# Department of Mathematics

## 2023 - 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 2023

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

*(updated 01/17/23)*

### SENIOR UNDERGRADUATE COURSES

| Course | Section | Course Title | Course Day/Time | Rm # | Instructor |
|---|---|---|---|---|---|
| Math 4309 | 12392 | Mathematical Biology | MW, 2:30—4PM, (F2F) | SEC 104 | R. Azevedo |
| Math 4315 | 17794 | Graph Theory with Applications | TuTh, 4—5:30PM, (F2F) | CBB 214 | K. Josic |
| Math 4322 | 16274 | Introduction to Data Science and Machine Learning | TuTh, 11:30AM—1PM, (F2F) | SEC 104 | C. Poliak |
| Math 4323 | 15666 | Data Science and Statistical Learning | MWF, 11AM—Noon, (F2F) | SEC 104 | W. Wang |
| Math 4332/6313 | 11165 | Introduction to Real Analysis II | TuTh, 1—2:30PM, (F2F) | F 162 | M. Kalantar |
| Math 4335 | 20411 | Partial Differential Equations I | MWF, 9—10AM, (F2F) | CBB 214 | G. Jaramillo |
| Math 4351 | 20834 | Calculus on Manifolds | MWF, Noon—1PM, (F2F) | CBB 214 | M. Nicol |
| Math 4362 | 14935 | Theory of Differential Equations and Nonlinear Dynamics | MWF, 10—11AM, (F2F) | SEC 201 | A. Török |
| Math 4364 | 13420 | Intro. to Numerical Analysis in Scientific Computing | MW, 4—5:30PM, (F2F) | SEC 205 | T.W. Pan |
| Math 4364 | 20284 | Intro. to Numerical Analysis in Scientific Computing | TuTh, 8:30—10AM, (F2F) | SEC 205 | L. Cappanera |

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|---|---|---|---|---|---|
| Math 4365 | 12870 | Numerical Methods for Differential Equations | TuTh, 11:30AM—1PM, (F2F) | CBB 214 | J. He |
| Math 4370 | 20540 | Mathematics for Physicists | MWF, 9—10AM, (F2F) | AH 301 | A. Cardoso Barato |
| Math 4377/6308 | 13148 | Advanced Linear Algebra I | MW, 1—2:30PM, (F2F) | SEC 202 | A. Quaini |
| Math 4378/6309 | 11166 | Advanced Linear Algebra II | MW, 1—2:30PM, (F2F) | F 154 | A. Mamonov |
| Math 4380 | 11167 | A Mathematical Introduction to Options | TuTh, 2:30—4PM, (F2F) | F 162 | E. Kao |
| Math 4389 | 11168 | Survey of Undergraduate Mathematics | TuTh, 1—2:30PM, (F2F) | GAR G201 | M. Almus |

## GRADUATE ONLINE COURSES

| Course | Section | Course Title | Course Day & Time | Instructor |
|---|---|---|---|---|
| *Math 5330* | 11727 | *Abstract Algebra* | ***(Asynch.**/on-campus exams)* | *A. Haynes* |
| *Math 5332* | 11175 | *Differential Equations* | ***(Asynch.**/on-campus exams)* | *G. Etgen* |
| *Math 5385* | 16296 | *Statistics* | ***(Asynch.**/on-campus exams)* | *J. Kwon* |

## GRADUATE COURSES

| Course | Section | Course Title | Course Day & Time | Rm # | Instructor |
|---|---|---|---|---|---|
| Math 6303 | 11176 | Modern Algebra II | TuTh, 2:30—4PM | S 115 | G. Heier |
| Math 6308 | 13149 | Advanced Linear Algebra I | MW, 1—2:30PM | SEC 202 | A. Quaini |
| Math 6309 | 11784 | Advanced Linear Algebra II | MW, 1—2:30PM | F 154 | A. Mamonov |
| Math 6313 | 11783 | Introduction to Real Analysis | TuTh, 1—2:30PM | F 162 | M. Kalantar |
| Math 6321 | 11181 | Theory of Functions of a Real Variable | MWF, 10—11AM | S 115 | A. Vershynina |
| Math 6361 | 17797 | Applicable Analysis | TuTh, 1—2:30PM | S 202 | D. Onofrei |
| Math 6367 | 11182 | Optimization Theory | MW, 1—2:30PM | S 102 | R. Hoppe |
| Math 6371 | 11183 | Numerical Analysis | MW, 5:30—7PM | S 102 | M. Olshanskiy |
| Math 6383 | 11184 | Probability Statistics | TuTh, 11:30AM—1PM | FH 130 | M. Jun |
| Math 6397 | 20344 | Math of Deep Learning | TuTh, 10—11:30AM | S 115 | D. Labate |
| Math 6397 | 20393 | Bayesian Inverse Problems and Uncertainty Quantification | MW, 4—5:30PM | S 202 | A. Mang |
| Math 6397 | 20396 | Algebraic Topology | TuTh, 11:30AM—1PM | S 115 | D. Blecher |
| Math 7321 | 25318 | Functional Analysis | TuTh, 10—11:30AM | SW 219 | B. Bodmann |
| Math 7326 | 20389 | Dynamical Systems | TuTh, 1—2:30PM | S 201 | W. Ott |

**MSDS Courses** *(MSDS Students Only)*

| Course | Section | Course Title | Course Day & Time | Rm # | Instructor |
|---|---|---|---|---|---|
| Math 6359 | 16309 | Applied Statistics & Multivariate Analysis | F, 1—3PM (Synch—on-campus exams) | **online** | C. Poliak |
| Math 6373 | 15440 | Deep Learning and Artificial Neural Networks | MW, 1—2:30PM (F2F) | CBB 214 | R. Azencott |
| Math 6381 | 18626 | Information Visualization ** | F, 3—5PM (Synch—on-campus exams) | **online** | D. Shastri |
| Math 6397 | 20890 | Case Studies in Data Analysis | W, 5:30—8:30PM (F2F) | AH 301 | L. Arregoces |
| Math 6397 | 20891 | Financial & Commodity Mkts | W, 5:30—8:30PM (F2F) | SEC 203 | J. Ryan |

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

**SENIOR UNDERGRADUATE COURSES**

| **Math 4309** - Mathematical Biology | |
|---|---|
| Prerequisites: | MATH 3331 and BIOL 3306 or consent of instructor. |

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| 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)<br>ISBN-13:9780691123448<br><br>**Reference texts**: (excerpts will be provided)<br><br>• An Introduction to Systems Biology, 2/e, U. Alon (an excellent, recently updated text on the "design principles of biological circuits")<br>• Random Walks in Biology, H.C. Berg (a classic introduction to the applicability of diffusive processes and the Reynolds number at the cellular scale)<br>• Mathematical Models in Biology, L. Edelstein-Keshet (a systematic development of discrete, continuous, and spatially distributed biological models)<br>• 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)<br>• 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)<br>• Adaptive Control Processes: A Guided Tour, R. Bellman (a classic, more technical introduction to self-regulating systems, feedback control, decision processes, and dynamic programming) |

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| 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.<br><br>**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.<br><br>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.<br><br>The course will be taught from two complementary perspectives:<br>(1) critical analysis of biological systems' modeling using applicable mathematical tools, and<br>(2) a deeper understanding of mathematical theory, illustrated through biological applications.<br><br>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.<br><br>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 |

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| 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** - 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 (13420) -** Introduction to Numerical Analysis in Scientific Computing | |
|---|---|
| Prerequisites: | MATH 3331 and COSC 1410 or equivalent or consent of instructor.<br><br>**Instructor's Prerequisite Notes:**<br><br>1. MATH 2331, In depth knowledge of Math 3331 (Differential Equations) or Math 3321 (Engineering Mathematics)<br><br>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.<br><br>**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 (20284)-** Introduction to Numerical Analysis in Scientific Computing |
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| Prerequisites: | MATH 3331 and COSC 1410 or equivalent or consent of instructor.<br><br>**Instructor's Prerequisite Notes:**<br><br>1. MATH 2331, In depth knowledge of Math 3331 (Differential Equations) or Math 3321 (Engineering Mathematics)<br><br>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.<br><br>**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 -** 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 |

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| Description: | Linear systems of equations, matrices, determinants, vector spaces and linear transformations, eigenvalues and eigenvectors.<br><br>**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 -** 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.<br><br>**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 | |
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| Prerequisites: | Graduate standing. |

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| Text(s): | *Abstract Algebra , A First Course* by Dan Saracino. Waveland Press, Inc. ISBN 0-88133-665-3<br>(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.<br><br>**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: | 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. |

| **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<br><br>**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.<br><br>**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;<br>ISBN: 9780130084514 |
| Description: | Transformations, eigenvalues and eigenvectors.<br><br>**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 |

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|---|---|
| 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.<br><br>**Instructor's Prerequisite Notes:** MATH 6320 |
| Text(s): | Primary (Required): Real Analysis for Graduate Students, Richard F. Bass<br><br>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.<br><br>**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 6361 -** Applicable Analysis |
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| 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): | *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<br>• 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.<br><br>**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 6383** - Probability Statistics | |
|---|---|
| Prerequisites: | Graduate standing. MATH 3334, MATH 3338 and MATH 4378. |

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| Text(s): | **Recommended Text**: John A. Rice : Mathematical Statistics and Data Analysis, 3rd editionBrooks / Cole, 2007. ISBN-13: 978-0-534-39942-9.<br><br>**Reference Texts:**<br><br>-P. MuCullagh and J.A. Nelder: Generealized Linear Models, 2nd ed. 1999 Chapman Hall/CRC. ISBN: 978-0412317606<br><br>-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.<br><br>**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 (20344) -** Math of Deep Learning | |
|---|---|
| Prerequisites: | Graduate standing. Students attending this course are expected to have a solid background in linear algebra, undergraduate real analysis (MATH 4331-4332) and basic probability. |
| Text(s): | Reference texts:<br><br>• "Review of Lebesgue Measure and Integration" by Christopher Heil<br>• "Banach and Hilbert Space Review" by Christopher Heil |

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| Description: | This is a course of mathematics exploring foundational and theorical concepts underlying the development and applications of intelligent systems and deep learning algorithms. The emphasis of the course will be theoretical aspects. The aim of the course is to provide the necessary background to start a graduate research project in this emerging area of investigation.<br><br>Topics of the course include: statistical learning theory, Support Vector Machines, geometry of high-dimensional data, manifold learning, dimensionality reduction, expressive power of neural networks, generalization in neural networks, convolutional neural networks.<br><br>This is class is targeted to graduate students interested in mastering theoretical tools underlying machine learning and data science.<br><br>Even though algorithmic aspects of the topics will not be ignored and exploration of algorithmic issues will be assigned for individual or group projects, this course will not duplicate existing courses on machine learning or data science offered in the Computer Science Department that are focused on algorithmic implementation and computation |

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| **MATH 6397 (20393) -** Bayesian Inverse Problems and Uncertainty Quantification | |
|---|---|
| Prerequisites: | Graduate standing. Credit for or concurrent enrollment in MATH 4331 and MATH 4377/4378, or consent of instructor. Students are expected to have a good grounding in basic real analysis and linear algebra. Basic knowledge about optimization theory (MATH 6366/6367) and (deterministic) inverse problems is helpful but not required. |
| Text(s): | No particular textbook is required. The following lists several good references for various topics related to this course (which go far beyond the material covered in class).<br><br>*References for Bayesian (statistical) inverse problems and uncertainty quantification are:*<br><br>• Statistical and Computational Inverse Problems by J. Kaipio and E. Somersalo. Springer 2005.<br>• Computational Uncertainty Quantification for Inverse Problems by J. Bardsley. SIAM 2018.<br>• Introduction to Uncertainty Quantification by T. J. Sullivan. Springer 2015.<br>• An Introduction to Data Analysis and Uncertainty Quantification for Inverse Problems by L. Tenorio. SIAM 2017.<br><br>*References for inverse problems in general as well as optimization algorithms are:*<br><br>• Computational Methods for Inverse Problems by C. R. Vogel, SIAM 2002.<br>• Discrete Inverse Problems: Insight and Algorithms by P. C. Hansen, SIAM 2010.<br>• An Introduction to the Mathematical Theory of Inverse Problems by A. Kirsch, Springer 2011.<br>• Inverse Problem Theory by A. Tarantola, SIAM 2005.<br>• Numerical Optimization by J. Nocedal and S. J. Wright. Springer 2006. |

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| Description: | Course syllabus: https://www.math.uh.edu/~andreas/resources/material/2023SP-math6397-syllabus.pdf |

| **MATH 6397 (20396) -** Algebraic Topology | |
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| Prerequisites: | Graduate standing. A course in general topology, or consent of the instructor. |
| Text(s): | • (The second half of) "Topology, A First Course," J. R. Munkres.<br>• A. Hatcher, Algebraic topology (free online at the authors website) |
| Description: | The course will begin with reviewing the fundamental group, and will cover much of the second half of Munkres' book (which contains many important and beautiful topics), with additions from other books such as Hatcher's Algebraic topology. We emphasize the many striking applications. Special requests will be honored if possible. |

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| **MATH 7321 -** Functional Analysis | |
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| 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.<br><br>**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.<br><br>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 | |
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| Prerequisites: | Graduate standing. MATH 6320 |
| Text(s): | TBD |

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

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