Advanced Graduate Certificate in Human-Centered Data Science

Course Catalog

CS/DS Core Courses: Students must take two core courses, one in the category of algorithms and one in the category of machine learning.

Algorithms

AMS 561/DCS 521: Introduction to Computational and Data Science
This course provides a foundation of knowledge and basic skills for the successful application in graduate research of modern techniques in computational and data science relevant to engineering, the humanities, and the physical, life and social sciences. It is consciously crafted to provide a rich, project-oriented, multidisciplinary experience that establishes a common vocabulary and skill set. Centered around the popular programming language Python, the course will serve as an introduction to programming including data structures, algorithms, numerical methods, basic concepts in computer architecture, and elements of object-oriented design. Also introduced will be important concepts and tools associated with the analysis and management of data, both big and small, including basic statistical modeling in R, aspects of machine learning and data mining, data management, and visualization. No previous computing experience is assumed. Students are assumed to have taken some introductory courses in two of these three math subjects: linear algebra, calculus, and probability. *Anti-requisite:* AMS 595 *Pre-requisite: Requires departmental consent. 3 credits, ABCF grading*

CSE 548: Analysis of Algorithms
Techniques for designing efficient algorithms, including choice of data structures, recursion, branch and bound, divide, and conquer, and dynamic programming. Complexity analysis of searching, sorting, matrix multiplication, and graph algorithms. Standard NP-complete problems and polynomial transformation techniques. This course is offered as both AMS 542 and CSE 548. Prerequisite: CSE 373.
3 credits, Letter graded (A, A-, B+, etc.)

CSE 582: Computer Science Fundamentals: Data Structures and Algorithms
The course consists of two parts. The first part covers data structures to efficiently store, organize, modify, and access data. Topics include: arrays, stacks, queues, linked lists, trees, sets, hash maps, priority queues, and graphs. The second part covers the design and analysis of algorithms for solving computer science problems. Topics include: algorithm analysis, exhaustive search algorithms, divide and-conquer algorithms, greedy algorithms, and dynamic programming algorithms. *3 credits, Letter graded (A, A-, B+, etc.)*

Machine Learning

AMS 520: Machine Learning in Quantitative Finance
This course will merge ML and traditional quantitative finance techniques employed at investment banks, asset management, and securities trading firms. It will provide a systematic introduction to statistical learning and machine learning methods applied in Quantitative Finance. The topics discussed in the course fall broadly into four categories which (as time permits) will be discussed in this order: Probabilistic Modeling, Feedforward neural networks, Sequential Learning, and Reinforcement Learning.

Prerequisite: AMS 572& AMS 595 (or AMS 561 or based on Python knowledge per Instructor Consent) *3 credits, Letter graded (A, A-, B+, etc.)*

AMS 580: Statistical Learning
This course teaches the following fundamental topics: (1) General and Generalized Linear Models; (2) Basics of Multivariate Statistical Analysis including dimension reduction methods, and multivariate regression analysis; (3) Supervised and unsupervised statistical learning. This course will first review classical linear and generalized linear models such as Linear Regression, Logistic Regression, and Linear Discriminant Analysis. We shall then study modern Resampling Methods such as Bootstrapping, and modern variable selection methods such as the Shrinkage Method. We will study traditional multivariate analysis methods including cluster analysis, principal component analysis, and multivariate regression methods such as structural equation modeling. Finally, we shall introduce modern non-linear statistical learning methods such as the Generalized Additive Models, Decision Trees, Random Forest, Boosting, Bagging, Support Vector Machines, and Neural Networks. Offered: *Spring, 3 credits, Letter graded (A, A-, B+, etc.)*

CSE 512: Machine Learning
Machine Learning is centered around automated methods that improve their own performance through learning patterns in data, and then use the uncovered patterns to predict the future and make decisions. Examples include document/image/handwriting classification, spam filtering, face/speech recognition, medical decision making, robot navigation, to name a few. See this for an extended introduction. This course covers the theory and practical algorithms for machine learning from a variety of perspectives. The topics include Bayesian networks, decision tree learning, Support Vector Machines, statistical learning methods and unsupervised learning, as well as theoretical concepts such as the PAC learning framework, margin-based learning, and VC dimension. Short programming assignments include hands-on experiments with various learning algorithms, and a larger course project gives students a chance to dig into an area of their choice. See the syllabus for more. This course is designed to give a graduate-level student a thorough grounding in the methodologies, technologies, mathematics, and algorithms currently needed by people who do research in machine learning. *3 credits, Letter graded (A, A-, B+, etc.)*

Electives: Student must choose two electives. At least one must be outside of their home department and not cross-listed.

AFS 502: Research Methods in Africana Studies
This course introduces students to basic concepts of research methodology, specifically as they pertain to studies of the African diaspora. Students will be exposed to a variety of critical approaches across such disciplines as history, literature, political science, and sociology in the context of Africana studies. Students will examine the ways in which theoretical, ideological, and philosophical assumptions about race, class, and gender shape the kinds of research questions we ask and the types of instruments we use to investigate and evaluate the experiences and contributions of people from the African diaspora. *Permission of advisor required. Fall, 3 credits, Letter graded (A, A-, B+, etc.)*

AFS 533: Race, Gender, and Globalization
This seminar explores current issues and debates relating to the racialized and gendered effects of globalization. Topics include an overview of the sociology of globalization and theories of globalism/the global system, transnational classes and a transnational state, global culture and ideology, transnational migrations and the new global labor market, globalization and race/ethnicity, women and globalization,

local-global linkages, and resistance to globalization. *Offered: Fall or Spring, 3 credits, Letter graded (A, A-, B+, etc.)*

CSE 564: Visualization *(AMS and CS students require approval)*
Visualization plays an increasingly important role in the understanding of the massive data that are nowadays being collected in almost any domain – science, medicine, business, commerce, finance, social networks, and many more. As such, visualization is often deeply integrated into the analytics tools developed for data science. This course will discuss both foundations and applications of this emerging paradigm known as visual analytics. It will begin with the basics – visual perception, cognition, human-computer interaction, the sense-making process, data mining, computer graphics, and information visualization/It will then move to discuss how these elementary constituents are coupled into an effective visual analytics pipeline that allows humans to interactively reason with data and gain insight. *3 credits, Letter graded (A, A-, B+, etc.)*

ECO 522: Applied Econometrics
A continuation of ECO 521. The application and extension of econometric techniques developed in ECO 521. Emphasis on the relationship among economic theory, econometric modeling and estimation, and empirical inference. Computer usage for calculation of estimators. Critical examination of econometric studies in current journals. *Prerequisite: ECO 521, Graduate standing in the Economics Department or permission of the Graduate Director.* Offered: *Fall, 3 credits, Letter graded (A, A-, B+, etc.)*

ECO 612: Computational Economics and Dynamic Modeling
An analysis of the theory and applications of the dynamic modeling literature using computational methods, and on the methods themselves. Dynamic Modeling and Computational Economics are possibly the fastest growing areas of interest in the profession due to its suitability to model, solve and estimate realistic decision-making problems in most areas of economics. *Prerequisite: Graduate standing in the Economics Department or permission of the Graduate Director Offered*: *Fall, 3 credits, Letter graded (A, A-, B+, etc.)*

ECO 640: Labor Economics I
This is the first course in the graduate sequence in labor economic theory and empirical applications. Topics include human capital theory, labor supply, life cycle behaviors, and the behavioral effects of social insurance programs. The emphasis is on up-to-date treatments of these topics in the literature. Offered: *Fall, 3 credits, Letter graded (A, A-, B+, etc.)*

ISE 503: Data Management *(AMS and CS students require approval)*
This course provides an understanding of the issues in managing database systems as an essential organizational resource. Students learn the enterprise data architecture components, data storage configurations, and information retrieval methods. It expands from the relational model to the multidimensional model, object-relational techniques, and web accessed data. The course includes concepts, principles, issues, and techniques for managing corporate data resources. Techniques for managing the design and development of large database systems including logical data models, concurrent processing, data distribution, database administration, data warehousing, data cleansing, and data mining. Students will use current methods and tools for database design and development. *Limited to CSE/ISE graduate students; others, permission of instructor. 3 credits, Letter graded (A, A-, B+, etc.)*

LIN 521: Syntax I
A study of formal grammar as one aspect of our knowledge of language. Concepts and elements of modern syntactic analysis are introduced and motivated using a variety of grammatical phenomena and

processes, across a wide range of languages. *Prerequisite: Enrollment in LIN program or permission of instructor. 0-3 credits, Letter graded (A, A-, B+, etc.)*

LIN 523: Phonology I
An introduction to the formal study of sound patterns. Problems from various languages serve as the basis for developing a theory of the representation of sound structure. *Prerequisite: Enrollment in LIN program or permission of instructor. 0-3 credits, Letter graded (A, A-, B+, etc.)*

LIN 637: Computational Linguistics 2
An introduction to the theoretical foundation of computational linguistics. The course emphasizes the importance of algorithms, algebra, logic, and formal language theory in the development of new tools and software applications. Empirical phenomena in phonology and syntax are sampled from a variety of languages to motivate and illustrate the use of concepts such as strictly local string languages, tree transducers, and semirings. Students will develop familiarity with the literature and tools of the field. *0-3 credits, Letter graded (A, A-, B+, etc.) May be repeated for credit.*

NEU 534: Principles of Neurobiology
Neuroscience investigates how the brain functions. This course begins with a review of cellular and molecular mechanisms of brain function, considers brain systems for motor control and sensory processing, and then finishes with a description of the cellular and molecular underpinnings of higher brain functions such as learning, emotion, and cognition. Semester *Offered: Summer, 3 credits, Letter graded (A, A-, B+, etc.)*

NEU 536: Introduction to Computational Neuroscience
This course will introduce students to the fundamental principles and methods underlying computational modeling of neurobiological systems, spanning a range of topics from the biophysics of excitable membranes to models of learning and memory. A major focus of the course will be on the process by which a model of a neurobiological system is developed. Students will be introduced to the mathematical methods required for the modeling of such systems, as well as to tools for numerical and computational simulation. The students will also learn programming skills in the Matlab computing environment and will be required to perform Matlab projects to complement the material learned in the lectures. *2-3 credits, Letter graded (A, A-, B+, etc.)*

NEU 537: Neurotransmission and Neuromodulation
Exploration of fundamental concepts of neurotransmission and neuromodulation of synaptic transmission. The subject matter includes an overview of the basic principles of neurotransmission and of the neuromodulatory systems in the brain. The involvement of these systems in behavior and neurological disorders is emphasized. We will discuss how specific neurological disorders can be investigated experimentally and how experimental results can contribute to understanding and treating these disorders. *3 credits, Letter graded (A, A-, B+, etc.)*

NEU 547: Introduction to Neural Computation
A broad introduction to neural computation. This course will discuss what counts as ¿computation¿ and in what sense the brain computes, how it computes, and whether those computations look anything like those performed by digital computers. These ideas and concepts will be introduced through examples of computation in the brain, including the neural bases of sensory perception, decision making, learning and memory, and motor control. Students will learn through in-class demonstrations and activities, as well as homework assignments that give students the opportunity to analyze real neural recordings relevant to

each of the topic modules. Students taking this class will be expected to have basic working knowledge in undergraduate-level calculus and statistics. *3 credits, Letter graded (A, A-, B+, etc.)*

POL 633: Social Influence and Group Processes in Political Decision Making
Review of contemporary theories of social influence processes and group decision making, with emphasis on applications to decision making in politics. Special focus on small-group methods and research applications. *3 credits, Letter graded (A, A-, B+, etc.)*

POL 676: Advanced Topics: Methods I
A course reviewing the literature and methodology of specific areas of political science research. The course relates directly to research applications and provides students with an opportunity to apply advanced research tools to selected substantive problems. *3 credits, Letter graded (A, A-, B+, etc.) May be repeated for credit.*

PSY 507: Meta-Analysis
This course is an introduction to research synthesis and the use of meta-analytic techniques. The content is intended to be a thorough yet practical coverage of basic principles, with an emphasis on leading students through the steps of conducting their own meta-analytic project. A basic knowledge of statistics commonly used in the social and behavioral sciences is essential. Class meetings will involve both didactic instruction and discussion of readings and homework assignments. *3 credits, Letter graded (A, A-, B+, etc.)*

PSY 513: Theories of Attention
This course covers some of the major theoretical perspectives that have shaped the attention literature, staring with historical distinctions of early versus late selection and ending with more contemporary mathematical, neurophysiological, and neurocomputational theories. Specific questions will include: "What is attention?" (Is it a unitary thing or a grab-bag of assorted processes?), "How does it work," and "What paradigms have researchers used to study attention?" (Dichotic listening, priming, search, etc.). *Offered: Fall or Spring, alternate years, 3 credits, Letter graded (A, A-, B+, etc.)*

PSY 520: Psycholinguistics
The psychology of language, including the mental lexicon, sentence processing, pragmatics, discourse, production, and comprehension of utterances in conversation, language and thought, first-language acquisition, and computational approaches. *Offered: Fall or Spring, 3 credits, Letter graded (A, A-, B+, etc.)*

PSY 549: Prejudice and Discrimination
This course will provide an overview of theoretical perspectives, research methods, empirical findings, and practical applications of psychological research on prejudice, stigma, and intergroup relations. Critical thinking about theorizing and research in this area will be emphasized during class discussions and through a course project. Students are admitted with permission by instructor. *Offered: Fall or Spring, alternate years, 3 credits, Letter graded (A, A-, B+, etc.)*

PSY 620: Bayesian Analysis (Seminars in Selected Topics)
Topics selected on the basis of the needs of the graduate program and research interests of the staff. *Prerequisite: Permission of instructor. Offered: Spring, 0-3 credits, Letter graded (A, A-, B+, etc.) May be repeated for credit.*

SOC 504: Logic and Practice of Sociology
This course provides an introduction to the logic of empirical research in sociology. It takes a broad

overview of both quantitative and qualitative methods; inductive and deductive reasoning; and the process of theory construction and testing, with an emphasis on research design and the logic of causal analysis. A knowledge of advanced statistics is not assumed. Topics covered include survey research, participant observation and field methods, the comparative method, experimental and quasi-experimental design, content analysis, and the logic of multivariate analysis. *3 credits, Letter graded (A, A-, B+, etc.)*

SOC 556: Political Sociology
The study of political institutions and of the politically relevant actions and attitudes of individuals and groups. Particular stress is placed on the reciprocal relationship between social movements and political institutions. *3 credits, Letter graded (A, A-, B+, etc.)*

SOC 561: Cultural Sociology
Cultural sociology is a multi-faceted approach used to analyze phenomena as varied as the arts and popular culture, social identities, social movements, markets, and politics. In this course the major theoretical approaches are presented along with the most significant empirical work done in recent years. Classical as well as contemporary texts are considered. *Offered: Fall or Spring, 3 credits, Letter graded (A, A-, B+, etc.) May be repeated 2 times for credit.*