Department of Mathematics

Fall 2022

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

GRADUATE COURSES - FALL 2022

SENIOR UNDERGRADUATE COURSES

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<td>Math 4310-01</td>
<td>16365</td>
<td>Biostatistics</td>
<td>MWF, 11AM—Noon, (F2F)</td>
<td>AH 301</td>
<td>D. Labate</td>
</tr>
<tr>
<td>Math 4320-01</td>
<td>11630</td>
<td>Intro. To Stochastic Processes</td>
<td>TTh, 10—11:30AM, (F2F)</td>
<td>SEC 105</td>
<td>E. Kao</td>
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<tr>
<td>Math 4322-02</td>
<td>17199</td>
<td>Intro. to Data Science and Machine Learning</td>
<td>TTh, 11:30AM—1PM, (F2F)</td>
<td>GAR 201</td>
<td>C. Poliak</td>
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<tr>
<td>Math 4323-01</td>
<td>17145</td>
<td>Data Science and Statistical Learning</td>
<td>TTh, 10—11:30AM, (F2F)</td>
<td>CBB 106</td>
<td>W. Wang</td>
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<tr>
<td>Math 4331-02</td>
<td>13140</td>
<td>Introduction to Real Analysis I</td>
<td>TTh, 1—2:30PM, (F2F)</td>
<td>F 154</td>
<td>M. Kalantar</td>
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<tr>
<td>Math 4335-01</td>
<td>15291</td>
<td>Partial Differential Equations I</td>
<td>MWF, 9—10AM, (F2F)</td>
<td>SEC 201</td>
<td>G. Jaramillo</td>
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<tr>
<td>Math 4339-02</td>
<td>16536</td>
<td>Multivariate Statistics</td>
<td>TTh, 1—2:30PM, (F2F)</td>
<td>SEC 201</td>
<td>C. Poliak</td>
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<tr>
<td>Math 4350-01</td>
<td>24420</td>
<td>Differential Geometry I</td>
<td>MW, 1—2:30PM, (F2F)</td>
<td>S 102</td>
<td>M. Ru</td>
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<td>Course</td>
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<td>Math 4364-01</td>
<td>13590</td>
<td>Intro. to Numerical Analysis in Scientific Computing</td>
<td>MW, 4—5:30PM, (F2F)</td>
<td>T. Pan</td>
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<tr>
<td>Math 4364-02</td>
<td>16887</td>
<td>Intro. to Numerical Analysis in Scientific Computing</td>
<td>Asynchronous/Online</td>
<td>J. Morgan</td>
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<tr>
<td>Math 4366-01</td>
<td>14942</td>
<td>Numerical Linear Algebra</td>
<td>TTh, 11:30AM—1PM, (F2F)</td>
<td>J. He</td>
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<tr>
<td>Math 4370-01</td>
<td>25580</td>
<td>Mathematics for Physicists</td>
<td>MWF, 11AM—Noon, (F2F)</td>
<td>A. Barato</td>
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<tr>
<td>Math 4377-01</td>
<td>13142</td>
<td>Advanced Linear Algebra I</td>
<td>MWF, Noon—1PM, (F2F)</td>
<td>A. Haynes</td>
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<tr>
<td>Math 4388-01</td>
<td>12472</td>
<td>History of Mathematics</td>
<td>Asynchronous/Online</td>
<td>S. Ji</td>
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<tr>
<td>Math 4389-01</td>
<td>12090</td>
<td>Survey of Undergraduate Mathematics</td>
<td>MWF, 11AM—Noon, (F2F)</td>
<td>D. Blecher</td>
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<tr>
<td>Math 4397-01</td>
<td>24332</td>
<td>Classical &amp; Quantum Information Theory (syllabus)</td>
<td>MWF, Noon—1PM, (F2F)</td>
<td>L. Gao</td>
<td></td>
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<tr>
<td>Math 4397-02</td>
<td>24334</td>
<td>Selected Topics in Mathematics</td>
<td>MWF, 11AM—Noon, (F2F)</td>
<td>TBD</td>
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**GRADUATE ONLINE COURSES**

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<td>Math 5310-01</td>
<td>24331</td>
<td>History of Mathematics</td>
<td>Asynchronous/On-campus Exams; Online</td>
<td>S. Ji</td>
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<tr>
<td>Math 5333-01</td>
<td>24321</td>
<td>Analysis</td>
<td>Asynchronous/On-campus Exams; Online</td>
<td>G. Etgen</td>
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<td>Math 5344-01</td>
<td>24330</td>
<td>Intro. to Scientific Computing</td>
<td>Asynchronous/On-campus Exams; Online</td>
<td>J. Morgan</td>
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<tr>
<td>Math 5382-01</td>
<td>16953</td>
<td>Probability</td>
<td>Asynchronous/On-campus Exams; Online</td>
<td>A. Török</td>
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<tr>
<td>Math 6302-01</td>
<td>11631</td>
<td>Modern Algebra I</td>
<td>TuTh, 2:30—4PM (F2F)</td>
<td>CBB 214</td>
<td>G. Heier</td>
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<tr>
<td>Math 6308-04</td>
<td>13143</td>
<td>Advanced Linear Algebra I</td>
<td>MWF, Noon—1PM</td>
<td>F 154</td>
<td>A. Haynes</td>
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<tr>
<td>Math 6312-02</td>
<td>13141</td>
<td>Introduction to Real Analysis</td>
<td>TuTh, 1—2:30PM</td>
<td>F 154</td>
<td>M. Kalantar</td>
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<tr>
<td>Math 6320-01</td>
<td>11658</td>
<td>Theory of Functions of a Real Variable</td>
<td>MWF, 10—11AM</td>
<td>CBB 214</td>
<td>A. Vershynina</td>
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<td>Math 6322-01</td>
<td>24322</td>
<td>Function Complex Variable</td>
<td>MWF, 9—10AM</td>
<td>AH 301</td>
<td>S. Ji</td>
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<td>Math 6324-01</td>
<td>24323</td>
<td>Differential Equations</td>
<td>TuTh, 11:30AM—1PM</td>
<td>SEC 203</td>
<td>M. Nicol</td>
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<td>Math 6342-01</td>
<td>11659</td>
<td>Topology</td>
<td>TuTh, 11:30AM—1PM</td>
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<td>A. Török</td>
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<td>Math 6360-01</td>
<td>18340</td>
<td>Applicable Analysis</td>
<td>TuTh, 1—2:30PM</td>
<td>CBB 214</td>
<td>D. Onofrei</td>
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<td>Math 6366-01</td>
<td>11660</td>
<td>Optimization Theory</td>
<td>TuTh 2:30—4PM</td>
<td>AH 301</td>
<td>A. Mang</td>
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<td>Math 6370-01</td>
<td>11661</td>
<td>Numerical Analysis</td>
<td>TuTh 5:30PM—7PM</td>
<td>S 115</td>
<td>M. Olshanskii</td>
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<td>15367</td>
<td>Probability</td>
<td>TuTh, 1—2:30PM</td>
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<td>24324/24325</td>
<td>Spatial Statistics</td>
<td>TuTh, 10—11:30AM (F2F)</td>
<td>S 119</td>
<td>M. Jun</td>
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<td>Math 6397-05</td>
<td>24333</td>
<td>Classical &amp; Quantum Information Theory (syllabus)</td>
<td>MWF, Noon—1PM</td>
<td>S 116</td>
<td>L. Gao</td>
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<td>Math 6397-09</td>
<td>26531</td>
<td>Pattern Recognition (syllabus)</td>
<td>TuTh, 4—5:30PM</td>
<td>SEC 204</td>
<td>K. Josic</td>
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<td>Math 7320-01</td>
<td>24328</td>
<td>Functional Analysis</td>
<td>TuTh, 10—11:30AM</td>
<td>MH 129</td>
<td>B. Bodmann</td>
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### MSDS Courses

*(MSDS Students Only)*
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<td>Math 6350-01</td>
<td>16374</td>
<td>Statistical Learning and Data Mining</td>
<td>MW, 1—2:30PM (F2F)</td>
<td>SEC 203</td>
<td>R. Azencott</td>
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<tr>
<td>Math 6357-01</td>
<td>16534</td>
<td>Linear Models &amp; Design of Experiments</td>
<td>MW, 2:30—4PM (F2F)</td>
<td>SEC 203</td>
<td>W. Wang</td>
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<tr>
<td>Math 6358-02</td>
<td>15515</td>
<td>Probability Models and Statistical Computing</td>
<td>Fr., 1—3PM (F2F)</td>
<td>CBB 120</td>
<td>C. Poliak</td>
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<tr>
<td>Math 6358-03</td>
<td>19160</td>
<td>Probability Models and Statistical Computing</td>
<td>Fr., 1—3PM, Synchronous/On-campus Exams</td>
<td>Online</td>
<td>C. Poliak</td>
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<tr>
<td>Math 6358-04</td>
<td>19243</td>
<td>Probability Models and Statistical Computing</td>
<td>Fr., 1—3PM, Asynchronous</td>
<td>Online</td>
<td>C. Poliak</td>
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<tr>
<td>Math 6380-01</td>
<td>16670</td>
<td>Programming Foundation for Data Analytics</td>
<td>Fr., 3—5PM (F2F)</td>
<td>CBB 120</td>
<td>D. Shastri</td>
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<tr>
<td>Math 6380-02</td>
<td>19159</td>
<td>Programming Foundation for Data Analytics</td>
<td>Fr., 3—5PM, Synchronous/On-campus Exams</td>
<td>Online</td>
<td>D. Shastri</td>
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<tr>
<td>Math 6380-03</td>
<td>19249</td>
<td>Programming Foundation for Data Analytics</td>
<td>Fr., 3—5PM, Asynchronous</td>
<td>Online</td>
<td>D. Shastri</td>
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**SENIOR UNDERGRADUATE COURSES**

Math 4310 Biostatistics
Prerequisites: **MATH 3339** and **BIOL 3306**
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<td>Description:</td>
<td>Statistics for biological and biomedical data, exploratory methods, generalized linear models, analysis of variance, cross-sectional studies, and nonparametric methods. Students may not receive credit for both MATH 4310 and BIOL 4310.</td>
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Math 4320 - Intro to Stochastic Processes

Prerequisites: **MATH 3338**


Catalog Description: We study the theory and applications of stochastic processes. Topics include discrete-time and continuous-time Markov chains, Poisson process, branching process, Brownian motion. Considerable emphasis will be given to applications and examples.

**Instructor's description**: This course provides an overview of stochastic processes. We cover Poisson processes, discrete-time and continuous-time Markov chains, renewal processes, diffusion process and its variants, martingales. We also study Markov chain Monte Carlo methods, and regenerative processes. In addition to covering basic theories, we also explore applications in various areas such as mathematical finance.

Syllabus can be found here: https://www.math.uh.edu/~edkao/MyWeb/doc/math4320_fall2022_syllabus.pdf

Math 4322 - Introduction to Data Science and Machine Learning

Prerequisites: MATH 3339
While lecture notes will serve as the main source of material for the course, the following book constitutes a great reference:

”An Introduction to Statistical Learning (with applications in R)” by James, Witten et al. ISBN: 978-1461471370

”Neural Networks with R” by G. Ciaburro. ISBN: 978-1788397872
Course will deal with theory and applications for such statistical learning techniques as linear and logistic regression, classification and regression trees, random forests, neural networks. Other topics might include: fit quality assessment, model validation, resampling methods. R Statistical programming will be used throughout the course.

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

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

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

Course Outline:
Introduction: What is Statistical Learning?


Assessing quality of fit.


Math 4323 - Introduction to Data Science and Machine Learning

Prerequisites: MATH 3339

Text(s): TBA

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

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Math 4331 - Introduction to Real Analysis I

Prerequisites: MATH 3333.


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

Topics: Open and closed sets, compact and connected sets, convergence of sequences, Cauchy sequences and completeness, properties of continuous functions, fixed points and the contraction mapping principle, differentiation and integration.
Math 4335 - Partial Differential Equations I

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


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

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

Math 4339 - Multivariate Statistics

Prerequisites: MATH 3349

Course Description: Multivariate analysis is a set of techniques used for analysis of data sets that contain more than one variable, and the techniques are especially valuable when working with correlated variables. The techniques provide a method for information extraction, regression, or classification. This includes applications of data sets using statistical software.

Course Objectives:

- Understand how to use R and R Markdown
- Understand matrix algebra using R
- Understand the geometry of a sample and random sampling
- Understand the properties of multivariate normal distribution
- Make inferences about a mean vector
- Compare several multivariate means
- Identify and interpret multivariate linear regression models

Course Topics:

- Introduction to R Markdown, Review of R commands (Notes)
- Introduction to Multivariate Analysis (Ch.1)
- Matrix Algebra, R Matrix Commands (Ch.2)
- Sample Geometry and Random Sampling (Ch.3)
- Multivariate Normal Distribution (Ch.4)
- MANOVA (Ch.6)
- Multiple Regression (Ch.7)
- Logistic Regression (Notes)
- Classification (Ch.11)

Math 4350 - Differential Geometry I

Prerequisites:  **MATH 2415** and six additional hours of 3000-4000 level Mathematics.

Description: Curves in the plane and in space, global properties of curves and surfaces in three dimensions, the first fundamental form, curvature of surfaces, Gaussian curvature and the Gaussian map, geodesics, minimal surfaces, Gauss' Theorem Egregium, The Codazzi and Gauss Equations, Covariant Differentiation, Parallel Translation.

Math 4364 (13590) - Introduction to Numerical Analysis in Scientific Computing

Prerequisites: MATH 3331 or MATH 3321 or equivalent, and three additional hours of 3000-4000 level Mathematics

*Ability to do computer assignments in FORTRAN, C, Matlab, Pascal, Mathematica or Maple.


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.
**Prerequisites:**

* MATH 3331 or MATH 3321 or equivalent, and three additional hours of 3000-4000 level Mathematics

* Ability to do computer assignments in FORTRAN, C, Matlab, Pascal, Mathematica or Maple.

**Text(s):**

Instructor's notes

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

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**Math 4366 - Numerical Linear Algebra**

**Prerequisites:**

* MATH 2331, or equivalent, and six additional hours of 3000-4000 level Mathematics.

**Text(s):**

Instructor will use his own notes.

Conditioning and stability of linear systems, matrix factorizations, direct and iterative methods for solving linear systems, computing eigenvalues and eigenvectors, introduction to linear and nonlinear optimization

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**Math 4370 - Mathematics for Physicists**

**Prerequisites:**

* MATH 2331, or equivalent, and a minimum of three semester hours of 3000-4000 level Mathematics.

**Text(s):**

Math 4377 - Advanced Linear Algebra I
Prerequisites: MATH 2331, or equivalent, and a minimum of three semester hours of 3000-4000 level Mathematics.

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

Instructor's Description: The course covers the following topics: vector spaces, subspaces, linear combinations, systems of linear equations, linear dependence and linear independence, bases and dimension, linear transformations, null spaces, ranges, matrix rank, matrix inverse and invertibility, determinants and their properties, eigenvalues and eigenvectors, diagonalizability.

Math 4388 - History of Mathematics
Prerequisites: MATH 3333
Text(s): No textbook is required. Instructor notes will be provided
This course is designed to provide a college-level experience in history of mathematics. Students will understand some critical historical mathematics events, such as creation of classical Greek mathematics, and development of calculus; recognize notable mathematicians and the impact of their discoveries, such as Fermat, Descartes, Newton and Leibniz, Euler and Gauss; understand the development of certain mathematical topics, such as Pythagoras theorem, the real number theory and calculus.

Aims of the course: To help students to understand the history of mathematics; to attain an orientation in the history and philosophy of mathematics; to gain an appreciation for our ancestor’s effort and great contribution; to gain an appreciation for the current state of mathematics; to obtain inspiration for mathematical education, and to obtain inspiration for further development of mathematics.

On-line course is taught through Blackboard Learn, visit http://www.uh.edu/webct/ for information on obtaining ID and password.

The course will be based on my notes.

Homework and Essays assignment are posted in Blackboard Learn. There are four submissions for homework and essays and each of them covers 10 lecture notes. The dates of submission will be announced.

All homework and essays, handwriting or typed, should be turned into PDF files and be submitted through Blackboard Learn. Late homework is not acceptable.

There is one final exam in multiple choice.

Grading: 35% homework, 45% projects, 20 % Final exam.

Math 4389 - Survey of Undergraduate Mathematics

Prerequisites: MATH 3331, MATH 3333, and three hours of 4000-level Mathematics.
No textbook is required. Instructor notes will be provided

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

Math 4397 (24332) / Math 6397 (24333) - Classical & Quantum Information Theory

Math 4397 Prerequisites: MATH 3333. Instructor's prerequisites: Math 3338 (Probability), Math 4377 (Advanced Linear Algebra), and Math 4331 (Real Analysis)

Math 6397 Prerequisites: Graduate standing. Quantum Mechanics will be appreciated but not required.

- Quantum Computation and Quantum Information, by I. Chuang and M. Nielsen
- The Theory of Quantum Information, by John Watrous
- Quantum information theory, by Mark Wilde

Information theory is the scientific study of the quantification, storage, and communication of digital information. It has been widely used in the communication and cryptography in our daily life. In last several decades, motivated by quantum computation, quantum information theory has been a rapid growing area studying how information can be processed, transmit and stored in quantum mechanics system.

The aim of this course is to give a minimal introduction to both classical and quantum information theory in a unified manner. We will start with some basics in Shannon's classical information theory and then study their counterpart in quantum mechanics model. After that, we will focus on the quantum side and covers some selected topics such as entanglement, Bell's inequality, Shor's algorithm, Quantum Teleportation and Superdense coding, etc.

Math 4397 (24334) - Selected Topics in Mathematics

Prerequisites: MATH 3333 or consent of instructor.

Text(s): No textbook is required. Instructor notes will be provided
ONLINE GRADUATE COURSES

MATH 5310 - History of Mathematics

Prerequisites: Graduate standing.

Text(s): TBA

Description: Mathematics of the ancient world, classical Greek mathematics, the development of calculus, notable mathematicians and their accomplishments.

MATH 5333 - Analysis

Prerequisites: Graduate standing and two semesters of Calculus.

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

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

MATH 5344 - Introduction to Scientific Computing

Prerequisites: Graduate Standing and Math 2318 (Linear Algebra) or equivalent.

Text(s): TBA
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.

MATH 5350  - Introduction to Differential Geometry
Prerequisites:  Graduate Standing and MATH 2415 (Calculus III) or equivalent
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 5382  - Probability
Prerequisites:  Graduate Standing. Instructor's prerequisite: Calculus 3 (multi-dimensional integrals), very minimal background in Probability.
Text(s):  Sheldon Ross, A First Course in Probability (10th Edition)
This course is for students who would like to learn about Probability concepts; I’ll assume very minimal background in probability. Calculus 3 (multi-dimensional integrals) is the only prerequisite for this class. This class will emphasize practical aspects, such as analytical calculations related to conditional probability and computational aspects of probability. No measure-theoretical concepts will be covered in this class. This class is intended for students who want to learn more practical concepts in probability. This class is particularly suitable for Master students and non-math majors.

**GRADUATE COURSES**

**MATH 6302 - Modern Algebra I**

**Prerequisites:**
Graduate standing.

**Required Text:** Abstract Algebra by David S. Dummit and Richard M. Foote, ISBN: 9780471433347

**Text(s):**
This book is encyclopedic with good examples and it is one of the few books that includes material for all of the four main topics we will cover: groups, rings, field, and modules. While some students find it difficult to learn solely from this book, it does provide a nice resource to be used in parallel with class notes or other sources.

**Description:**
We will cover basic concepts from the theories of groups, rings, fields, and modules. These topics form a basic foundation in Modern Algebra that every working mathematician should know. The Math 6302--6303 sequence also prepares students for the department’s Algebra Preliminary Exam.

**MATH 6308 - Advanced Linear Algebra I**
**Catalog Prerequisite:** Graduate standing, MATH 2331 and a minimum of 3 semester hours transformations, eigenvalues and eigenvectors.

**Prerequisites:**

Instructor's Prerequisite: **MATH 2331**, or equivalent, and a minimum of three semester hours of 3000-4000 level Mathematics.

**Text(s):**


**Catalog Description:** An expository paper or talk on a subject related to the course content is required.

**Instructor's Description:** The course covers the following topics: vector spaces, subspaces, linear combinations, systems of linear equations, linear dependence and linear independence, bases and dimension, linear transformations, null spaces, ranges, matrix rank, matrix inverse and invertibility, determinants and their properties, eigenvalues and eigenvectors, diagonalizability.

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**MATH 6312 - Introduction to Real Analysis**

**Prerequisites:**

Graduate standing and **MATH 3334**.

In depth knowledge of Math 3225 and Math 3333 is required.

**Text(s):**

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

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

MATH 6320- Theory Functions of a Real Variable

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


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

MATH 6322- Function Complex Variable

**Prerequisites:** Graduate standing and MATH 4331

**Text(s):** TBD

Geometry of the complex plane, mappings of the complex plane, integration, singularities, spaces of analytic functions, special function, analytic continuation, and Riemann surfaces.

MATH 6324- Differential Equations

**Prerequisites:** Graduate standing and MATH 4331

**Text(s):** TBD
MATH 6342 - Topology

Catalog prerequisite: Graduate standing. MATH 4331.

Prerequisites:

Instructor's prerequisite: Graduate standing. MATH 4331 or consent of instructor

Text(s):


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

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

Description:

Though traditionally viewed as a pure subject, algebraic topology has experienced a renaissance in recent years with the emergence of applied algebraic topology. To wit, SIAM has recently launched a new journal on applied algebra and geometry.
MATH 6350 - Statistical Learning and Data Mining

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

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

Text(s):

- Introduction to Statistical Learning w/Applications in R, by James, Witten, Hastie, Tibshirani (This book is freely available online). ISBN: 9781461471370
- "Neural Networks with R" by G. Ciaburro. ISBN: 978-1788397872
Summary: A typical task of Machine Learning is to automatically classify observed "cases" or "individuals" into one of several "classes", on the basis of a fixed and possibly large number of features describing each "case". Machine Learning Algorithms (MLAs) implement computationally intensive algorithmic exploration of large set of observed cases. In supervised learning, adequate classification of cases is known for many training cases, and the MLA goal is to generate an accurate Automatic Classification of any new case. In unsupervised learning, no known classification of cases is provided, and the MLA goal is Automatic Clustering, which partitions the set of all cases into disjoint categories (discovered by the MLA).

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

This MSDSfall 2019 course will successively study:

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

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

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

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

4) Computation of Data Features Discriminative Power

5) Automatic Classification by Support Vector Machines (SVMs)

Emphasis will be on concrete algorithmic implementation and testing on actual data sets, as well as on understanding important concepts.
MATH 6357- Linear Models and Design of Experiments

**Prerequisites:**

**Graduate Standing** and must be in the **MSDS Program.** MATH 2433, MATH 3338, MATH 3339, and MATH 6308

**Text(s):**

Required Text: "Neural Networks with R" by G. Ciaburro. **ISBN:** 9781788397872

**Description:**

Linear models with L-S estimation, interpretation of parameters, inference, model diagnostics, one-way and two-way ANOVA models, completely randomized design and randomized complete block designs.

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MATH 6358- Probability Models and Statistical Computing

**Prerequisites:**

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

- **Recommended:** Introduction to Probability Models by Sheldon Axler 11th edition
- Lecture Notes

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

Topics Covered:

- Probability spaces, random variables, axioms of probability.
- Combinatorial analysis (sampling with, without replacement etc)
- Distribution of a random variable, distribution functions, probability density function. Independence.
- Strong law of large numbers and the central limit theorem.
- Major discrete distributions- Bernoulli, Binomial, Poisson, Geometric. Modeling with the major discrete distributions.
- Important continuous distributions- Normal, Exponential. Beta and Gamma.
- Jointly distributed random variables, joint distribution function, joint probability density function, marginal distribution.
- Conditional probability- Bayes theorem. Discrete conditional distributions, continuous conditional distributions, conditional expectations and conditional probabilities. Applications of conditional probability.

Software Used:

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

MATH 6360 - Applicable Analysis
Prerequisites:

Graduate standing.

Text(s):

**No obligatory text.** Part of the material will be collected from Ken Davidson and Alan Donsig, “Real Analysis with Applications: Theory in Practice”, Springer, 2009. Other sources on Applied Functional Analysis will complement the material.
This course covers topics in analysis that are motivated by applications.

1. Review of metric spaces, completeness, characterization of compactness, extreme value theorem.
5. Consequences of uniform boundedness for Fourier series and polynomial interpolation.
15. Other topics in coordination with faculty.

MATH 6366 - Optimization Theory
Graduate standing and **MATH 4331** and **MATH 4377**

**Prerequisites:**
Students are expected to have a good grounding in basic real analysis and linear algebra.

"Convex Optimization", Stephen Boyd, Lieven Vandenberghe, Cambridge University Press, ISBN: 9780521833783 *(This text is available online. Speak to the instructor for more details)*

**Description:**
The focus is on key topics in optimization that are connected through the themes of convexity, Lagrange multipliers, and duality. The aim is to develop a analytical treatment of finite dimensional constrained optimization, duality, and saddle point theory, using a few of unifying principles that can be easily visualized and readily understood. The course is divided into three parts that deal with convex analysis, optimality conditions and duality, computational techniques. In Part I, the mathematical theory of convex sets and functions is developed, which allows an intuitive, geometrical approach to the subject of duality and saddle point theory. This theory is developed in detail in Part II and in parallel with other convex optimization topics. In Part III, a comprehensive and up-to-date description of the most effective algorithms is given along with convergence analysis.

**MATH 6370 - Numerical Analysis**

**Prerequisites:**
**Graduate standing.** Students should have knowledge in Calculus and Linear Algebra.

The course introduces to the methods of scientific computing and their application in analysis, linear algebra, approximation theory, optimization and differential equations. The purpose of the course to provide mathematical foundations of numerical methods, analyse their basic properties (stability, accuracy, computational complexity) and discuss performance of particular algorithms. This first part of the two-semester course spans over the following topics: (i) Principles of Numerical Mathematics (Numerical well-posedness, condition number of a problem, numerical stability, complexity); (ii) Direct methods for solving linear algebraic systems; (iii) Iterative methods for solving linear algebraic systems; (iv) numerical methods for solving eigenvalue problems; (v) non-linear equations and systems, optimization.

MATH 6380 - Programming Foundation for Data Analytics

Graduate Standing and must be in the MSDS Program.

Instructor prerequisites: The course is essentially self-contained. The necessary material from statistics and linear algebra is integrated into the course. Background in writing computer programs is preferred but not required.


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

MATH 6382- Probability and Statistics

Prerequisites: Graduate standing and MATH 3334, MATH 3338 and MATH 4378.

Recommended Texts:

Review of Undergraduate Probability:

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

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

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

MATH 6397 (24324) - Spatial Statistics

Prerequisites: Graduate standing.
Math 6397 (24333) - Classical & Quantum Information Theory

**Graduate standing.** Quantum Mechanics will be appreciated but not required.

- Quantum Computation and Quantum Information, by I. Chuang and M. Nielsen
- The Theory of Quantum Information, by John Watrous
- Quantum information theory, by Mark Wilde

Information theory is the scientific study of the quantification, storage, and communication of digital information. It has been widely used in the communication and cryptography in our daily life. In last several decades, motivated by quantum computation, quantum information theory has been a rapid growing area studying how information can be processed, transmit and stored in quantum mechanics system.

**Description:**

The aim of this course is to give a minimal introduction to both classical and quantum information theory in a unified manner. We will start with some basics in Shannon's classical information theory and then study their counterpart in quantum mechanics model. After that, we will focus on the quantum side and covers some selected topics such as entanglement, Bell’s inequality, Shor's algorithm, Quantum Teleportation and Superdense coding, etc.

MATH 6397 (25841) - Pattern Recognition

**Graduate standing.** Undergraduate calculus sequence, undergraduate probability (MATH 3338), differential equations (MATH 3331) and two semesters of linear algebra.
We will use the following two books:

- Data-Driven Science and Engineering by Steven L. Brunton and J. Nathan Kutz
- Pattern Recognition and Machine Learning by Christopher M. Bishop.

The first book is a useful resource and is highly recommended. However, since online lectures will be mostly followed, it is not necessary to purchase.

**Course Format:** This course is being offered in the Synchronous Online format. Synchronous online class meetings will take place according to the class schedule. There is no face-to-face component to this course. All lectures and discussions will be delivered online.

**Topics Covered:** This course is devoted to the mathematical methods of finding patterns in data.

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**MATH 7320 - Functional Analysis**

**Prerequisites:** Graduate standing. MATH 6320, Linear Algebra (MATH 4377) and Real Analysis (MATH 4331/4332). Knowledge of Lebesgue integration is desirable.

Catalog description: Linear topological spaces, Banach and Hilbert spaces, duality, and spectral analysis.

Instructor's description: This course is part of a two semester sequence covering the main results in functional analysis, including Hilbert spaces, Banach spaces, topological vector spaces such as distributions, and linear operators on these spaces.

Description: Functional analysis combines two fundamental branches of mathematics: analysis and linear algebra.

Topics covered in this first part of the course sequence include: Topological vector spaces; Completeness; Convexity; Spectral theory; Distributions.

Course requirement: Assignments will consist of the student taking notes and they must be typeset in LaTeX.