

Network Science PhD Program Handbook

ACADEMIC YEAR 2023-24



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NETWORK SCIENCE PROGRAM FACULTY MEMBERS

ALBERT-LÁSZLÓ BARABÁSI

László Barabási is the Robert Gray Dodge Professor of Network Science and a Distinguished University Professor of Physics. He investigates biological networks, science of success, applications of control theory to networks, development of network models of resiliency in systems.

NICK BEAUCHAMP

Nick Beauchamp is an Associate Professor in the Department of Political Science. He investigates how political opinions form and change as a result of discussion, deliberation and argument in political domains using techniques from machine learning, automated text analysis, and social network analysis.

TINA ELIASSI-RAD

Tina Eliassi-Rad is a Professor of Computer Science. Her research interests include (a) statistical relational learning and graph mining, (b) axiomatic approaches to descriptive measures on graphs, and (c) unifying the physics of networks with the mining of graphs. Applications of interests include anomaly detection, cultural analytics, cyber situational awareness, and ranking systems.

DIMA KRIOUKOV

Dima Krioukov is an Associate Professor in the Departments of Physics, Mathematics, and Electrical & Computer Engineering. He develops novel applications of geometry and physics to the analysis of massive networks, including those involved in navigation/routing in the Internet, neuroscience, and cosmology.

DAVID LAZER

David Lazer is a University Distinguished Professor in the Department of Political Science and College of Computer and Information Science, and co-director of the NULab for Texts, Maps, and Networks. His research interests include group learning in technology-mediated environments; consensus and opinion formation in groups, particularly in political settings, or pertaining to governance.

MAURICIO SANTILLANA

Mauricio Santillana is a Professor in the Departments of Physics and Electrical & Computer Engineering. His research is in mathematical modeling and scientific computing, specializing in the analysis of big data sets in multiple contexts to understand and predict the behavior of complex systems. He also has expertise in the design and analysis of numerical methods to solve partial differential equations (PDEs) for a diverse array of applications.

CHRISTOPH RIEDL

Chris Riedl is an Associate Professor for Information Systems at the D'Amore McKim School of Business. He employs business analytics and data science to investigate research questions about group-decision making, network science, and social media, and develops novel computational approaches to study collective intelligence mechanisms.

ALESSANDRO VESPIGNANI

Alex Vespignani is the Director of the Network Science Institute and Sternberg Family Distinguished University Professor with interdisciplinary appointments in the College of Computer and Information Science, College of Science and the Bouvé College of Health Sciences. His research interests include complex systems & networks; and the data-driven computational modeling of epidemics.

BROOKE FOUCAULT WELLES

Brooke Welles is an Associate Professor of Communication Studies in the College of Arts, Media and Design. Her research examines how social networks shape behavior, including how individuals identify resources within their social networks and leverage them to achieve personal and organizational goals.

MATTEO CHINAZZI

Matteo Chinazzi is a Research Associate Professor at Northeastern University (Department of Physics), Roux Institute member, and Core Faculty at the Network Science Institute. He conducts research at the intersection between network science, data science, epidemiology, economics, and artificial intelligence. His research interests include the development of computational and analytical models to study and forecast the spatial spread of infectious diseases and the development of agent-based models to create realistic representations of population dynamics.

ALINA LUNGEANU

Alina is an Assistant Professor of Communication Studies in the College of Arts, Media and Design, with a joint appointment in the D'Amore McKim School of Business in the Management and Organizational Development Group. Her research combines insights from social science and network science to examine how team networks configure to advance the frontier of science.

BRIONY SWIRE-THOMPSON

Briony Swire-Thompson is the Director of the Psychology of Misinformation Lab. Her research examines what drives belief in inaccurate information, why people share misinformation online, and how corrections can be designed to maximize impact. She is currently funded by a Pathway to Independence Award from the National Institutes of Health to study cancer misinformation.

SAMUEL V. SCARPINO

Samuel Scarpino is the director of AI plus Life Sciences in the Institute for Experiential AI at Northeastern. Sam is a complex systems scientist investigating questions at the intersection of network science and human behavior, whose work spans a broad range of topics, including infectious disease modeling, forecasting in complex systems, genetic topology of disease, and decision making under uncertainty.

DAKOTA MURRAY

Dakota Murray is a Research Assistant Professor in the College of Sciences and the Network Science Institute. His research applies data science and computational techniques to examine the social processes underlying how communities innovate and produce knowledge, with a particular focus on the role of bias, mobility, and conflict in science & technology.

STUDENT RESPONSIBILITIES

Students are required to track of academic progress, student accounts, and registration. Resources to assist with this process are listed below, but students should reach out to the Program Manager with any questions.

ACADEMICS RESOURCES

Academic Catalog

The Academic Catalog contains all requirements and expectations for students throughout their program. The top link will redirect to the current academic catalog. Students must refer to the catalog that aligns with their year of entry.

[Current Catalog \(for students beginning in Fall 2023\)](#)

[Catalog Archives \(before Fall 2023\)](#)

Degree Audit

The degree audit is the official record of academic progress. Please review this regularly and contact the Program Manager with any questions.

[Graduate Degree Audit](#)

Registrar

The Registrar provides many useful articles and videos to assist with including course registration and tracking important dates. Please click below for useful links to track important information.

[Registering for Courses \(general instructions\)](#)

[Registering for Individual Instruction \(Research, Directed Study, Dissertation\)](#)

[Academic Calendar](#)

COLLEGE SUPPORT

College of Science Graduate Student Support

The College of Science Graduate Student Support website is a resource for students who began the program before fall 2020. This resource is helpful as students approach graduation. Please email gradcos@northeastern.edu with questions about the material on the website

[CoS Graduate Student Services](#) (must log in using NU credentials)

College of Social Sciences and Humanities Graduate Student Support

The College of Social Sciences and Humanities provides resources for New and Current Graduate students. This includes information about general university resources as well as college specific fellowships and funding opportunities. Click the links below to navigate to the appropriate page. Email gradcssh@northeastern.edu for college-level assistance.

[CSSH Resources for New Graduate Students](#)

[CSSH Resources for Current Graduate Students](#)

FINANCIAL SERVICES AND INTERNATIONAL STUDENT SUPPORT

Financial and international student status are individualized. Students are encouraged to contact the appropriate offices to discuss any changes or questions regarding financial obligations or maintaining student status.

Student Financial Services and Student health plan

All PhD students receive coverage for course tuition and the student health plan; however, students are still responsible for student fees. Please use the links below to view student fees and student health plan waiver, if applicable.

[Student Financial Services Fees](#) (Graduate Programs → Fees)

[Student Health Plan Waiver](#)

Office of Global Services and Global Student Success

It is important that international students maintain their status to study in the United States. Please see common topics linked below and visit the websites to find additional assistance.

[Maintaining Status](#)

[Immigration Attorneys and Pro-Bono Legal Services](#)

[Tax Information](#)

[Research Abroad](#) (international students only)

[F-1 Curricular Practical Training](#)

[Leave of Absence](#) (international students only)

[Global Student Support](#) (Academic and cultural support)

HEALTH AND WELLNESS

Below are a few university resources to support students' health and wellness. Graduate school can be stressful but Northeastern provides many resources to support students' health and wellbeing. Please contact the Program Manager if you need support and assistance for something not listed here.

[Leave of Absence and University Withdrawal](#)

[Disability Resource Center](#)

[LGBTQA+ Resource Center](#)

[Center for Spirituality, Dialogue, and Service](#)

[Office for University Equity and Compliance](#) (Title IX)

[Graduate Ombuds](#)

[Graduate Student Government and Groups](#)

[University Health and Counseling Support Groups](#)

PROGRAM OVERVIEW

Northeastern University offers a full-time doctoral program culminating in a PhD in Network Science. The objective of the program is to train a select group of students to become experts in the interdisciplinary field of network science. Network Science research covers a broad range of topics, including: Control of Networks, Computation Social Science, Biological Networks, Spreading and Influence, Group-Decision Making, Data and Graph Mining, and Network Geometry.

COURSE REQUIREMENTS

Prerequisites - Students will be required to complete courses or show equivalent knowledge in both of the following subjects: 1) Computational Statistics and 2) Network Data OR equivalent knowledge of data science techniques using Python

A minimum of 40 credit hours of coursework is required. Prerequisites do not count towards the minimum of 40 credit hour requirement. All network science students are expected to take the following five core courses (20 credits): 1) NETS 5116: Network Science 1, 2) NETS 6116: Network Science 2, 3) NETS 7332 Machine Learning with Graphs, 4) NETS: 7335 Dynamical Processes in Complex Systems, 5) NETS 7334: Social Network Analysis

In addition to the core course above, students are expected to take additional five courses (20 credits). Typically, in year 2 of the program. This coursework should be taken at the graduate level and relevant to the students' research. Students seeking to specialize in the following areas would take the following:

Social Science – 1) NETS 7360: Network Research Design, 2) NETS 7350: Bayesian and Network Statistics, 3) Three additional electives

Computer Science -1) CS 5800: Algorithms, 2) CS 6140: Machine Learning OR CS 6220: Data Mining Techniques, 3) Three additional electives

Physics/Theory – 1) PHYS 7337: Statistical Physics of Complex Networks, 2) MATH 7233: Graph Theory OR an approved alternative, 3) Three additional electives

The graduate program may recommend additional course work based on student research interests and in consultation with the student's faculty advisor.

NETWORK SCIENCE PHD PROGRAM - SAMPLE COURSE PLAN

YEAR	FALL	S.H.	SPRING	S.H.
1	NETS 5116 Network Science 1	4	NETS 6116 Network Science 2	4
	NETS 7334 Social Networks	4	NETS 7332 Machine Learning with Graphs	4
	Prerequisite Course (If Required)	4	Elective (1)	4
2	NETS 7335 Dynamical Processes in Complex Networks	4	Specialization Requirement (2)	4
	Specialization Requirement (1)	4	Elective (3)	4
	Elective (2)	4	Elective (4)	4
3	Qualifying Exam Research		Comprehensive Exam (Dissertation Proposal) Research	
4	Dissertation 1		Dissertation 2	
5	Dissertation Continuation		Dissertation Continuation	

COURSE WAIVERS

Course waivers may be accepted toward the PhD degree course requirements, though they will not change the number of credits required for the program. The student must be able to demonstrate a graduate level of understanding of the course material they are seeking to waive. Course waivers must be approved by the Academic Director. In cases where a course waiver is granted for a required course, the student is expected to take an additional elective to meet the programs credit requirement.

ACADEMIC PROGRESS

Satisfactory progress in the program will be ongoing and formally evaluated at the end of both the first and second years of the program. Students are expected to maintain a cumulative GPA of 3.000 or better in all course work. Students are not allowed to retake courses without the express permission of the academic director. A student who does not maintain the 3.000 GPA or is not making satisfactory progress on their dissertation research may be recommended for termination by the graduate program committee.

In addition to satisfactory progress in coursework, students are expected to excel in their research obligations, under the direction and supervision of their faculty advisor. Failure to meet research obligations may result in the loss of funding, termination from the program, or both. Satisfactory performance of research obligations will be ongoing and formally evaluated at least once per year.

PHD CANDIDACY

A student is considered a PhD candidate upon completion of all required coursework with a minimum cumulative GPA of 3.0, satisfactory completion of the Qualification Exam, and satisfactory completion of the Comprehensive Exam.

QUALIFICATION EXAM

The Qualification Exam will be an oral examination of the material during the students' coursework. The exam will be an hour in length and consist of questions selected by Network Science faculty who comprise the Qualifying Examination and Dissertation Committee. Students will receive 50 – 80 potential questions, which they must be prepared to answer, one month before the exam. The exam will consist of a subset of these questions. The Qualifying Exam will be offered twice annually, in the fall and spring term. All students are required to initially sit for the exam in the fall, typically in their third year of the PhD program. Students who do not pass the Qualifying Exam on their first attempt are expected to retake the exam in the spring term. Students may sit for the Qualifying exam no more than twice.

Students who fail to complete the Qualifying Examination but who have completed all the PhD program's required course work with a cumulative GPA of 3.000 or better will be awarded a terminal Master of Science in Network Science degree. Note that no students will be admitted directly into the network science program for receipt of a master's degree.

COMPREHENSIVE EXAM

Students must submit a written dissertation proposal to the Dissertation Committee. The proposal (with the aid and approval of their dissertation advisor) will outline a plan to carry out new and original research. The proposal should identify relevant literature, the research problem, the research plan, and the potential impact on the field. An oral presentation of the proposal will be made in an open forum before a public audience and the Dissertation Committee, followed by questions from non-committee members. The written proposal must be given to committee member at least two weeks prior to the oral presentation. After the presentation, the student will meet with the dissertation committee to address any concerns raised in either the written proposal or the presentation. The Comprehensive Exam must precede the final dissertation defense by at least one year.

DISSERTATION DEFENSE

The proposed final draft of the dissertation should be distributed to each dissertation committee member at least two weeks prior to the defense. The program will post public notification of the dissertation defense at least two weeks prior to the defense. The defense is public and consists of three parts: student presentation of the work; public questions from non-committee members; and, after dismissal of the public, questions from committee members, all of whom must be present at the defense.

The final dissertation must adhere to the policy and formatting required by Northeastern University's College of Science. Dissertations must consist of a minimum of three research chapters deemed publishable units based on novel experiments and empirical data. The results of the dissertation defense are decided by majority vote of the dissertation committee. The student's performance will result in one of three possible actions by the committee:

- A) Pass;
- B) Pass with revisions; or,
- C) Fail.

DISSERTATION ADVISORS

The program takes a mentoring approach whereby the graduate students are researcher assistants in faculty laboratories, with opportunities to conduct research across traditional disciplines utilizing network methodologies. In the laboratory, responsibility for collaboration in research gradually shifts from the faculty advisor to the student, culminating in the student's doctoral dissertation.

Each student will have one primary faculty advisor from the Network Science Doctoral Program faculty. Students are admitted into the program with a faculty advisor. Students will be expected to select their dissertation advisors by the end of the spring semester of their second year in the program. In most cases, the student's faculty advisor is expected to become their dissertation advisor.

In rare circumstances, students can elect to change their dissertation advisor during the course of their study, but this requires the approval of the new dissertation advisor, the graduate committee, and the academic director. The dissertation advisor must be a full time tenured or tenure-track member of the Northeastern University faculty. If a student's advisor leaves Northeastern, the student may continue the research direction of the dissertation with a Northeastern faculty member serving as their co-advisor. The co-advisor must first agree to act as the student's primary advisor and then be approved by the graduate committee and academic director. The student will then have two advisors: an official member of the Northeastern faculty who will be available for research and administrative matters and the ex-Northeastern advisor. If a new advisor is appointed, the ex-Northeastern faculty member may serve as an outside member of the committee.

DISSERTATION COMMITTEE

The Dissertation Committee will consist of at least 4 members: the dissertation advisor, one Network Science faculty member (in addition to the dissertation advisor), one additional tenured/tenure-track faculty member from Northeastern, and one expert in the specific topic of research (can be from outside the university).

LEARNING OUTCOMES

- 1) Students will demonstrate a graduate-level understanding of foundational network science concepts, including:
 - a. Comprehension of the mathematics of networks, and their applications to biology, sociology, technology and other fields, and their use in the research of real complex systems in nature and man-made systems.
 - b. Essential network data mining techniques from real world datasets to networks.
 - c. Statistical descriptors of networks and statistical biases.
 - d. Measures and metrics of networks.
 - e. Network clustering techniques.
 - f. Network modeling.
 - g. Understanding process modeling on networks
 - h. Networks visualization.
- 2) Familiarity with the ongoing research in the field of Network Science.
- 3) Students will also demonstrate a graduate-level understanding of non-network methods that enable network research, including:
 - a. Computational statistics.
 - b. Data acquisition and handling.
 - c. Measurement and research design.
- 4) Graduates will attain a critical mass of understanding of some substantive domain complementary to network science, such as physics, political science, or computer science.
- 5) Graduates of the program should be capable of leading and performing independent, new research projects related to network sciences.
- 6) Students will communicate network science concepts, processes, and results effectively, both verbally and in writing.

COURSE DESCRIPTIONS

Core Coursework

NETS 5116 – Network Science 1

Introduces network science and the set of analytical, numerical, and modeling tools used to understand complex networks emerging in nature and technology. Focuses on the empirical study of real networks, with examples coming from biology (metabolic, protein interaction networks), computer science (World Wide Web, Internet), or social systems (e-mail, friendship networks). Shows the organizing principles that govern the emergence of networks and the set of tools necessary to characterize and model them. Covers elements of graph theory, statistical physics, biology, and social science as they pertain to the understanding of complex systems.

NETS 6116 – Network Science 2

Further exploration of network science and the set of analytical, numerical, and modeling tools used to understand complex networks emerging in nature and technology. Focuses on the empirical study of real networks. Investigates the organizing principles that govern the emergence of networks and the set of tools necessary to characterize and model them. Builds a deeper understanding of complex systems.

NETS 7332 – Machine Learning with Graphs

Covers a number of advanced topics in machine learning and data mining on graphs, including vertex classification, graph clustering, link prediction and analysis, graph distance functions, graph embedding and representation learning, deep learning for graphs, anomaly detection, graph summarization, network inference, adversarial learning on networks, and notions of fairness in social networks. Seeks to familiarize students with state-of-the-art descriptive and predictive algorithms on graphs. Requires a foundational understanding of calculus and linear algebra, probability, machine learning or data mining, algorithms, and programming skills.

NETS 7334 - Social Networks Analysis

Offers an overview of the literature on social networks, with literature from political science, sociology, economics, and physics. Analyzes the underlying topology of networks and how we visualize and analyze network data. Key topics include small-world literature and the spread of information and disease

NETS 7335 - Dynamical Processes in Complex Networks

Immerses students in the modeling of dynamical processes (contagion, diffusion, routing, consensus formation, etc.) in complex networks. Includes guest lectures from local and national experts working in process modeling on networks. Dynamical processes in complex networks provide a rationale for understanding the emerging tipping points and nonlinear properties that often underpin the most interesting characteristics of socio-technical systems. The course reviews the recent progress in modeling dynamical processes that integrates the complex features and heterogeneities of real-world systems.

Specialization Coursework

CS 5800 - Algorithms

Presents the mathematical techniques used for the design and analysis of computer algorithms. Focuses on algorithmic design paradigms and techniques for analyzing the correctness, time, and space complexity of algorithms. Topics may include asymptotic notation, recurrences, loop invariants, Hoare triples, sorting and searching, advanced data structures, lower bounds, hashing, greedy algorithms, dynamic programming, graph algorithms, and NP-completeness.

CS 6220 - Data Mining Techniques

Covers various aspects of data mining, including classification, prediction, ensemble methods, association rules, sequence mining, and cluster analysis. The class project involves hands-on practice of mining useful knowledge from a large data set.

MATH 7233 - Graph Theory

Covers fundamental concepts in graph theory. Topics include adjacency and incidence matrices, paths and connectedness, and vertex degrees and counting; trees and distance including properties of trees, distance in graphs, spanning trees, minimum spanning trees, and shortest paths; matchings and factors including matchings in bipartite graphs, Hall's matching condition, and min-max theorems; connectivity, such as vertex connectivity, edge connectivity, k-connected graphs, and Menger's theorem; network flows including maximum network flow, and integral flows; vertex colorings, such as upper bounds, Brooks' theorem, graphs with large chromatic number, and critical graphs; Eulerian circuits and Hamiltonian cycles including Euler's theorem, necessary conditions for Hamiltonian cycles, and sufficient conditions; planar graphs including embeddings and Euler's formula, characterization of planar graphs (Kuratowski's theorem); and Ramsey theory including Ramsey's theorem, Ramsey numbers, and graph Ramsey theory.

NETS 7350 – Bayesian and Network Statistics

Introduces advanced quantitative methods including maximum likelihood, hierarchical models, sampling, and network modeling. Offers students an opportunity to learn to estimate and develop models from the probabilistic and Bayesian perspective and pursue their own research project, focusing on the methodological challenges. Reviews probability and examines maximum likelihood methods for estimating regression models with continuous and categorical dependent variables. Examines a variety of procedures for sampling from posterior distributions, including grid, quadratic, Gibbs, and Metropolis sampling. Applies these methods to hierarchical modeling and other simple probabilistic models, then takes a closer look at the statistical modeling of networks as it has been developed in the social sciences, beginning with the exponential random graph model (ERGM) and finishing with the temporal SIENA model.

NETS 7360 – Research Design for Social Networks

Analyzes the architecture of research—how to design ethical research projects that empower the researcher to make useful and interesting claims about the world. Topics include design research about social networks and how to measure such varied relational concepts such as friendship, love, and proximity; the effective study of "recycled" data—data not collected for research—such as Twitter, cell phone, or email data, and the ethical constraints in using this data; and how to design data collection so as to make robust causal claims.

PHYS 7337 - Statistical Physics of Complex Networks

Covers applications of statistical physics to network science. Focuses on maximum-entropy ensembles of networks and on applicability of network models to real networks. Main topics include microcanonical, canonical, and grand canonical ensembles of networks, exponential random graphs, latent variable network models, graphons, random geometric graphs and other geometric network models, and statistical inference methods using these models. Covers applications of maximum-entropy geometric network models to efficient navigation in real networks, link prediction, and community structure inference.

SAMPLE Electives

ARTG 5130 – Visual Communication for Information Design

Explores graphic and typographic theory, principles, and practices. Introduces students to visual communication design with a primary focus on typography as the fundamental means of conveying content. Readings locate design and typography within the larger history of visual art and writing development. Covers methods of organizing content through hierarchy and spatial organization of grid structures. Considers relationships between positive and negative space, depth perception, transparency, and color theory. Requires graduate standing or permission of program coordinator or instructor.

BIOL 6401 – Research Methods and Critical Analysis in Molecular Cell Biology

Encompasses biochemical and cell biological approaches to understanding cell structure and function, including membranes, organelles, vesicle trafficking, cytoskeleton, cell cycle, and signaling. Structured activities integrate critical analysis of recently published literature and methods. Offers students an opportunity to prepare for the professional practice of molecular cell biology. Permission of instructor required for those students not enrolled in biology.

CHEM 7317 – Analytical Biotechnology

Focuses on the analytical methods used for the characterization of recombinant DNA-derived proteins for human therapeutic use. Combines the description of advanced analytical methods, in particular HPLC and mass spectrometry, with protein chemistry. An important aspect is the development of a method that can identify protein modifications that are present in a product as a result of biosynthetic modifications, contaminants, or degradative reactions. Provides an integrative overview of the role of analytical methods at the different stages of development and production of protein therapeutics including upstream (cell line development, cell culture), downstream (recovery and purifications), formulation development, stability studies, and clinical assay.

CS 7250 – Information Visualization: Theory and Applications. (4 Hours)

Covers foundational as well as contemporary topics of interest in data visualization to enable the effective representation of data across disciplines, including examples drawn from computer science, physical sciences, biomedical sciences, humanities, and economics. Topics include data visualization theory and methodology, visualization design and evaluation, visual perception and cognition, interaction principles, and data encoding and representation techniques. Students who do not meet course restrictions may seek permission of instructor.

CS 7260 – Visualization for Network Science

Covers the principles of information visualization in the specific context of network science. Introduces visual encoding of data and our understanding of human vision and perception; interaction principles including filtering, pivoting, aggregation; and both quantitative and human subject evaluation techniques. Covers visualization techniques for several network types, including multivariate networks with attributes for entities and relationships, evolving and dynamic networks that change over time, heterogeneous networks with multiple types of entities, and geospatial networks. Offers students an opportunity to learn about the design of layout algorithms for node-link and matrix visualizations.

CS 7300 – Empirical Research Methods for Human Computer Interaction

Introduces concepts related to human subject studies for human computer interaction and personal health informatics. Discusses the methodological foundations, as well as issues of practical implementation and use. Provides an overview of the most common experimental designs used in these fields, and how studies should be proposed, conducted, analyzed, and documented for publication. Covers qualitative methods, including interviewing and focus groups, along with approaches to inductive qualitative data analysis. Methods discussed in the course are useful in any area of science that involves the application of the scientific method to situations involving people interacting with computational artifacts or systems, including observation, hypothesis formation, measurement, and descriptive and inferential statistical analyses.

CS 7340 – Theory and Methods in Human Computer Interaction

Covers the foundations of human abilities, computational artifacts, design, and evaluation. Human computer interaction concerns the design and evaluation of software based on a deep understanding of how humans interact with computers, devices, and sensors. The field merges theories from psychology and computer science, using methods from AI and design. Introduces cognitive, perceptual, and affective theories and theories of individual differences that allow us to design and develop better computer software and systems. Also covers research methods for designing and evaluating computer software systems. Topics discussed in the context of next-generation interaction modalities include sensors, haptics, wearables, and performative interfaces. Students who do not meet course restrictions may seek permission of instructor.

ECON 6140 – Advanced Applied Econometrics

Offers students an opportunity to obtain the theoretical tools, computer skills, and experience using econometrics needed to appreciate and do high-quality applied research in economics. Emphasizes understanding how the properties of estimators can be found and their implications for applied research. Introduces the programming language Python, which is integrated into the course. Focuses on methods that are most useful in microeconomic analysis, including classical linear regressions, Gauss-Markov theorem and hypothesis testing, endogeneity, instrumental variable estimation and causality analysis, heteroskedasticity and serial correlations, nonlinearity, panel data methods, difference-in-difference, and regression discontinuity. This is the first advanced graduate-level course on econometrics.

ECON 7200 – Topics in Applied Economics

Presents an application of microeconomic and macroeconomic theory, as well as quantitative methods, to a variety of social issues, both domestic and international. May be repeated without limit.

HIST 7370 – Texts, Maps, and Networks: Readings and Methods for Digital History

Introduces the methods and practice of history in a digital age. Offers students an opportunity to see the wide variety of work being done computationally by historians and other humanists today and to obtain the background to be creative producers of new work and critical consumers of existing projects. The rise of computing technology and the Internet has the potential to reshape all parts of historical practice, from curation to research to dissemination. Examines the historian's craft in three primary domains: the creation of digital sources, the algorithmic transformations that computers can enact on cultural materials like texts, and the new ecologies of publishing and scholarly communication made possible by new media.

INAM 6300 – Models for Applied Inquiry in Creative Practice

Focuses on thoughtful engagement with diverse and emerging forms of critical inquiry, professional engagement, and creative practice for artists, entrepreneurs, and administrators. Through course work and interaction with leading practitioners, offers students an opportunity to gain an understanding of the impact that forms of production and business models have on potential contribution to fields of critical practice and their diverse culture, while developing innovative models for their own creative, critical, and entrepreneurial endeavors.

INAM 7001 – Research Methods in Interdisciplinary Design and Media

Offers an overview of research designs and methods across disciplines. Discusses how to select and use these methods and strategies and discusses IRB procedures. Includes guest presentations from faculty across the campus. This course is not meant as a comprehensive methodological training but rather an overview that should be complemented with at least one specialized methods course from a university-wide list of courses in the first semester of study and two others in the second semester of study.

JRNL 5400 – Media and Advocacy in Theory and Practice

Examines time-tested and cutting-edge methods for shaping and presenting messages across multimedia platforms to effectively disseminate an organization's message, change a public conversation, or shift public opinion. Examines case studies in mainstream media, public advocacy, and strategic communications to explore the motivations and methods of the organizations as well as the tools and techniques used. Examines the practice of digital advocacy by exploring and applying pertinent findings from politics, advertising, and behavioral science that are increasingly employed by professionals looking to "micro-target" voters, "convert" customers, or "nudge" the public. One major component of the course is hands-on workshops through which students are offered an opportunity to learn how to leverage the latest digital tools for communicating across social media and online platforms.

MATH 7351 – Mathematical Methods of Classical Mechanics

Overviews the mathematical formulation of classical mechanics. Topics include Hamilton's principle and Lagrange's equations; solution of the two-body central force problem; rigid body rotation and Euler's equations; the spinning top; Hamilton's equations; the Poisson bracket; Liouville's theorem; and canonical transformations.

NETS 7341 – Network Economics

Covers seminal works in the economics of information and networks, including Akerlof, Arrow, Spence, Stiglitz, and von Hayek. Proceeds through concepts of information, its value, and measurement; search and choice under uncertainty; signaling, screening, and how rational actors use information for private advantage; strategy-given network effects; two-sided (or multisided) network effects, organizational information processing, learning, and social networks; and other micro- and macroeconomic effects such as matching markets. Although primarily a theory course, it may be of interest to any student applying information economics and network economics in academic, commercial, or government policy contexts. Expects students to produce a major paper suitable for publication or inclusion in a thesis. Requires prior completion of graduate coursework in microeconomics and mathematics at the level of introductory calculus and statistics.

PHYS 7301 – Classical Mechanics/Math Methods

Covers mathematical methods of physics and classical mechanics. Topics include differential equations, boundary value problems, functions of a complex variable, linear vector spaces, Green's functions, Lagrangian and Hamiltonian mechanics, linear oscillators, and scattering. May include additional topics as time permits.