PREDICTIVE ANALYTICS

SPS Certificate website: https://sps.northwestern.edu/advanced-graduate-certificate/advanced-data-science/

For students who have completed a graduate degree in Data Science, Predictive Analytics, or a similar field, this certificate provides a unique and in-depth exploration into the various industry-based applications of their specific skillset.

Certificate Offered

- Data Science, Advanced Graduate Certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/predictive-analytics/data-science-advance-graduate-certificate/)

Data Science Courses

MSDS 400-0 Math for Modelers (1 Unit)
Students learn how to build and interpret mathematical models of real-world phenomena in many areas. The course covers linear algebra, discrete mathematics, calculus and graph theory, with an emphasis on applications in data science and data engineering. It provides an introduction to these fields of mathematics prior to enrolling in courses that assume understanding of mathematical concepts. Required: None.

MSDS 400-DL Math for Modelers (1 Unit)
Students learn how to build and interpret mathematical models of real-world phenomena in many areas. The course covers linear algebra, discrete mathematics, calculus and graph theory, with an emphasis on applications in data science and data engineering. It provides an introduction to these fields of mathematics prior to enrolling in courses that assume understanding of mathematical concepts. Required: None.

MSDS 401-0 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 Math for Modelers.

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 402-0 Research Design for Data Science (1 Unit)
This course introduces the scientific method and research design for data science. It distinguishes between primary and secondary research, drawing on survey, observational, and experimental studies. Students learn about sampling techniques and ways of obtaining relevant data. They see how to prepare data for modeling and analysis. They employ feature engineering, constructing new measures from original measures. They learn how to assess the reliability and validity of measures, construct valid research designs, and build trustworthy models. Numerous case studies illustrate rational decision making guided by science. Required: None.

MSDS 402-DL Research Design for Data Science (1 Unit)
This course introduces the scientific method and research design for data science. It distinguishes between primary and secondary research, drawing on survey, observational, and experimental studies. Students learn about sampling techniques and ways of obtaining relevant data. They see how to prepare data for modeling and analysis. They employ feature engineering, constructing new measures from original measures. They learn how to assess the reliability and validity of measures, construct valid research designs, and build trustworthy models. Numerous case studies illustrate rational decision making guided by science. Required: None.

MSDS 403-DL Data Science and Digital Transformation (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 introduces 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. Required: 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. (Required: (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. Students learn how to explain relationships among many continuous variables in terms of underlying dimensions, as with principal components and factor analysis. They find lower-dimensional representations for multivariate cross-classified data, as with log-linear models. They visualize data with traditional multidimensional scaling and t-distributed stochastic neighbor embedding. And they identify groups of variables and 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. (Required: MSDS 400-DL and MSDS 401-DL.)

MSDS 413-DL Times Series Analysis and Forecasting (1 Unit)
This course covers analytical methods for time series analysis and forecasting. 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. Recommended prior course: MSDS 410-DL. (Required: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.)

MSDS 420-0 Database Systems (1 Unit)
This course introduces data management and database systems with a focus on applications in large-scale analytics projects utilizing relational, document, graph, and graph-relational databases. Students learn about the relational model, the normalization process, and query languages, including structured query language. They learn about data cleaning and integration, and database programming for extract, transform, and load operations. Students work with unstructured data, indexing and scoring documents for effective and relevant responses to user queries. They learn about graph data models and query processing. Students write programs for data preparation and extraction using various data sources and file formats. Recommended prior programming experience or MSDS 430-DL Python for Data Science. Required: none.

MSDS 420-DL Database Systems (1 Unit)
This course introduces data management and database systems with a focus on applications in large-scale analytics projects utilizing relational, document, graph, and graph-relational databases. Students learn about the relational model, the normalization process, and query languages, including structured query language. They learn about data cleaning and integration, and database programming for extract, transform, and load operations. Students work with unstructured data, indexing and scoring documents for effective and relevant responses to user queries. They learn about graph data models and query processing. Students write programs for data preparation and extraction using various data sources and file formats. Recommended prior programming experience or MSDS 430-DL Python for Data Science. Required: None.

MSDS 422-0 Practical Machine Learning (1 Unit)
The course introduces machine learning with business applications. It provides a survey of statistical and machine learning algorithms and techniques including the machine learning framework, regression, classification, regularization and reduction, tree-based methods, unsupervised learning, and fully connected, convolutional, and recurrent neural networks. 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. (Required: MSDS 400-0 Math for Modelers and MSDS 401-0 Applied Statistics with R)

MSDS 422-DL Practical Machine Learning (1 Unit)
The course introduces machine learning with business applications. It provides a survey of statistical and machine learning algorithms and techniques including the machine learning framework, regression, classification, regularization and reduction, tree-based methods, unsupervised learning, and fully connected, convolutional, and recurrent neural networks. 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. (Required: MSDS 400-DL Math for Modelers and MSDS 401-DL Applied Statistics with R.)

MSDS 430-0 Python for Data Analysis (1 Unit)
This course provides an extensive overview of Python programming language with emphasis on its capabilities to analyze data. Students will develop skills to use Python language to perform data science tasks including importing data from various sources, exploratory data analysis, visualization, data preprocessing, descriptive analytics, and predictive modeling. Python-based, open-source development frameworks, including the Scikit-Learn, Pandas, NumPy, and Matplotlib libraries, are exposed to students. This course takes a hands-on approach to prepare students for applying appropriate Python functions to analyze structured and unstructured data. The course will conclude with students completing a data science project on real-world dataset where students apply data analytics and machine learning techniques.

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. Required: None.

MSDS 431-DL Go and AI-Assisted Programming (1 Unit)
This comprehensive introduction to the Go programming language reviews data structures and algorithms, the Go standard library, and packages for communications, database access, analytics, and modeling. Students learn how to work within the Go programming environment, employing best practices in software engineering. They design, develop, and test programs for data science. They utilize AI-assisted programming, including methods for translating from one computer language to another. And they learn how to run concurrent processes, as needed in distributed and parallel processing environments. **Prerequisite:** None.

MSDS 432-DL Foundations of Data Engineering (1 Unit)
This course introduces data engineering concepts and technologies relevant to development and operations (DevOps). It reviews design principles and development processes for data pipelines in analytics applications, focusing on containerized microservices and cloud-native applications. It reviews data exchange formats, process concurrency control, communication protocols, application programming interfaces, distributed processing, and systems architecture. Students learn about automated deployment and scaling of batch, interactive, and streaming data pipelines. They learn how to design, implement, and maintain applications in cloud and on-premises environments. This is a programming-intensive course that includes a full-stack development project. Recommended prior course: MSDS 431-DL. (Required: (1) MSDS 400-DL and (2) MSDS 420-DL or CIS 417-DL.)

MSDS 434-DL Data Science and Cloud Computing (1 Unit)
This course introduces technologies and systems for developing and implementing data science solutions. It takes a cloud-native approach to delivering analytics applications that are scalable, highly available, and easy to maintain. Students work on systems integration projects, automating stages of application development and using open-source programming languages and systems. They learn about continuous integration and continuous delivery (CI/CD) in the cloud, employing best practices in software engineering. Recommended prior courses: (A) MSDS 431-DL, (B) MSDS 432-DL, and (C) MSDS 422-DL or CIS 435-DL. (Required: (1) MSDS 400-DL and (2) MSDS 420-DL or CIS 417-DL.)

MSDS 436-DL Technology Product Engineering (1 Unit)
This course introduces design principles and best practices for implementing systems for data ingestion, processing, storage, and analytics. Students learn about full-stack development and software alternatives for implementing analytics solutions and intelligent, knowledge-based systems. They evaluate system performance and resource utilization in batch, interactive, and streaming environments.

They create and run performance benchmarks for comparing alternative software stacks. Students work in software engineering teams, practicing agile/scrum project management as they develop new technology products. Recommended prior course: MSDS 430-DL Python for Data Science or MSDS 431-DL Data Engineering with Go.
Prerequisite: (1) MSDS 420-DL Database Systems or CIS 417 Database Systems Design and Implementation and (2) MSDS 422-DL Practical Machine Learning or CIS 435 Practical Data Science Using Machine Learning.

MSDS 440-DL Conversational AI Assistants (1 Unit)
This is an applied artificial intelligence (AI) course. It introduces the development life cycle process, methods, and technologies for developing, configuring, and training conversational AI assistants. It draws on traditional natural language understanding, large language models, and open-source generative AI frameworks and libraries. The course surveys fundamental concepts of dialogue and domain engineering. It examines three pillars for building conversational AI assistants: business process workflow, dialogue understanding, and automatic conversation repair with fallbacks. Students employ common patterns and templates in dialogue engineering. They learn how to use conversational assistants in business process workflows across various industries, including services, healthcare, transportation, and retail. This is a case-study and project-based course with a programming component.
Prerequisite: none.

MSDS 442-DL AI Agent Design and Development (1 Unit)
This is an applied artificial intelligence (AI) course. It provides an in-depth exploration of designing, developing, and deploying AI agents, with a focus on creating stateful, autonomous, and multi-agent systems. Students learn key concepts behind reason-and-act methods, intelligent prompting, finite state machines, and agent architectures. They use open-source frameworks and libraries to build multi-actor applications with large language models. They develop dynamic, reliable agents capable of executing complex multi-step workflows, incorporating human-in-the-loop processes, and interacting with external tools and application programming interfaces. Students learn how to design and deploy sophisticated AI agents, ranging from simple reactive systems to advanced goal-driven systems. This is a case-study and project-based course with a programming component.
Prerequisite: None.

MSDS 450-DL Marketing Analytics (1 Unit)
This course reviews applications of data science in marketing, the strategic marketing process, and the design of marketing surveys and experiments. Students explore methods for understanding consumer preferences, market segments, and competitive brands and products. Students address problems in new product design and pricing. They study the marketing mix, highlighting the effects of advertising and promotion. And they are introduced to algorithms and methods for digital marketing. Recommended prior courses: MSDS 410-DL and MSDS 411-DL. (Required: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.)

MSDS 451-DL Financial Engineering (1 Unit)
This course introduces quantitative finance and methods for assessing the value of financial instruments. Students learn about asset price dynamics, volatility, and prediction. They model and analyze financial time series. They study principles of asset management, evaluating portfolio risks, returns, and market performance. A term project involves developing an algorithmic trading program for an actively managed fund. This case study course requires active participation in class discussions. (Required: MSDS 400-DL and MSDS 401-DL)

MSDS 452-DL Graphical and Network Models (1 Unit)
This survey course introduces applications of graphs in data science. It begins with the mathematics of graphs, with nodes (vertices) and links (edges). Students utilize graph and graph-relational databases for knowledge graphs. Drawing on network science, they employ random graph, small world, and preferential attachment models, analyzing connections across information networks and social networks. Students utilize graph neural networks for deep learning. They see event graphs and queuing networks for process and performance analysis. The course ends with graphical probability models and their applications to causal inference and automated reasoning.
Prerequisite: 1) MSDS 420-DL Database Systems or CIS 417 Database Systems Design and Implementation and (2) MSDS 422-DL Practical Machine Learning or CIS 435 Practical Data Science Using Machine Learning.

MSDS 453-DL Natural Language Processing (1 Unit)
This course explores cutting-edge developments in computational linguistics and machine learning, with a focus on deep learning techniques. Students work with unstructured and semi-structured text, transforming text into numerical vectors and converting higher-dimensional vectors into lower-dimensional ones for analysis and modeling. The course covers parts-of-speech parsing, information extraction, semantic processing, text classification, sentiment analysis, text embeddings, topic modeling, text summarization and generation, and question answering. Students explore large-scale language models, particularly generative pretrained transformers (GPTs). This is a project-based course with extensive programming assignments. (Required: (1) MSDS 420-DL Database Systems or CIS 417-DL Database Systems Design and Implementation and (2) MSDS 422-DL Practical Machine Learning or CIS 435-DL Practical Data Science Using Machine Learning.)

MSDS 454-DL Applied Probability and Simulation Modeling (1 Unit)
This advanced modeling course begins by reviewing probability theory and models. Students learn principals of random number generation and Monte Carlo methods for classical and Bayesian statistics. They are introduced to applied probability models and stochastic processes, including Markov Chains, exploring applications in business and scientific research. Students work with open-source and proprietary systems, implementing discrete event and agent-based simulations. This is a case study and project-based course with an extensive programming component. Recommended prior course: MSDS 460-DL. (Required: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.)

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. (Required: (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. (Required: (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. (Required: (1) MSDS 400-DL and (2) MSDS 401-DL.)

MSDS 458-DL Artificial Intelligence and Deep Learning (1 Unit)
An introduction to artificial intelligence, this course illustrates probability-rule-based generative models as well as discriminative models for learning from data. It reviews applications of artificial intelligence and deep learning in vision and language processing. Students learn best practices for building deep learning models for classification and regression. The 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. (Required: (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 reviews methods for developing knowledge-based systems, providing examples of their use in intelligent applications and conversational agents. The course uses knowledge graphs to store information about entities and their relationships, where the entities can be words, documents, people, places, events, products, services, or other things. Students design graph data models, implement graph-relational databases, and build applications that draw on those databases. They build end-to-end applications for information retrieval, information extraction, question answering, and product recommendations. Students use graph data science, machine learning, and large language models for knowledge representation, search, and inference. Recommended prior courses: MSDS 431-DL Data Engineering with Go and MSDS 453-DL Natural Language Processing. (Required: (1) MSDS 420-DL Database Systems and Data Preparation or CIS 417-DL Database Systems Design and Implementation and (2) MSDS 422-DL Practical Machine Learning or CIS 435-DL Practical Data Science Using Machine Learning.)

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 optimizations, 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 state-of-the-art analytical modeling platforms. This is a problem and project-based course. (Required: MSDS 400-0 Math for Modelers and MSDS 401-0 Applied Statistics with R.)

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. (Required: (1) MSDS 400-DL and (2) MSDS 401-DL.)

MSDS 462-DL Computer Vision (1 Unit)
This course reviews deep learning methods for vision. Students work with raw image files, including digital representations of photographs, hand-written documents, x-rays, and sensor images. They process image data, converting pixels into numeric tensors for subsequent analysis and modeling. The course illustrates real-world applications for visual exploration, object recognition, image classification, facial recognition, remote sensing, navigation, and medical diagnostics. This is a project-based course with extensive programming assignments. Recommended prior course: MSDS 458-DL. (Required: (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. It reviews Markov decision processes, dynamic programming, temporal difference learning, Monte Carlo and deep reinforcement learning, eligibility traces, and function approximation. Students implement intelligent agents, solving sequential decision-making problems. They develop, debug, train, and visualize the results of programs. They see how to integrate learning and planning. This is a case study and project-based course with a substantial programming component. Recommended prior course: MSDS 458-DL. (Required: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.)

MSDS 466-DL Applied Generative AI for Enterprises (1 Unit)
This course explores recent developments in generative artificial intelligence, with applications to language processing, computer vision, and software development. Students work with deep generative models, including attention and transformer models, and generative pretrained transformers (GPTs). They build special-purpose applications from open-source software, utilizing application programming interfaces (APIs) to GPT-based models and knowledge bases. This is a project-based course with extensive hands-on programming assignments.
Prerequisite: (1) MSDS 420-DL Database Systems or CIS 417-DL Database Systems Design and Implementation and (2) MSDS 422-DL Practical Machine Learning or CIS 435-DL Practical Data Science Using Machine Learning.

MSDS 470-DL Technology Entrepreneurship (1 Unit)
This course prepares students to establish and run a technology-focused entrepreneurial organization. It identifies opportunities for technology products and services, including opportunities in data science, machine learning, and artificial intelligence. Students review methods of industry and market analysis to guide competitive strategy. They learn how to transform ideas into successful businesses, identifying the right data, information technology, and human resources, and aligning with unmet market demand. They learn how to deploy efficient operating models for independent and enterprise startups. They learn about growing a network of people and obtaining capital assets, creating innovative intellectual property, sharpening unique competitiveness, and making product

development and marketing choices. Students develop business plans and make presentations for starting entrepreneurial ventures. Required: None.

MSDS 472-DL Management Consulting (1 Unit)
his course introduces concepts, processes, tools, and techniques of analytics consulting. This includes winning consulting work, executing engagements, communicating with clients, and managing client relationships. Working in teams, students simulate a real-world consulting engagement, developing critical thinking, listening, speaking, and written communication skills. Students construct consulting presentations, communicating key findings and client impacts while employing data visualization best practices. The course is appropriate for students considering analytics consulting as a profession as well as students with internal subject matter expert or consultant roles. (Required: MSDS 401-DL and MSDS 402-DL or MSDS 403-DL.)

MSDS 474-DL Accounting and Finance for Technology Managers (1 Unit)
This course reviews corporate finance and managerial accounting with a focus on technology companies and projects. Technology managers and entrepreneurs need to secure adequate funding, coordinate with other organizations, employ specialized knowledge workers, and satisfy multiple stakeholders. Company success and sustainable growth depend on adequate cashflow and profitability. In this course, students learn how to read and analyze financial statements and evaluate risks. They learn how to conduct breakeven and return-on-investment analyses with special reference to technology projects. Students work in groups, analyzing cases and assessing the financial position of firms. They work with spreadsheet programs, setting the stage for subsequent financial modeling work. Required: None.

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. The course introduces traditional/waterfall, hybrid, and iterative/agile approaches to project management. Regarding traditional methods, the course reviews project integration management, portfolio and stakeholder management, chartering, scope definition, estimation, precedence diagrams, and the critical path method. It also reviews scheduling, risk analysis and management, resource loading and leveling, Gantt charts, earned value analysis and performance indices for project cost and schedule control. By applying methods discussed in this course, students will be able to execute information systems and data science projects more effectively. Required: None.

MSDS 476-0 Business Process Analytics (1 Unit)
This course introduces data-driven management methods, including business process workflows, mining, modeling, and simulation, activity-based costing, constrained optimization, and predictive analytics. Data from business operations, properly recorded in time-stamped logs of activities and their associated costs, represent essential information for business management. Students analyze business problems and provide a written report and recommendations for business intelligence and business process improvements, including those associated with robotic process automation and digital transformation. Analyzing business activities provides a guide to business intelligence and business process improvements, including those associated with robotic process automation and digital transformation. By reviewing detailed case studies and using commercial and open-source analytics platforms, students learn how data and models can be used to guide management decisions. Required: None.

MSDS 476-DL Business Process Analytics (1 Unit)

This course introduces data-driven management methods, including business process workflows, mining, modeling, and simulation, activity-based costing, constrained optimization, and predictive analytics. Data from business operations, properly recorded in time-stamped logs of activities and their associated costs, represent essential information for business management. Analyzing business activities provides a guide to business intelligence and business process improvements, including those associated with robotic process automation and digital transformation. By reviewing detailed case studies and using commercial and open-source analytics platforms, students learn how data and models can be used to guide management decisions. Required: 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. Required: None.

MSDS 480-DL Business Leadership and Communications (1 Unit)
This course introduces concepts of leadership and organizational behavior. It builds on the premise that leadership is learned and discusses how to drive effective change in organizations at various stages. Students spend three weeks on analytics-specific project management, in which they design an analytics project plan using an agile approach. They learn how to incorporate the cross-industry standard processes for data analysis and modeling. They practice executing plans in simulated business settings. Working on case studies and theory-based assignments, students see how to address leadership challenges unique to analytics organizations. The course focuses on developing effective communication strategies and presentations that resonate across business and technical teams. Required: None.

MSDS 485-0 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. Required: 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 laws relating to data privacy and cybersecurity. Required: None.

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 (1 Unit)
Topics vary from term to term.
Prerequisite: Vary by topic.

MSDS 492-DL Special Topics in Data Science (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. Required: 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. Required: 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.