Course Change Request

New Course Proposal

Date Submitted: 04/25/21 4:40 pm

Viewing: MATH 465 : Mathematics of Data Science

Last edit: 04/27/21 10:51 am

Changes proposed by: csausvil

In Workflow

1. **MATH Chair**
2. **SC Curriculum Committee**
3. SC Associate Dean
4. Assoc Provost-Undergraduate
5. Registrar-Courses
6. Banner

Approval Path

1. 04/25/21 10:35 pm David Walnut (dwalnut): Approved for MATH Chair

Are you completing this form on someone else's behalf?

No

Effective Term:	Fall 2021
Subject Code:	MATH - Mathematics
Course Number:	465
Bundled Courses:	
Is this course replacing another course?	No
Equivalent Courses:	
Catalog Title:	Mathematics of Data Science
Banner Title:	Mathematics of Data Science
Will section titles vary by semester?	No
Credits:	3
Schedule Type:	Lecture
Hours of Lecture or Seminar per week:	3
Repeatable:	

May be only taken once for credit, limited to 3 attempts (N3)

Max Allowable Credits: 9

Default Grade Mode: Undergraduate Regular

Recommended Prerequisite(s):

Math 352 or Stat 350 or Stat 360 or Stat 356

Recommended Corequisite(s):

Required Prerequisite(s) / Corequisite(s) (Updates only):

Math 214 and Math 464

Registrar's Office Use Only - Required Prerequisite(s)/Corequisite(s):

And/Or	(	Course/Test Code	Min Grade/Score	Academic Level	)	Concurrency?

Registration Restrictions (Updates only):

Registrar's Office Use Only - Registration Restrictions:

Field(s) of Study:

Class(es):

Level(s):

Degree(s):

School(s):

Catalog Description:

Covers mathematical aspects of data science including theory of linear and nonlinear dimension reduction, elements of spectral graph theory, function spaces and regularity in regression, and data-driven dynamics identification and discovery. Computational and analytic assignments are given.

Justification:

This course is being created to meet the ever changing needs of the department. Data Science is a growing domain of study that spans many fields, including Mathematics. This course will allow our students to better prepare for either a job or a graduate program where a solid understanding of the mathematics of data science is desired. It will also help support the university's initiative regarding the Tech Talent Investment Program (TTIP) created by the Commonwealth of Virginia.

Does this course cover material which crosses into another department? No

Learning Outcomes:

Stated on attached syllabus.

Attach Syllabus

465-syllabus_rev4272021.pdf

Additional Attachments

Staffing:

H. Antil, M. Emelianenko, T. Berry, T. Sauer, E. Sander, I. Griva, C. Rautenberg, P. Seshaiyer

Relationship to Existing Programs:

This course will supplement our current concentrations in Applied Mathematics and Mathematical Statistics as well as our new concetration in Data Science which is under development.

Relationship to Existing Courses:

We have run this course in previous semesters as a special topics course and had both graduate and undergraduate students who were interested in these topics so we are making this a permanent course.

Additional Comments:

Reviewer Comments

Key: 17202

GMU Department of Mathematical Sciences
Math 465: Mathematics of Data Science
Syllabus

Required prerequisites:
MATH 214, MATH 464 or permission of the instructor.

Recommended prerequisites:
MATH 352 or STAT 350/356/360.

Textbook: Recommended textbooks are provided below. Supplementary materials may be used.

1. Steven L. Brunton, J. Nathan Kutz, "Data-driven science and engineering", Cambridge University Press, 2019
2. James Ramsay, Giles Hooker, "Dynamic Data Analysis: modeling data with differential equations", Springer, 2017
3. Ralph C. Smith, "Uncertainty Quantification: theory, implementation and applications", SIAM 2014

Course Description: This course is aimed at providing rigorous mathematical foundation for data science related methodologies often omitted in computational curriculum. Matrix algebra, differential equations and graph theory techniques are integrated throughout the course. Foundational aspects of data science including mathematical theory of linear and nonlinear dimension reduction, elements of spectral graph theory, parametric and non-parametric modeling and data-driven dynamics identification and discovery are introduced. The following specific concepts will be discussed:

1. Types of data: continuous vs. categorical, meta-structures (time, space, network)
2. Overfitting: Dimensionality reduction vs. regularization
3. Modeling/Regressions: Parametric vs. Nonparametric
4. Dimensionality/Features: Intrinsic vs. extrinsic
5. Dynamical vs. static models: identification of model type and learning dynamics from data

Learning outcomes: Students will gain an initial exposure to the topics listed above and mathematical connections between them. Graded assignments will be testing students' ability to grasp main mathematical ideas and apply them in specific settings using analytical and computational methods discussed in class. Students will be expected to use the computational routines provided in class to test performance of specific algorithms.

Tentative schedule:

1. Weeks 1-2: Review of linear methods optimizing quadratic forms: PCA, MDS, Linear models, l^2 regularization, kernel regression, sliced inverse regression. Overview of optimization techniques: Duality, SVM and KSVM, LDA, sparsity and the l^1 regularization. Overview of numerical methods for derivatives: numerical, symbolic, and automatic.
2. Weeks 3-4: Nonlinear dimensionality reduction: nonlinear PCA, diffusion mapping, tSNE/UMAP, autoencoders, gradient based methods.
3. Weeks 5-7: Spectral methods and elements of graph theory, information entropy, random graph models, overview of clustering and classification.
4. Weeks 8-10: Parametric Modeling: Variational/Least squares, Kalman filter, parameter estimation, MCMC, parameter identifiability, uncertainty quantification.

5. Weeks 11-14: Dynamics and data: discovery of dynamics, dynamic mode decomposition, sparse dynamics identification.

Optional topics include tensor decompositions, wavelets, Gabor transform, connections with combinatorics, geometry and topology.

Grading policy:
Students' grade in this course will depend on several graded projects and one take-home final exam, each containing an analytical and computational part. 3-4 projects will be given during the course of the semester and oral presentations will be scheduled. Groups of up to 3 people are allowed to work on each assignment, and group members are allowed to switch groups between assignments with instructor's approval. Participation credit will be given for taking part in at least 75% of in-class and online activities.

Tentative grading scale:
Homework assignments and group projects: 60%
Take-home final exam: 30%
Participation: 10%

Academic Policies Mason is an Honor Code university; please see the Office for Academic Integrity for a full description of the code and the honor committee process. With collaborative work, names of all the participants should appear on the work. Collaborative projects may be divided up so that individual group members complete portions of the whole, provided that group members take sufficient steps to ensure that the pieces conceptually fit together in the end product. Other projects are designed to be undertaken independently. In the latter case, you may discuss your ideas with others and conference with peers on drafts of the work; however, it is not appropriate to give your paper to someone else to revise. You are responsible for making certain that there is no question that the work you hand in is your own. If only your name appears on an assignment, your professor has the right to expect that you have done the work yourself, fully and independently.

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In this class we welcome and value individuals and their differences including race, economic status, gender expression and identity, sex, sexual orientation, ethnicity, national origin, first language, religion, age, and disability.