DATA SCIENCE

SPS Certificate website: https://sps.northwestern.edu/program-search/certificates.php

Analytics and Modeling, Graduate Certificate

The ability to harness data for actionable insight is increasingly essential for nearly every sector of the economy. We are awash in data, yet companies and organizations don't always know how best to leverage their data to meet strategic goals, improve outcomes, or simply gain deeper understanding of their operations. This stackable graduate certificate in analytics and modeling focuses on foundational skills and knowledge for those working in or hoping to work in data science and analytics in any industry.

Students will learn various techniques to test real-world predictions about data. They explore data, identify appropriate models, and validate those models. With a focus on traditional methods of applied statistics, this certificate prepares data scientists to utilize algorithms for predictive modeling and analytics, developing models for marketing, finance, and other business applications.

Analytics Management, Graduate Certificate

The ability to harness data for actionable insight is increasingly essential for nearly every sector of the economy. We are awash in data, yet companies and organizations don't always know how best to leverage their data to meet strategic goals, improve outcomes, or simply gain deeper understanding of their operations. This stackable graduate certificate in Analytics and Management focuses on foundational skills and knowledge for those working in or hoping to work in data science and analytics in any industry.

Analytics managers bridge the work of analysts and modelers with business operations and strategy to help address future business needs, identify business opportunities, and translate the work of data scientists into language that business management understands. This certificate equips data scientists with the communication and management strategies needed to be data-driven leaders who utilize models, analyses, and statistical data to improve business performance.

Data Engineering, Graduate Certificate

The ability to harness data for actionable insight is increasingly essential for nearly every sector of the economy. We are awash in data, yet companies and organizations don't always know how best to leverage their data to meet strategic goals, improve outcomes, or simply gain deeper understanding of their operations. This stackable graduate certificate in data engineering focuses on foundational skills and knowledge for those working in or hoping to work in data science and analytics in any industry.

Data engineers implement models to scale within an information infrastructure, creating systems and workflows to organize and manage large quantities of data. This means understanding computer systems and solving problems related to data collection, security, and organization. This certificate trains data scientists to utilize system-wide problem-solving skills, choose hardware systems, and build software systems for implementing models made by data analysts to scale in productions systems.

This certificate would appeal to students with strong undergraduate backgrounds in data science, computer science, mathematics, engineering, and information systems programs at Northwestern and elsewhere.

Artificial Intelligence, Advanced Graduate Certificate

Recent advances in and integrations of machine learning and artificial intelligence are significantly impacting the ways that data scientists build and program computer software, statistical models, and neural networks. Each of these areas is comprised of different analytical approaches; artificial intelligence utilizes rules-based, logic, and knowledge-based systems, while machine learning relies upon data-adaptive methods such as naïve Bayes models, nearest neighbor models, classification and regression trees, random forests, support vector machines, and neural networks. Data-adaptive models are the next step in the progression of modeling and analytics, from traditional statistics to data mining to machine learning, where computer software learns from data and makes traditional models more flexible. Many of today's prominent applications of artificial intelligence – including computer vision, natural language processing, and robotics – rely on deep learning, the area where machine learning and artificial intelligence overlap.

Certificates Offered

- Analytics and Modeling, Graduate Certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/data-science/analytics-modeling-graduate-certificate/)
- Analytics Management, Graduate Certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/data-science/analytics-management-graduate-certificate/)
- Artificial Intelligence, Advanced Graduate Certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/data-science/artificial-intelligence-advance-graduate-certificate/)
- Data Engineering, Graduate Certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/data-science/data-engineering-graduate-certificate/)

Data Science Courses

MSDS 400-DL Math For Data Scientists (1 Unit)
Students learn techniques for building and interpreting mathematical models of real-world phenomena in and across multiple disciplines, including linear algebra, discrete mathematics, probability, and calculus, with an emphasis on applications in data science and data engineering. Provides students with a firm understanding or review of these fields of mathematics prior to enrolling in courses that assume understanding of mathematical concepts.
Prerequisite: None.

MSDS 401-DL Applied Statistics with R (1 Unit)
This course teaches fundamentals of statistical analysis. This includes evaluating statistical information, performing data analyses, and interpreting and communicating analytical results. Students will learn to use the R language for statistical analysis, data visualization, and report generation. Topics covered include descriptive statistics, central tendency, exploratory data analysis, probability theory, discrete and continuous distributions, statistical inference, correlation, multiple linear regression, contingency tables, and chi-square tests. Selected

contemporary statistical concepts, such as bootstrapping, are introduced to supplement traditional statistical methods. Recommended prior course: MSDS 400-DL.

MSDS 402-DL Introduction to Data Science (1 Unit)
This course introduces the field of data science, which combines business strategy, information technology, and modeling methods. The course reviews the benefits and opportunities of data science, as well as organizational, implementation, and ethical issues. The course provides an overview of modeling methods, analytics software, and information systems. It discusses business problems and solutions for traditional and contemporary data management systems, and the selection of appropriate tools for data collection and analysis. The course also reviews approaches to business research, sampling, and survey design.
Prerequisite: None.

MSDS 403-DL Data Science in Practice (1 Unit)
This is a case study course that gives students an opportunity to gain experience solving business problems and applying core skills needed for data science technical and leadership roles. The course provides an introduction to digital transformation, industry use cases, designing and measuring analytics projects, data considerations, data governance, digital trust and ethics, enterprise architecture and technology platforms, and organizational change management. Students act as data scientists, as strategists and leaders, evaluating alternative analytics projects and solving digital transformation challenges. Students learn how to apply a step-by-#step development process, creating digital transformation roadmaps and addressing real-#world business problems.
Prerequisite: None.

MSDS 410-DL Supervised Learning Methods (1 Unit)
This course introduces traditional statistics and data modeling for supervised learning problems, as employed in observational and experimental research. With supervised learning there is a clear distinction between explanatory and response variables. The objective is to predict responses, whether they be quantitative as with multiple regression or categorical as with logistic regression and multinomial logit models. Students work on research and programming assignments, exploring data, identifying appropriate models, and validating models. They utilize techniques for observational and experimental research design, data visualization, variable transformation, model diagnostics, and model selection.
Prerequisite: (1) MSDS 400-DL and (2) MSDS 401-DL.

MSDS 411-DL Unsupervised Learning Methods (1 Unit)
This course introduces data modeling for studies in which there is no clear distinction between explanatory and response variables. The objective may be to explain relationships among many continuous variables in terms of underlying dimensions, latent variables, or factors; to find a lower-dimensional representation for multivariate cross-classified data, as with log-#linear models; to construct a visualization of variables, as with traditional multidimensional scaling and t-#distributed stochastic neighbor embedding; or to identify groups of variables and/or objects that are similar to one another, as with cluster analysis and biclustering. Students work on research and programming assignments, exploring multivariate data and methods.
Prerequisite: MSDS 410-DL.

MSDS 413-DL Times Series Analysis and Forecasting (1 Unit)
This course covers key analytical methods and techniques used in the analysis and forecasting of time series data. Specific topics include the role of forecasting in organizations, exploratory data analysis, stationary and non-stationary time series, autocorrelation and partial autocorrelation functions, univariate autoregressive integrated moving average (ARIMA) models, seasonal models, Box-Jenkins methodology, regression models with ARIMA errors, multivariate time series analysis, and non-linear time series modeling including exponential smoothing methods, random forest analysis, and hidden Markov modeling.

MSDS 420-DL Database Systems and Data Preparation (1 Unit)
In this course students explore the fundamental concepts of database management and data preparation. Focusing on applications in large-scale-data analytics projects, the course introduces relational database systems, the relational model, normalization process, and structured query language (SQL). The course discusses topics related to data integration and cleaning, database programming for extract, transform, and load (ETL) operations. Students learn NoSQL technologies for working with unstructured data and document-oriented information retrieval systems. They learn how to index and score documents for effective and relevant responses to user queries. Students acquire hands-on programming experience for data preparation and data extraction. Recommended prior programming experience or MSDS 430-DL.
Prerequisite: MSDS 402-DL or MSDS 403-DL.

MSDS 422-DL Practical Machine Learning (1 Unit)
The course introduces machine learning with business applications. It provides a survey of machine learning techniques, including traditional statistical methods, resampling techniques, model selection and regularization, tree-based methods, principal components analysis, cluster analysis, artificial neural networks, and deep learning. Students implement machine learning models with open-source software for data science. They explore data and learn from data, finding underlying patterns useful for data reduction, feature analysis, prediction, and classification.
Prerequisite: (1) MSDS 400-DL, (2) MSDS 401-DL, and (3) MSDS 402-DL or MSDS 403-DL.

MSDS 430-DL Python for Data Analysis (1 Unit)
This course introduces core features of the Python programming language, demonstrating fundamental concepts in computer science. It provides an in-#depth discussion of data representation strategies, showing how data structures are implemented in Python and demonstrating tools for data science and software engineering. Working on data analysis problems, students employ various programming paradigms, including functional programming, object-#oriented programming, and data stream processing. Special attention is paid to the standard Python library and packages for analytics and modeling.
Prerequisite: None.

MSDS 432-DL Foundations for Data Engineering (1 Unit)
This course provides an overview of the discipline of data engineering. It introduces software and systems for data science and software development as required in the design of data intensive applications. Students learn about algorithms, data structures, and technologies for storing and processing data. Students gain experience with open-source software, text editors, and integrated development environments. Students employ best practices in software development, utilizing tools for syntax checking, testing, debugging, and version control. The course also introduces formal models, simulations, and benchmark experiments for evaluating software, systems, and processes.
Prerequisite: MSDS 420-DL or CIS 417-DL.

MSDS 434-DL Analytics Application Engineering (1 Unit)
This course covers programming components essential to the development of analytics applications. The focus is analytics software engineering. Students learn to develop single-# system/desktop solutions as well as client#server solutions. They learn about web-based, client-# server solutions employing a variety of front-end and back-end system components. Students develop software, working on open-source

programming, database, and systems integration projects. They employ best practices in software development.
Prerequisite: (1) MSDS 432-DL and (2) MSDS 422-DL or CIS 435-DL.

MSDS 436-DL Analytics Systems Engineering (1 Unit)
This course introduces design principles and best practices for implementing large-scale systems for data ingestion, processing, storage, and analytics. Students learn about cloud-based computer architecture and scalable systems for data science. They learn how to package and distribute containerized computer software. They apply tools of systems analysis, evaluating end-to-end performance and resource utilization in batch, interactive, and streaming environments. Students review formats and protocols for application programming interfaces. They compare data models, resource requirements, and performance of applications implemented with relational versus graph database systems.
Prerequisite: (1) MSDS 432-DL and (2) MSDS 422-DL or CIS 435-DL.

MSDS 440-DL Real-Time Interactive Processing and Analytics (1 Unit)
This course introduces application engineering and analytics within an integrated environment and full-stack development process. Students learn how to implement client-side, web-based applications using a model-view-controller framework. Students work with server-side systems for responding to website requests and database queries. Students learn how to prepare indices for efficient and relevant search across large document collections. They learn how to implement real-time analytics applications for interactive environments, finding information from databases and document collections, making service and product recommendations, and detecting anomalies or security violations. This is a case study and project-based course with a strong programming component.

MSDS 442-DL Real-Time Stream Processing and Analytics (1 Unit)
This course introduces application engineering and analytics within stream and event processing environments. Data feeds or sources include monitoring of continuous processes through electronic sensors, observing channels of communication and social interaction, and tracking goods through production lines and distribution channels. The course reviews stream-processing systems designed to provide high throughput and low latency. It introduces data models and algorithms for analyzing event logs and understanding business processes. Special attention is given to applications in operations support, logistics, and supply chain management. This is a case study and project-based course with a strong programming component, including work with relational and graph.

MSDS 450-DL Marketing Analytics (1 Unit)
This course provides a comprehensive review of data science as it relates to marketing management and business strategy. The course allows students to work with data relating to customer demographics, marketing communications, and purchasing behavior. Students perform data cleansing, aggregation, and analysis, exploring alternative segmentation schemes for targeted marketing. They design tools for reporting research results to management, including information about consumer purchasing behavior and the effectiveness of marketing campaigns. Conjoint analysis and choice studies are introduced as tools for consumer preference measurement, product design, and pricing research. This is a case study and project-#based course involving extensive data analysis. Recommended prior course: MSDS 411-DL.
Prerequisite: MSDS 420-DL and MSDS 422-DL.

MSDS 451-DL Financial and Risk Analytics (1 Unit)
Building upon probability theory and inferential statistics, this course provides an introduction to risk analytics. Examples from economics and finance show how to incorporate risk within regression and time series models. Monte Carlo simulation is used to demonstrate how variability in data affects uncertainty about model parameters. Additional topics include subjectivity in risk analysis, causal modeling, stochastic optimization, portfolio analysis, and risk model evaluation. Recommended prior course: MSDS 413-#DL.
Prerequisite: (1) MSDS 420-DL and (2) MSDS 422#DL .

MSDS 452-DL Web and Network Data Science (1 Unit)
This course shows how to acquire and analyze information from the web. It provides a comprehensive review of web analytics, including website usage and search performance metrics. The course introduces the mathematics of network science, including random graph, small world, and preferential attachment models. Students compute a variety of network metrics as they analyze software systems, website structure, connections in information and social networks, and user interactions through electronic communications and social media. They employ network/graph algorithms within a graph database system. This is a case study and project-based course with a strong programming component.

MSDS 453-DL Natural Language Processing (1 Unit)
A comprehensive review of text analytics and natural language processing with a focus on recent developments in computational linguistics and machine learning. Students work with unstructured and semi-structured text from online sources, document collections, and databases. Using methods of artificial intelligence and machine learning, students learn how to parse text into numeric vectors and to convert higher dimensional vectors into lower dimensional vectors for subsequent analysis and modeling. Applications include speech recognition, semantic processing, text classification, relevant search, recommendation systems, sentiment analysis, and topic modeling. This is a project#based course with extensive programming assignments.
Prerequisite: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

MSDS 454-DL Advanced Modeling Techniques (1 Unit)
This advanced modeling course is divided into two major sections. The first section concerns theory and application of stochastic processes, including Markov processes. The second section concerns Bayesian statistics, including Bayesian belief modeling. Throughout the course, students explore applied probability models that represent business processes in graphs or networks. Students execute simulation experiments, both discrete-event and process simulations. This is a case study and project-based course with an extensive programming component.

MSDS 455-DL Data Visualization (1 Unit)
This course begins with a review of human perception and cognition, drawing upon psychological studies of perceptual accuracy and preferences. The course reviews principles of graphic design, what makes for a good graph, and why some data visualizations effectively present information and others do not. It considers visualization as a component of systems for data science and presents examples of visualizing categorical, hierarchical, relational, temporal and spatial data. It reviews methods for static and interactive graphics and introduces tools for building web-browser-based presentations. This is a project-# based course with programming assignments.
Prerequisite: (1) MSDS 400-DL and (2) MSDS 401-DL.

MSDS 456-DL Sports Performance Analytics (1 Unit)
An introduction to sports performance measurement and analytics, this course reviews roles of athletes at each position in sports selected by the instructor. With a focus on the individual athlete, the course discusses the development and use of accurate assessments and variability due to factors such as body type, climate, and training regimen. The course reviews athletic performance measurements, including jumping ability, running speed, agility, and strength. Students work with player on-#field

and on-#court performance measures. The course utilizes exploratory data analysis, predictive modeling, and presentation graphics, showing real-#world implications for athletes, coaches, team managers, and the sports industry.
Prerequisite: (1) MSDS 400-DL and (2) MSDS 401-DL.

MSDS 457-DL Sports Management Analytics (1 Unit)
This course provides a comprehensive review of financial, statistical, and mathematical models as they relate to sports team performance, administration, marketing, and business management. The course gives students an opportunity to work with data and models relating to sports team performance, tactics, and strategy. Students employ modeling methods in studying player and team valuation, sports media, ticket pricing, game-day events management, loyalty and sponsorship program development, and customer relationship management. The course makes extensive use of sports business case studies.
Prerequisite: (1) MSDS 400-DL and (2) MSDS 401-DL.

MSDS 458-DL Artificial Intelligence and Deep Learning (1 Unit)
An introduction to the field of artificial intelligence, this course illustrates probability-rule-based generative models as well as discriminative models that learn from training data. The course reviews applications of artificial intelligence and deep learning in vision and language processing. Students learn best practices for building supervised learning models and, in particular, deep neural networks for classification and regression. Students also learn about feature engineering, autoencoders, and strategies of unsupervised and semi-supervised learning, as well as reinforcement learning. This is a project-based course with extensive programming assignments.
Prerequisite: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

MSDS 459-DL Knowledge Engineering (1 Unit)
This course introduces knowledge representation as a subfield of artificial intelligence. It reviews methods for developing knowledge--based systems, providing examples of their use in intelligent applications and agents. The course makes heavy use of graph databases for storing information about words in semantic networks and for storing information about relationships. Students learn how to encode and access knowledge on the World Wide Web. They learn how to use knowledge bases for automated reasoning and question answering. This is a project-based course with extensive programming assignments. Recommended prior courses: MSDS 453-DL and MSDS 458-DL.
Prerequisite: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

MSDS 460-0 Decision Analytics (1 Unit)
This course covers fundamental concepts, solution techniques, modeling approaches, and applications of decision analytics. It introduces commonly used methods of optimization, simulation and decision analysis techniques for prescriptive analytics in business. Students explore linear programming, network optimization, integer linear programming, goal programming, multiple objective optimization, nonlinear programming, metaheuristic algorithms, stochastic simulation, queuing modeling, decision analysis, and Markov decision processes. Students develop a contextual understanding of techniques useful for managerial decision support. They implement decision-analytic techniques using a state-#of-#the-#art analytical modeling platform. This is a problem and project-based course.
Prerequisite: (1) MSDS 400-DL and (2) MSDS 401-DL.

MSDS 460-DL Decision Analytics (1 Unit)
This course covers fundamental concepts, solution techniques, modeling approaches, and applications of decision analytics. It introduces commonly used methods of optimization, simulation and decision analysis techniques for prescriptive analytics in business. Students explore linear programming, network optimization, integer linear programming, goal programming, multiple objective optimization, nonlinear programming, metaheuristic algorithms, stochastic simulation, queuing modeling, decision analysis, and Markov decision processes. Students develop a contextual understanding of techniques useful for managerial decision support. They implement decision-analytic techniques using a state-#of-#the-#art analytical modeling platform. This is a problem and project-based course.
Prerequisite: (1) MSDS 400-DL and (2) MSDS 401-DL.

MSDS 462-DL Computer Vision (1 Unit)
A review of specialized deep learning methods for vision, including convolutional neural networks and recurrent neural networks. Students work with raw image files, including digital representations of photographs, hand-written documents, x-rays, and sensor images. Students process image data, converting pixels into numeric tensors for subsequent analysis and modeling. The course illustrates real-world applications for visual exploration, discovery and navigation, and for image classification, facial recognition, remote sensing, and medical diagnostics. This is a project-based course with extensive programming assignments. Recommended prior course: MSDS 458-DL.
Prerequisite: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

MSDS 464-DL Intelligent Systems and Robotics (1 Unit)
This course introduces reinforcement learning as an approach to intelligent systems, emphasizing applications such as robotic processes automation, conversational agents and robotics that mimic human behavior. Students implement intelligent agents to solve both discrete- and continuous-valued sequential decision-making problems. Students develop, debug, train, visualize, and customize programs in a variety of learning environments. The course reviews Markov decision processes, dynamic programming, temporal difference learning, Monte Carlo reinforcement learning, eligibility traces, and the integration of learning and planning. This is a case study and project-based course with a substantial programming component. Recommended prior course: MSDS 458-DL.
Prerequisite: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

MSDS 470-DL Analytics Entrepreneurship (1 Unit)
This course prepares students for establishing and running a data-# sciences-oriented entrepreneurial organization. Topics include evaluating preparedness for entrepreneurial work, activities that would help transform an idea into a running organization, identifying the right data, analytics tools, and resources platform, and aligning with unmet market demands. Students learn about growing a network of people and obtaining capital assets, creating innovative intellectual property and sharpening unique competitiveness, and making product development and marketing choices. Students develop essential elements of business plans in order to present a final business pitch for starting an entrepreneurial data science venture.
Prerequisite: (1) MSDS 400-DL, (2) MSDS 401-DL, and (3) MSDS 402-DL or MSDS 403-DL.

MSDS 472-DL Analytics Consulting (1 Unit)
Analytics consulting brings together consultative processes and tools for creating a trusted advisor relationship with clients. This course covers concepts, processes, and tools for developing consulting proposals. The course is structured around an analytics consulting simulation and students work in teams. Students learn how to identify and meet business requirements through gathering information, developing reports, and managing client relationships. The course also addresses ethical

issues and career challenges. The course is appropriate for students interested in or currently acting as an internal or external consultant. Considerations associated with operating your own consulting company are also addressed.
Prerequisite: (1) MSDS 400-DL, (2) MSDS 401-DL, and (3) MSDS 402-DL or MSDS 403-DL.

MSDS 474-DL Accounting and Finance for Analytics Managers (1 Unit)
This course reviews principles of corporate finance and managerial accounting with a focus on the work of analytics managers. Analytics managers are often responsible for the profit-and-loss (P&L) of their projects and divisions which have certain unique needs in terms of workflow, co-#working with other businesses, cooperating with multiple stakeholders (especially IT), and employing highly specialized knowledge professionals. To support these responsibilities, students learn how to conduct breakeven (cost-volume-profit) analysis, apply discounted cash flow analysis, and compute return on investments. Students also learn how to read balance sheets, income statements, and cash flow statements. The course provides in-depth coverage of spreadsheet programming methods.
Prerequisite: MSDS 402-DL or MSDS 403-DL.

MSDS 475-DL Project Management (1 Unit)
This course introduces best practices in project management, covering the full project life cycle with a focus on globally accepted standards. It reviews traditional methods and shows how the project management maturity model, leadership, team development, and principles of negotiation apply to organizations of various types: hierarchical and matrix organizations, international teams, and virtual teams. Options in project management software systems are included. Using methods and models from this course, analytics managers and team leaders should experience greater project definition and structure. They should be able to execute data science and data engineering projects more effectively.
Prerequisite: None.

MSDS 480-0 Business Leadership and Communication (1 Unit)
This course introduces fundamental leadership theory and associated behaviors to enable students to excel in their analytics careers. The course examines the theory and practice of leadership at the individual and organizational levels, and discusses how to drive effective change at various stages in an enterprise analytics transformation process. Students spend three weeks on analytics-specific project management, in which they design an analytics project plan using an agile approach. Leadership challenges unique to analytics departments are addressed through the use of case studies and theory-based assignments. The course focuses on developing effective communication strategies and presentations that resonate across business and technical teams.
Prerequisite: None.

MSDS 480-DL Business Leadership and Communications (1 Unit)
This course introduces fundamental leadership theory and associated behaviors to enable students to excel in their analytics careers. The course examines the theory and practice of leadership at the individual and organizational levels, and discusses how to drive effective change at various stages in an enterprise analytics transformation process. Students spend three weeks on analytics-specific project management, in which they design an analytics project plan using an agile approach. Leadership challenges unique to analytics departments are addressed through the use of case studies and theory-based assignments. The course focuses on developing effective communication strategies and presentations that resonate across business and technical teams.
Prerequisite: None.

MSDS 485-DL Data Governance, Ethics, and Law (1 Unit)
This course introduces data management concepts, including data quality, integrity, usability, consistency, availability, and security. It considers the lineage or life cycle of data, sometimes referred to as data provenance. It reviews ethical, legal, and technical issues relating to data acquisition, data dissemination, and privacy protection. The course provides a management introduction to cybersecurity, including network, system, and database security. It reviews encryption and blockchain technologies. The course also covers United States and European Union law relating to data privacy and cybersecurity.

MSDS 490-DL Special Topics in Data Science (1 Unit)
Topics vary from term to term.
Prerequisite: Vary by topic.

MSDS 491-DL Special Topics in Data Science-Analytics and Modeling (1 Unit)
Topics vary from term to term.
Prerequisite: Vary by topic.

MSDS 492-DL Special Topics in Data Science-Data Engineering (1 Unit)
Topics vary from term to term.
Prerequisite: Vary by topic.

MSDS 493-DL Special Topics in Data Science-Analytics Management (1 Unit)
Topics vary from term to term.
Prerequisite: Vary by topic.

MSDS 498-0 Capstone (1 Unit)
The capstone course focuses upon the practice of data science. This course is the culmination of the data science program. It gives students an opportunity to demonstrate their business strategic thinking, communication, and consulting skills. Business cases across various industries and application areas illustrate strategic advantages of analytics, as well as organizational issues in implementing systems for data science. Students work in project teams, generating business plans and project implementation plans. Students may choose this course or the master's thesis to fulfill their capstone requirement.
Prerequisite: Completion of all core courses in the student's graduate program and specialization.

MSDS 498-DL Capstone Class (1 Unit)
The capstone course focuses upon the practice of data science. This course is the culmination of the data science program. It gives students an opportunity to demonstrate their business strategic thinking, communication, and consulting skills. Business cases across various industries and application areas illustrate strategic advantages of analytics, as well as organizational issues in implementing systems for data science. Students work in project teams, generating business plans and project implementation plans. Students may choose this course or the master's thesis to fulfill their capstone requirement.
Prerequisite: Completion of all core courses in the student's graduate program and specialization.

MSDS 499-DL Independent Study (1 Unit)
Topics vary from term to term.
Prerequisite: Vary by topic.

MSDS 579-0 Practicum (1 Unit)

MSDS 590-DL Thesis Research (1 Unit)
This final project is meant to represent the culmination of students' experience in the program and must demonstrate mastery of the curriculum and ability to conduct sustained independent research and analysis. The project may be applied or may be a traditional scholarly paper, in both cases a write-up following the paper's program-specific guidelines is required. Students must submit a proposal and secure a

first reader in order to register; for further details students are advised to review the student handbook and contact their academic adviser.