF, 11AM—Noon	S 101	M. Nicol
Math 7352	25834	Riemannian Geometry	TBD	TBD	TBD

MSDS Courses *(MSDS Students Only)*

Course	Section	Course Title	Course Day & Time	Rm #	Instructor
Math 6315	14773	Masters Tutorial: Internship	TBD	**N/A**	C. Poliak
Math 6359	14771	Applied Statistics & Multivariate Analysis	F, 1—3PM	**CBB 104**	C. Poliak
Math 6359	15462	Applied Statistics & Multivariate Analysis	F, 1—3PM (*synch. online)*	**N/A**	C. Poliak
Math 6373	14772	Deep Learning and Artificial Neural Networks	MW, 1—2:30PM (F2F)	**F 162**	D. Labate
Math 6381	14970	Information Visualization	F, 3—5PM	**CBB 104**	D. Shastri
Math 6381	17066	Information Visualization	F, 3—5PM (*synch. online)*	**N/A**	D. Shastri
Math 6397	19750	Case Studies In Data Analysis	W, 5:30—8:30PM	**S 202**	L. Arregoces
Math 6397	19739/20173	Bayesian Statistics	MW, 2:30—4PM	**SEC 202**	Y. Niu
Math 6397	20174	Financial & Commodity Markets	W, 5:30—8:30PM	**AH 301**	J. Ryan

----------Course Details----------

SENIOR UNDERGRADUATE COURSES

Math 4309 - Mathematical Biology	
Prerequisites:	MATH 3331 and BIOL 3306 or consent of instructor.
Text(s):	**Required texts**: A Biologist's Guide to Mathematical Modeling in Ecology and Evolution, Sarah P. Otto and Troy Day; (2007, Princeton University Press) ISBN-13:9780691123448 **Reference texts**: (excerpts will be provided) • An Introduction to Systems Biology, 2/e, U. Alon (an excellent, recently updated text on the "design principles of biological circuits") • Random Walks in Biology, H.C. Berg (a classic introduction to the applicability of diffusive processes and the Reynolds number at the cellular scale) • Mathematical Models in Biology, L. Edelstein-Keshet (a systematic development of discrete, continuous, and spatially distributed biological models) • Nonlinear Dynamics and Chaos, S.H. Strogatz (a very readable introduction to phase-plane analysis and bifurcation theory in dynamical systems with an emphasis on visual thinking; contains numerous applications in biology) • Thinking in Systems, D.H. Meadows (a lay introduction to control systems and analyzing parts-to-whole relationships, their organizational principles, and sensitivity in their design) • Adaptive Control Processes: A Guided Tour, R. Bellman (a classic, more technical introduction to self-regulating systems, feedback control, decision processes, and dynamic programming)
Description:	**Catalog 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. **Instructor's description**: An introduction to mathematical methods for modeling biological dynamical systems. This course will survey canonical models of biological systems using the mathematics of calculus, differential equations, logic, matrix theory, and probability. Applications will span several spatial orders-of-magnitude, from the microscopic (sub-cellular), to the mesoscopic (multi-cellular tissue and organism) and macroscopic (population-level: ecological, and epidemiological) scales. Specific applications will include biological-signaling diffusion, enzyme kinetics, genetic feedback networks, population dynamics, neuroscience, and the dynamics of infectious diseases. Optional topics (depending on schedule and student interest) may be chosen from such topics as: game theory, artificial intelligence and learning, language processing, economic multi-agent modeling, Turing systems, information theory, and stochastic simulations. The course will be taught from two complementary perspectives: (1) critical analysis of biological systems' modeling using applicable mathematical tools, and (2) a deeper understanding of mathematical theory, illustrated through biological applications. Relevant mathematical theory for each course section will be reviewed from first principles, with an emphasis on bridging abstract formulations to practical modeling techniques and dynamical behavior prediction. The course will include some programming assignments, to be completed in Matlab or Python programming languages (available free through UH Software and public domain, respectively). However, advanced programming techniques are not required, and resources for introduction to these languages will be provided.

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Math 4315 - Graph Theory with Applications	
Prerequisites:	MATH 3325 or MATH 3336 and three additional hours at the MATH 3000-4000 level.
Text(s):	Intro to Statistical Learning, Gareth James, 9781461471370

Description:	Introduction to basic concepts, results, methods, and applications of graph theory.

Math 4322 - Introduction to Data Science and Machine Learning	
Prerequisites:	MATH 3339
Text(s):	Intro to Statistical Learning, Gareth James, 9781461471370
Description:	Theory and applications for such statistical learning techniques as linear and logistic regression, classification and regression trees, random forests, neutral networks. Other topics might include: fit quality assessment, model validation, resampling methods. R Statistical programming will be used throughout the course.

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Math 4323 - Data Science and Statistical Learning	
Prerequisites:	MATH 3339
Text(s):	Intro to Statistical Learning, Gareth James, 9781461471370
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 4332/6313 - 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.

Math 4335 - Partial Differential Equations I	
Prerequisites:	MATH 3331, or equivalent, and three additional hours of 3000-4000 level Mathematics.
Text(s):	TBA
Description:	Initial and boundary value problems, waves and diffusions, reflections, boundary values, Fourier series.

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Math 4351 - Calculus on Manifolds	
Prerequisites:	MATH 2415 and six additional hours of 3000-4000 level Mathematics.
Text(s):	TBA
Description:	Differential forms in R^n (particularly R^2 and integration, the intrinsic theory of surfaces through differential forms, the Gauss-Bonnet theorem, Stokes' theorem, manifolds, Riemannian metric and curvature. Other topics at discretion of instructor.

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Math 4362 - Theory of Differential Equations an Nonlinear Dynamics	
Prerequisites:	MATH 3331, or equivalent, and three additional hours of 3000-4000 level Mathematics.
Text(s):	Nonlinear Dynamics and Chaos (2nd Ed.) by Strogatz. ISBN: 978-0813349107
Description:	ODEs as models for systems in biology, physics, and elsewhere; existence and uniqueness of solutions; linear theory; stability of solutions; bifurcations in parameter space; applications to oscillators and classical mechanics.

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Math 4364 (13069) - Introduction to 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):	Instructor's notes
Description:	**Catalog Description**: Root finding, interpolation and approximation, numerical differentiation and integration, numerical linear algebra, numerical methods for differential equations. **Instructor's 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 (17730)- Introduction to 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:	**Catalog Description**: Root finding, interpolation and approximation, numerical differentiation and integration, numerical linear algebra, numerical methods for differential equations. **Instructor's 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.

Math 4370 - Mathematics for Physicists	
Prerequisites:	MATH 2415, and MATH 3321 or MATH 3331
Text(s):	TBD
Description:	Vector calculus, tensor analysis, partial differential equations, boundary value problems, series solutions to differential equations, and special functions as applied to junior-senior level physics courses.

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Math 4377/6308 - 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 4378/6309 - Advanced Linear Algebra II	
Prerequisites:	MATH 4377
Text(s):	Linear Algebra, Fourth Edition, by S.H. Friedberg, A.J Insel, L.E. Spence,Prentice Hall, ISBN 0-13-008451-4; 9780130084514
Description:	Similarity of matrices, diagonalization, Hermitian and positive definite matrices, normal matrices, and canonical forms, with applications. **Instructor's Additional notes:** This is the second semester of Advanced Linear Algebra. I plan to cover Chapters 5, 6, and 7 of textbook. These chapters cover Eigenvalues, Eigenvectors, Diagonalization, Cayley-Hamilton Theorem, Inner Product spaces, Gram-Schmidt, Normal Operators (in finite dimensions), Unitary and Orthogonal operators, the Singular Value Decomposition, Bilinear and Quadratic forms, Special Relativity (optional), Jordan Canonical form.

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

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.
Text(s):	The text material is posted on **Blackboard Learn**, under "**Content**".
Description:	First-order equations, existence and uniqueness theory; second and higher order linear equations; Laplace transforms; systems of linear equations; series solutions. Theory and applications emphasized throughout. 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 5334 - Complex Analysis	
Prerequisites:	Graduate standing. MATH 5333 or consent of instructor.
Text(s):	TBA
Description:	Complex numbers, holomorphic functions, linear transformations, Cauchy integral theorem and residue theorem

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MATH 5344 - Introduction to Scientific Computing	
Prerequisites:	Graduate standing. Math 2331 linear algebra or equivalent.
Text(s):	Instructor's notes
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 5350 - Introduction to Differential Geometry	
Prerequisites:	Graduate standing. MATH 2433, or consent of instructor.
Text(s):	TBA
Description:	Curves, arc-length, curvature, Frenet formula, surfaces, first and second fundamental forms, Guass' theorem egregium, geodesics, minimal surfaces. Does not apply toward the Master of Science in Mathematics or Applied Mathematics.

MATH 5341 - Mathematical Modeling	
Prerequisites:	**Graduate standing.** Three semesters of calculus or consent of instructor.
Text(s):	TBD
Description:	Proportionality and geometric similarity, empirical modeling with multiple regression, discrete dynamical systems, differential equations, simulation and optimization. Computing assignments require only common spreadsheet software and VBA programming.

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MATH 5385 - Statistics	
Prerequisites:	**Graduate standing**
Text(s):	Two semesters of calculus and one semester of linear algebra or consent of instructor.
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., R or Matlab) will be given. Applies toward the Master of Arts in Mathematics degree; does not apply toward Master of Science in Mathematics or the Master of Science in Applied Mathematics degrees.

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GRADUATE COURSES

MATH 6303 - Modern Algebra II	
Prerequisites:	Graduate standing, MATH 4333 or MATH 4378 **Additional Prerequisites**: students should be comfortable with basic measure theory, groups rings and fields, and point-set topology
Text(s):	No textbook is required.
Description:	Topics from the theory of groups, rings, fields, and modules. **Additional Description:** This is primarily a course about analysis on topological groups. The aim is to explain how many of the techniques from classical and harmonic analysis can be extended to the setting of locally compact groups (i.e. groups possessing a locally compact topology which is compatible with their algebraic structure). In the first part of the course we will review basic point set topology and introduce the concept of a topological group. The examples of p-adic numbers and the Adeles will be presented in detail, and we will also spend some time discussing SL_2(R). Next we will talk about characters on topological groups, Pontryagin duality, Haar measure, the Fourier transform, and the inversion formula. We will focus on developing details in specific groups (including those mentioned above), and applications to ergodic theory and to number theory will be discussed.

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MATH 6308 - Advanced Linear Algebra I	
Prerequisites:	Graduate standing, MATH 2331 and a minimum of 3 semester hours transformations, eigenvalues and eigenvectors.
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 6309 - Advanced Linear Algebra II	
Prerequisites:	Graduate standing and MATH 6308
Text(s):	Linear Algebra, Fourth Edition, by S.H. Friedberg, A.J Insel, L.E. Spence,Prentice Hall, ISBN 0-13-008451-4; 9780130084514
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.
Text(s):	Kenneth Davidson and Allan Donsig, “Real Analysis with Applications: Theory in Practice”, Springer, 2010; or (out of print) Kenneth Davidson and Allan Donsig, “Real Analysis with Real Applications”, Prentice Hall, 2001.
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 for Graduate Students, Richard F. Bass Supplementary (Recommended): Real Analysis: Modern Techniques and Their Applications, Gerald Folland (2nd edition); ISBN: 9780471317166.
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 6359 (14771/15462)- Applied Statistics & Multivariate Analysis	
Prerequisites:	Graduate standing. MATH 3334, MATH 3338 or MATH 3339, and MATH 4378. Students must be in the Statistics and Data Science, MS Program
Text(s):	While lecture notes will serve as the **main source** of material for the course, the following book constitutes a great reference: - ”**Statistics and Data Analysis from Elementary to Intermediate**” by Tamhane, Ajit and Dunlop, Dorothy ISBN: 0137444265 - ”**Applied Multivariate Statistics with R**”, by Daniel Zelterman, ISBN: 9783319140926 - ”**Applied Multivariate Statistical Analysis**, sixth edition”, by Richard A. Johnson and Dean W. Wichern, published by Pearson. - **Rstudio**: Make sure to download R and RStudio (which can’t be installed without R) before the course starts. Use the link R download to download R frst, then RStudio download to download it from the mirror appropriate for your platform.
Description:	Linear models, loglinear models, hypothesis testing, sampling, modeling and testing of multivariate data, dimension reduction. **< Course syllabus >**

MATH 6361 - Applicable Analysis

Prerequisites:	Graduate standing.
Text(s):	*Speak to the instructor for textbook information.*
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 Theory	
Prerequisites:	Graduate standing. MATH 4331 and MATH 4377.
Text(s):	• D.P. Bertsekas; Dynamic Programming and Optimal Con- trol, Vol. I, 4th Edition. Athena Scientific, 2017, ISBN-10: 1-886529-43-4 • J.R. Birge and F.V. Louveaux; Introduction to Stochastic Programming. Springer, New York, 1997, ISBN: 0-387-98217-
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. **Additional Description**: This course consists of two parts. The first part is concer- ned with an introduction to Stochastic Linear Programming (SLP) and Dynamic Programming (DP). As far as DP is concerned, the course focuses on the theory and the appli- cation of control problems for linear and nonlinear dynamic systems both in a deterministic and in a stochastic frame- work. Applications aim at decision problems in finance. In the second part, we deal with continuous-time systems and optimal control problems in function space with em- phasis on evolution equations.

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MATH 6371 - Numerical Analysis	
Prerequisites:	Graduate standing.
Text(s):	**Numerical Mathematics (Texts in Applied Mathematics)**, 2nd Ed., V.37, Springer, 2010. By A. Quarteroni, R. Sacco, F. Saleri. ISBN: 9783642071010
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 6373 (14772) - Deep Learning and Artificial Neural Networks	
Prerequisites:	Graduate standing. Probability/Statistic and linear algebra or consent of instructor. Students must be in Master's in Statistics and Data Science program.
Text(s):	**TBA**
Description:	Artificial neural networks for automatic classification and prediction. Training and testing of multi-layers perceptrons. Basic Deep Learning methods. Applications to real data will be studied via multiple projects.

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MATH 6377 - Numerical Analysis	
Prerequisites:	Graduate standing.Linear Algebra, Real Analysis (MATH 4331-4332), Probability.
Text(s):	**TBA**- *Please contact the instructor*

Descriptions:	Catalog Description: *(this description is currently not accurate. Please use the instructor's description below)* **Instructor's Description** *(contents of this course have been modified since last year)*: Lectures F2F & online via Microsoft Teams. Focus on understanding key algorithms for Automatic Learning . Emphasis on mathematical concepts but not on proving theorems. Applications of Machine Learning techniques to real data sets, through homeworks projects. **Instructor's Pre-requisites**: Basic linear algebra, probability, statistics (all at undergraduate level).

MATH 6381 (14970/17066) - Information Visualization	
Prerequisites:	Graduate standing. MATH 6320 or consent of instructor.
Text(s):	**TBA**
Description:	Random variables, conditional expectation, weak and strong laws of large numbers, central limit theorem, Kolmogorov extension theorem, martingales, separable processes, and Brownian motion.

MATH 6383 - Statistics	
Prerequisites:	Graduate standing. MATH 3334, MATH 3338 and MATH 4378.
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. ISBN: 978-0412317606 -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:	**Catalog 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 6397 (19706) - Computation & Math Methods in Data Science	
Prerequisites:	Graduate standing. TBA
Text(s):	TBA
Instructor's Description:	TBA

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MATH 6397 (19707) - Applied & Computational Topology	
Prerequisites:	Graduate standing. TBA

Text(s):	TBA
Instructor's Description:	TBA

MATH 6397 (19708) - Quantum Information and Computation	
Prerequisites:	Graduate standing.
Text(s):	Recommended: - M.Nielsen, I.Chuang, "**Quantum computation and quantum information**", Cambridge university press, 2010 - M.Wilde, "**From Classical to Quantum Shannon Theory**" arXiv:1106.1445
Description:	During the course we will cover the basics of quantum mechanics (qubits, gates, channels), universal quantum computation, quantum teleportation and other protocols, basics of quantum error-correction, and quantum algorithms (Shor's algorithm, Grover's algorithm). We will practice some of the protocols on the open access quantum computer chip made available online. No knowledge of quantum mechanics, computer science or information theory is needed. Knowledge of linear algebra and the basics of probability and complex numbers are required

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MATH 6397 (19709) - Stochastic Process	
Prerequisites:	Graduate standing. Graduate Probability
Text(s):	The main book for the class – "Stochastic Methods A Handbook for the Natural and Social Sciences" by C. Gardiner
Description:	This class will cover **Continuous-Time Markov Chains** *(first half)* and **Brownian Motion/Stochastic Differential Equations** *(second half)*. The first half is more relevant to math biology and application of queueing theory, the second half is also relevant for mathematical finance. We will consider math bio applications in the first half and financial applications in the second half. This is an applied class where we will consider various topics for **Continuous-Time Markov Chains** (CTMC) and **Stochastic Differential Equations** (SDEs) driven by **Brownian motion** (diffusions). There are many books on CTMC. We will mostly use notes for the first half. The book is more relevant for the second half of the class. It is very applied, this is one of the most applied books on stochastic processes. The goal of this class is to cover main background material and consider various applications. However, we will not concentrate on proofs and often consider examples that explain mathematical concepts in the context of a particular example and can be generalized to other cases. In particular, we will consider applications to biology and finance (especially in the second half on stochastic differential equations). We will discuss numerical methods for stochastic processes, but this is not a computational class, no computational assignments will be given.

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MATH 6397 (19739/20173) - Bayesian Statistics	
Prerequisites:	Graduate standing. Graduate Probability.
Text(s):	• Peter Hoff (2009). A first course in Bayesian statistical methods. Springer. • Brian J. Reich & Sujit K. Ghosh (2019). Bayesian Statistical Methods. CRC Press. • Christian P. Robert (2007). The Bayesian Choice: From Decision-Theoretic Foundations to Computational Implementation. Springer (2nd Edition).
Description:	This is an introductory course on Bayesian statistics for graduate students. The course introduces the Bayesian paradigm and focus on Bayesian modeling, computation, and inference. We first convey the ideology of Bayesian statistics which is a particular approach to statistical inference that differs philosophically and operationally from the classic frequentist approach. We then define Bayesian inference and discuss its advantages. Detailed applications are illustrated using some classical models, including binomial, Poisson, univariate normal, multivariate normal model, and linear regression. We go through each step of building Bayesian hierarchical models and apply Bayes' theorem to derive posterior distributions. To inference on posterior distributions, MCMC algorithm is introduced as a modern method of approximating posteriors

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MATH 6397 (19750) - Case Studies In Data Analysis	
Prerequisites:	Graduate standing. TBA
Text(s):	TBA
Description:	TBA

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MATH 6397 (25618) - Image Processing Methods	
Prerequisites:	Graduate standing. TBA
Text(s):	TBA
Description:	TBA

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MATH 6397 (20174) - Financial & Commodity Markets	
Prerequisites:	Graduate standing. TBA -
Text(s):	TBA
Description:	TBA

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MATH 7321 - Functional Analysis- TBD	
Prerequisites:	Graduate standing. MATH 7320 or instructor consent
Text(s):	W. Rudin, Functional Analysis, 2nd edition, McGraw Hill, 1991
Description:	**Catalog Description**: This course is part of a two semester sequence covering the main results in functional analysis, including Hilbert spaces, Banach spaces, and linear operators on these spaces. **Instructor's Description**: This is a continuation of what was discussed in 7320. The second semester will mostly be a more technical development of the theory of linear operators on Hilbert space and related subjects, including topics relevant in quantum theory, such as positivity and states. Some of the main topics covered include: Banach algebras and the Gelfand transform. C*-algebras and the functional calculus for normal operators. The spectral theorem for normal operators. Trace, Hilbert-Schmidt, and Schatten classes.

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MATH 7326 - Dynamical Systems	
Prerequisites:	Graduate standing. MATH 6320
Text(s):	TBD

Description:	**Catalog Description**: Ergodic theory, topological and symbolic dynamics, statistical properties, infinite-dimensional dynamical systems, random dynamical systems, and themodynamic formalism. **Instructor's Description**: TBA

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