SPORTS ADMINISTRATION

SPS Certificate website: https://sps.northwestern.edu/graduate-certificates/

College Sports Management, Graduate Certificate

The Graduate Certificate in College Sports Management (https://catalogs.northwestern.edu/sps/certificates/graduate/sports-administration/college-sports-management-graduate-certificate/) focuses on the unique management issues related to collegiate athletics in the United States. College sports, an ~$8 billion industry, plays a vital role in the US sports market, higher education, media, and the social justice landscape. In the College Sports Specialization, students learn how to manage the internal and external workings of an athletics department, including the unique human resource, legal, compliance, public relations, marketing, sponsorship, and financial issues facing college athletic departments.

Esports, Graduate Certificate

Much like the evolution of traditional sports esports has shifted from a niche hobby or something available only to a select few into a global industry and fan obsession. Video games and competitive gaming are now a mainstream form of global entertainment and analysts predict the global games market to grow from $137.9 billion in 2018 to more than $180.1 billion in 2021. To assist in arming students with the deep understanding and unique skills to help mold this ever-changing industry a dedicated Esports certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/sports-administration/esports-graduate-certificate/) has been developed in conjunction with the Master of Arts in Sports Administration. The curriculum will provide students with a deep understanding of the esports landscape, the malleability to adapt to the continual shifts in that industry, and the skills to become leaders in this rapidly expanding sports business sector.

Sports Analytics, Graduate Certificate

The Graduate Certificate in Sports Analytics (https://catalogs.northwestern.edu/sps/certificates/graduate/sports-administration/sports-analytics-advance-graduate-certificate/) focuses on the skills necessary to work in today's data-intensive and data-driven world. This online certificate provides the technical and leadership training required for key positions in sports team management and analytics. Building upon Northwestern University's graduate program in predictive analytics and data science, it reviews key technologies in analytics and modeling, probability theory, applied mathematics, statistics, and programming. It shows how analytic techniques may be utilized in evaluating player and team performance and in sports team administration.

Sports Communication, Graduate Certificate

The Graduate Certificate in Sports Communication (https://catalogs.northwestern.edu/sps/certificates/graduate/sports-administration/sports-communication-graduate-certificate/) allows students to explore both sports marketing and online communication strategies across multiple platforms. How do you manage messaging, brand consistency, content curation, fan engagement, etc., through the various online channels that exist today and may emerge tomorrow?

Combining courses from the Sports Administration and Information Design & Strategy programs, this certificate is designed for those interested in or already working in communications careers in the multi-faceted sports industry.

Certificates Offered

- College Sports Management, Graduate Certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/sports-administration/college-sports-management-graduate-certificate/)
- Esports, Graduate Certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/sports-administration/esports-graduate-certificate/)
- Sports Analytics, Graduate Certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/sports-administration/sports-analytics-advance-graduate-certificate/)
- Sports Communication, Graduate Certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/sports-administration/sports-communication-graduate-certificate/)

Sports Administration Courses

MSA 400-0 Sports in the Social Context (1 Unit)
This course introduces the tools used to research and write graduate-level papers in a framework of a critical examination of the sociology of sports in the United States and abroad. The course will also explore the history of the social phenomena that have shaped the world of sports. Students will be assigned readings that underscore how sports reflects the values of the larger society. Some of the issues include inequality in sports, commercialization and globalization of sports, the myth of the amateur athlete in big-time college sports, and behaviors deemed deviant in the world of sports. The course emphasizes writing skills, pushing students to examine their strengths and weaknesses, and helping them find effective ways to do solid research. Students will be assigned projects to demonstrate a proficiency in research and writing.

MSA 400-DL Sport in the Social Context: Core Issues in Sports Administration (1 Unit)
This course introduces the tools used to research and write graduate-level papers in a framework of the sociology of sports in the United States and abroad. The course will also explore the history of the social phenomena that have shaped the world of sports. Assigned readings that underscore how sports reflect the values of the larger society. Issues include inequality in sports, commercialization and globalization of sports, the myth of the amateur athlete in big-time college sports, and behaviors deemed deviant in the world of sports. The course emphasizes writing skills, pushing students to examine their strengths and weaknesses and helping them find effective ways to do research. Students will be assigned projects to demonstrate proficiency in research and writing.

MSA 401-0 Introduction to Sports Analytics (1 Unit)
This course provides a broad introduction to data analysis and statistical methods as they relate to the sports industry. Students will learn how to use these methods to better understand and analyze issues central to sports management. Students will be introduced to quantitative and analytical third-party services that are used by sports organizations as part of a larger exploration of the business economics of sports. When students leave the course they will be able to: analyze sports organizations; analyze revenue streams and recommend new, data-driven approaches to maximize monetization opportunities; and value teams, athletes, sponsorships, and brands using quantitative analysis.

MSA 401-DL Introduction to Sports Analytics (1 Unit)

This course provides a broad introduction to data analysis and statistical methods as they relate to the sports industry. Students will learn how to use these methods to better understand and analyze issues central to sports management. Students will be introduced to quantitative and analytical third-party services that are used by sports organizations as part of a larger exploration of the business economics of sports. When students leave the course they will be able to: analyze sports organizations; analyze revenue streams and recommend new, data-driven approaches to maximize monetization opportunities; and value teams, athletes, sponsorships, and brands using quantitative analysis.

MSA 402-0 Fundamentals of Sports Marketing (1 Unit)
This course will provide students the necessary theoretical and practical hands-on knowledge of marketing principles and techniques as it related to the sports industry through the in-depth study of the sport marketing mix. The course also covers marketing strategies of related businesses, such as the sporting goods industry and broadcasting. Additionally, students will explore the sports marketing industry at the professional, collegiate, and amateur levels through discussion of its many facets including: market research and segmentation, advertising, branding, sponsorship, licensing, public relations and media relations.

MSA 402-DL Fundamentals of Sports Marketing (1 Unit)
This course will provide students the necessary theoretical and practical hands-on knowledge of marketing principles and techniques as it related to the sports industry through the in-depth study of the sport marketing mix. The course also covers marketing strategies of related businesses, such as the sporting goods industry and broadcasting. Additionally, students will explore the sports marketing industry at the professional, collegiate, and amateur levels through discussion of its many facets including: market research and segmentation, advertising, branding, sponsorship, licensing, public relations and media relations.

MSA 403-0 Sports Organizations: Leadership Theory & Application (1 Unit)
The overall objective of this course is to develop students' understanding of the frameworks of organizations and facilitate critical analysis of organizational theories and leadership styles. Students will also become familiar with the types of organizational structures that are prevalent in the sports industry. Students will learn about structural frameworks of organizations, the relationship between people and organizations, the role diversity plays in creating a successful workplace, the role of power within an organization, the influence of leadership styles on organizations, and how to think critically about organizations to inform your capacity as a sports professional. The coursework is intended to support students through readings, small and large group discussions, and analysis.

MSA 403-DL Sports Organizations: Leadership Theory & Application (1 Unit)
The overall objective of this course is to develop students' understanding of the frameworks of organizations and facilitate critical analysis of organizational theories and leadership styles. Students will also become familiar with the types of organizational structures that are prevalent in the sports industry. Students will learn about structural frameworks of organizations, the relationship between people and organizations, the role diversity plays in creating a successful workplace, the role of power within an organization, the influence of leadership styles on organizations, and how to think critically about organizations to inform your capacity as a sports professional. The coursework is intended to support students through readings, small and large group discussions, and analysis.

MSA 404-0 Sports Business: Finance, Accounting and Economics (1 Unit)

This course covers financial management and managerial economics as they relate to the sports industry. The focus will be on understanding accounting and finance vocabulary, using financial information to analyze the performance of sports organizations, developing budgets for an organization or department, explaining salary cap logistics/impact, understanding tax implications and stadium financing options – all to make better organizational decisions.

MSA 404-DL Sports Business: Finance, Accounting and Economics (1 Unit)
This course covers financial management and managerial economics as they relate to the sports industry. The focus will be on understanding accounting and finance vocabulary, using financial information to analyze the performance of sports organizations, developing budgets for an organization or department, explaining salary cap logistics/impact, understanding tax implications and stadium financing options – all to make better organizational decisions.

MSA 405-0 Legal and Ethical Issues in Sports Management (1 Unit)
This course introduces the theories and concepts of applied ethics by focusing on legal questions, race and gender issues, public relations, budgeting, recruiting (in the collegiate context), evaluations, personnel, exploitation, and athletic reform in both the corporate and collegiate sport industries. Awareness of legal implications for the industry reduces the probability of litigation.

MSA 405-DL Legal and Ethical Issues in Sports Management (1 Unit)
This course introduces the theories and concepts of applied ethics by focusing on legal questions, race and gender issues, public relations, budgeting, recruiting (in the collegiate context), evaluations, personnel, exploitation, and athletic reform in both the corporate and collegiate sport industries. Awareness of legal implications for the industry reduces the probability of litigation.

MSA 406-0 Sports Public Relations and Crisis Communication (1 Unit)
This course examines the implications and mitigation of crisis and risk in the sports industry, with emphasis placed on managing public relations. Students develop the tools necessary to identify organizational vulnerabilities and to design and implement crisis strategies and communications to prevent these situations, and manage the situations effectively, should they occur. The course pays particular attention to public relations strategies for communication with internal and external constituencies.

MSA 406-DL Sports Public Relations and Crisis Communication (1 Unit)
This course examines the implications and mitigation of crisis and risk in the sports industry, with emphasis placed on managing public relations. Students develop the tools necessary to identify organizational vulnerabilities and to design and implement crisis strategies and communications to prevent these situations, and manage the situations effectively, should they occur. The course pays particular attention to public relations strategies for communication with internal and external constituencies.

MSA 407-0 Sports Labor Relations and Negotiation (1 Unit)
This course focuses on the legal issues of labor relations and negotiations as they relate to the sports industry. Focus on the major professional team sport leagues, with some international Olympic issues. Legal areas of contracts, antitrust law, labor law, arbitration, collective bargaining, and agency issues.

MSA 412-0 Fundamentals of Sponsorship for Sports Marketers and Administrators (1 Unit)
This course is a deep dive into sponsorship and its impact on corporate marketers and the sports organizations they partner with. Topics explored include how brands select what to sponsor, how they design

marketing communications and promotional programs that drive engagement with their target markets, and how they measure success. Additionally, students will examine how sponsorships are packaged, proposed, negotiated and agreed upon; what the benefits are to sports properties beyond direct revenue; and contractual and legal issues surrounding sponsorship.

MSA 413-0 Advertising Project: Sports Brand Management (1 Unit)
Concepts presented in this course include positioning, targeting, brand building and measurement, and how advertising, PR and experiential marketing are used to drive brand equity. Based on lectures, guest speakers, readings, classroom and homework exercises, case studies, and a major group project, the course is designed to present students with a practical, hands-on opportunity to work on current issues facing actual sports-industry businesses. The major small group project involves students collaborating in a consulting role with industry professionals from assigned "client companies". The project requires students to meet with their client and with their student-group members outside of class hours to ensure a well-delivered final product.

MSA 421-DL The Business of Esports (1 Unit)
In this course, students will become familiar will learn the various elements unique to the esports ecosystem including understanding different game genres, examination of the publisher's role in esports, different competitive structures, and the organization of professional teams and players. Students will examine the potential for growth and risks in the esports industry. The course will discuss differences between traditional sports and esports, the culture of esports including streaming, media platforms, inclusivity, online toxicity and sportsmanship, and scholastic esports.

MSA 424-DL Event Management for Sports (1 Unit)
This course addresses major trends and successful business practices in event management. Students will learn the unique characteristics of sporting and sports marketing events, manage event planning to improve profitability, identify and prioritize event goals and objectives, create proposals and agreements for event stakeholders, systematically analyze potential risks and threats to events, and choose appropriate solutions by using efficient event planning methods. Students will be evaluated on their grasp of event management at a macro level and a micro level comprehension of effective planning protocols. Students will examine case studies of sporting events to better understand the unique technical implementation aspects of events and the nuanced planning of those technical considerations.

MSA 441-0 Complexities of Management and Marketing in the Olympic Movement (1 Unit)
Students will analyze the actions of the International Olympic (IOC) Committee and study the bidding process for Olympic games to understand the global business dynamics of the Olympic marketing industry and the "Olympic Movement." Topics will include an examination of the global infrastructure and organization of the Olympic Movement; the Olympic charter and IOC goals; case study presentation on a TOP Olympic sponsor; and a general overview of a host city's obligations and opportunities regarding construction of venues, government support and participation, infrastructure, marketing, security, and more.

MSA 445-0 Entrepreneurship in the Sports Industry (1 Unit)
Entrepreneurial companies are disrupting the sports industry. From big data to wearable technology to mobile/social media, new companies are growing quickly to solve pressing challenges for leagues, teams, events, and athletes. This course is designed to help prepare students for a career path in sports entrepreneurship. More specifically, having a big idea is the start of launching a new venture. Building businesses requires raising capital, hiring the right people, acquiring customers, implementing

strategy, and communicating to internal and external audiences. By the end of this class, students will have the framework in place to start their own company in the sports industry. Recommended prior course: MSA 404-0 or MSA 404-DL.

MSA 445-DL Entrepreneurship in the Sports Industry (1 Unit)
Entrepreneurial companies are disrupting the sports industry. From big data to wearable technology to mobile/social media, new companies are growing quickly to solve pressing challenges for leagues, teams, events, and athletes. This course is designed to help prepare students for a career path in sports entrepreneurship. More specifically, having a big idea is the start of launching a new venture. Building businesses requires raising capital, hiring the right people, acquiring customers, implementing strategy, and communicating to internal and external audiences. By the end of this class, students will have the framework in place to start their own company in the sports industry. Recommended prior course: MSA 404-0 or MSA 404-DL.

MSA 451-0 Information Technology in Sports (1 Unit)
The Technology of Sport provides an interactive tour of technology, related products/services that form technical solutions, and the current and future state of technology as it relates to sports. MSA 451 goes beyond the what of technology, and explores the how highlighting technological impacts on the sports business landscape. Students will learn the terms and tools that comprise technology, specifically those most applicable to the sports industry and within a sports business setting. The course will evaluate student's comprehension of technological concepts, implementation of those concepts, and tangible business enhancements. A midterm examination and a final project are used to advance students' application of these technological skills.

MSA 451-DL The Technology of Sport (1 Unit)
MSA 451 provides an interactive tour of technology, related products/services that form technical solutions, and the current and future state of technology related to sports. MSA 451 goes beyond the what of technology, and explores the how, highlighting technological impacts on the sports business landscape. Students will learn the terms and tools that comprise technology, specifically those most applicable to the sports industry and within a sports business setting. The course will evaluate students' comprehension of technological concepts, implement those concepts, and tangible business enhancements. A midterm examination and a final project are used to advance students' application of these technological skills.

MSA 453-0 College Sports Management - Internal Affairs (1 Unit)
College athletic departments exist within a larger university ecosystem and regulatory environment that present unique challenges and opportunities. Students will examine the core tenets of sport management that address the day-to-day internal workings of a collegiate athletic department. The course will take an in-depth look at administrative leadership and college athletics within a university and its governance structure. Students will examine the challenges that present themselves across multiple departments and the management relationships that need to be developed among coaches, administrators, and student-athletes. Relevant topics include intellectual property rights, federal and NCAA requirements, budgeting issues, and multi-faceted student-athlete support.

MSA 453-DL College Sports Management - Internal Affairs (1 Unit)
College athletic departments exist within a larger university ecosystem and regulatory environment that present unique challenges and opportunities. Students will examine the core tenets of sport management that address the day-to-day internal workings of a collegiate athletic department. The course will take an in-depth look at administrative leadership and college athletics within a university and

its governance structure. Students will examine the challenges that present themselves across multiple departments and the management relationships that need to be developed among coaches, administrators, and student-athletes. Relevant topics include intellectual property rights, federal and NCAA requirements, budgeting issues, and multi-faceted student-athlete support.

MSA 454-0 College Sports Management - External Affairs (1 Unit)
College athletic departments engage many external stakeholders as they address revenue demands and the financial sustainability of their programs. Students will examine the core tenets of sport management related to the outward-facing responsibilities of a collegiate athletic department. The course will take an in-depth look at the day-to-day challenges that present themselves across the multiple revenue generating aspects of collegiate athletics, including corporate sponsorships, ticket sales, marketing, fundraising, and other public facing areas such as athletics communications, facilities, and crowd management.

MSA 454-DL College Sports Management - External Affairs (1 Unit)
College athletic departments engage many external stakeholders as they address revenue demands and the financial sustainability of their programs. Students will examine the core tenets of sport management related to the outward-facing responsibilities of a collegiate athletic department. The course will take an in-depth look at the day-to-day challenges that present themselves across the multiple revenue generating aspects of collegiate athletics, including corporate sponsorships, ticket sales, marketing, fundraising, and other public facing areas such as athletics communications, facilities, and crowd management.

MSA 455-0 NCAA Compliance (1 Unit)
NCAA rules and infractions can seem mysterious and arbitrary, given the way they are covered by the media. The NCAA has rules and processes that affect the daily workings of any NCAA institutions, particularly Division I. This course provides students with a working knowledge of NCAA compliance issues by examining and applying the bylaws of the NCAA (with a focus on Division I). Students will examine case studies to gain experience in applying this knowledge to everyday NCAA issues. Enforcement procedures, waivers processes, and the evolution of the NCAA rules will be examined as well. This course will offer valuable insights into career paths in NCAA compliance, college administration, and how the world of college sports really works.

MSA 455-DL NCAA Compliance (1 Unit)
This course provides students with a working knowledge of NCAA compliance issues by examining and applying the bylaws of the NCAA (with a focus on Division I). Students will examine case studies to gain experience in applying this knowledge to everyday NCAA issues. Enforcement procedures, waivers processes, and the evolution of the NCAA rules will be examined as well. This course will offer valuable insights into career paths in NCAA compliance, college administration, and how the world of college sports really works.

MSA 457-0 Front Office Operations (1 Unit)
This class will provide students with a working knowledge of the issues facing sports teams and organizations. This will include both for-profit and not-for-profit organizations. Students will apply critical thinking and analysis to the various stakeholders' interest in the business and operations of sports teams and organizations. This will include teams, leagues, municipalities, financial institutions, fans, corporations and other related companies that do business with the aforementioned entities. The class will utilize real life examples of organizational structures, actual team financials, economic models and discussion.

MSA 457-DL Front Office Operations (1 Unit)

This class will provide students with a working knowledge of the issues facing sports teams and organizations. This will include both for-profit and not-for-profit organizations. Students will apply critical thinking and analysis to the various stakeholders' interest in the business and operations of sports teams and organizations. This will include teams, leagues, municipalities, financial institutions, fans, corporations and other related companies that do business with the aforementioned entities. The class will utilize real life examples of organizational structures, actual team financials, economic models and discussion.

MSA 458-DL Digital Media in Sports (1 Unit)
This course will examine the impact of new technology on the business of sports, focusing on topics such as Over-the-Top (OTT) video distribution, social media, fantasy sports, eSports, data & analytics, stadium technology, digital advertising, and youth & amateur sports, among other subjects. In addition to covering the major leagues and media companies, the course will also provide insight into entrepreneurial ventures and start-ups that are reshaping the sports landscape.

MSA 460-0 Deviance and Violence in Sports (1 Unit)
This course examines the social and cultural meaning of deviance and violence in sport. Drawing from social science, legal cases, popular media, and contemporary events, students learn the various definitions of deviance and violence, as well as explore the ways in which the government, athletic associations, and players themselves manage, regulate, and perpetuate these behaviors. Topics include the prevalence of violence both on and off-field, the use of performance-enhancing drugs, extreme weight loss, and gambling.

MSA 460-DL Deviance and Violence in Sports (1 Unit)
This course examines the social and cultural meaning of deviance and violence in sport. Drawing from social science, legal cases, popular media, and contemporary events, students learn the various definitions of deviance and violence, as well as explore the ways in which the government, athletic associations, and players themselves manage, regulate, and perpetuate these behaviors. Topics include the prevalence of violence both on and off-field, the use of performance-enhancing drugs, extreme weight loss, and gambling.

MSA 463-0 Globalization in Sports (1 Unit)
The intent of this course is to develop the student's understanding of the global impact of sport. The overall objective is to examine the ways in which sport has developed internationally and influences culture, economics, nationalism, and social values. The class will aggressively dissect various aspects of international sports such as governing bodies, events, ethnic relations, marketing/sponsorships, media evolution, and agency. This course will attempt to give students the ability to process, analyze, and articulate the expansion of sport on a global level.

MSA 463-DL Globalization of Sport (1 Unit)
This course will examine the role of sport in a global world. From the massive amounts of data collected to political conflicts generated by mega-events, this course will give students the ability to process, analyze, and articulate the expansion of sport on a global level. By examining how sport has developed internationally and influenced culture, economics, nationalism, and social values, students will be able to discuss and draw connections between the business of sport, cultural and political impact, and historical traditions to predict future trends and increase cultural and societal understanding as it relates to sport. Issues of race and cultural identity, and gender (including transgender), and sexuality in sports will be examined.

MSA 490-0 Special Topics (1 Unit)
This class will be offered periodically to address special topics in Sports Administration. Please check the MSA website for specific topics.

MSA 498-0 Capstone Class (1 Unit)
The capstone project course is the culmination of the MSA program and demonstrates a student's mastery of the curriculum and a firm understanding of the fundamental principles that guide the diverse field of sports administration. Students may choose this course to fulfill their capstone requirement. Students should have completed 9 of 11 courses in the program, with all core courses completed.

MSA 498-DL Capstone (1 Unit)
The capstone project course is the culmination of the MSA program and demonstrates a student's mastery of the curriculum and a firm understanding of the fundamental principles that guide the diverse field of sports administration. Students may choose this course to fulfill their capstone requirement. Students should have completed 9 of 11 courses in the program, with all core courses completed.

MSA 499-0 Independent Study (1 Unit)
An independent study is a customized course of study undertaken by a single student under the guidance of an instructor. Independent studies are comparable in their demands to other graduate-level courses. Please see the SPS Graduate Student Handbook and your academic advisor for more information about independent study registration.

MSA 579-0 Practicum in Sports Administration (1 Unit)
This course will provide a framework for the development of your professional skills throughout the internship. Students will become familiar with a variety of techniques in networking, professionalism, and problem-solving in order to get the most out of their work experience. Students will share their experiences with classmates throughout the course in order to provide a framework for discussion and learning. As the experience in the internship is the most valuable piece of the class and where most of your energy, knowledge, and motivation will be expended, this class will not hold in-person class meetings, but will require weekly assignments, online class participation, as well as a final paper.

MSA 579-DL Practicum In Sports Admin (1 Unit)
This course will provide a framework for the development of your professional skills throughout the internship. Students will become familiar with a variety of techniques in networking, professionalism, and problem-solving in order to get the most out of their work experience. Students will share their experiences with classmates throughout the course in order to provide a framework for discussion and learning. As the experience in the internship is the most valuable piece of the class and where most of your energy, knowledge, and motivation will be expended, this class will not hold in-person class meetings, but will require weekly assignments, online class participation, as well as a final paper.

MSA 590-0 Thesis Research (1 Unit)
Instead of the Capstone class, students may elect to complete a thesis. This final project is meant to represent the culmination of students' experience in the program and must demonstrate mastery of the curriculum and the ability to conduct sustained independent research and analysis. The project may be applied or may be a traditional scholarly paper; in both cases a manuscript following program-specific guidelines is required. Students must submit a proposal and secure a first reader to register for the thesis course; for further details, students are advised to review the student handbook and contact their academic advisor.

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-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 Data Engineering with Go (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 implement database servers and clients. And they learn how to run concurrent processes, as needed in distributed and parallel processing environments. Required: 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 Analytics Application Engineering (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 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 computing, including infrastructure-, platform-, software-, and database-as-a-service systems for data science. They evaluate system performance and resource utilization in batch, interactive, and streaming environments. They create and run performance benchmarks comparing browser-based and desktop applications. The evaluate key-value stores, relational, document, graph, and graph-relational databases. Recommended prior course: MSDS 430-DL or MSDS 431-DL. (Required: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.)

MSDS 440-DL Full-Stack Data Engineering (1 Unit)
This course introduces the full-stack development process for data science. Students learn how to implement end-to-end applications using web-based technologies and the model-view-controller framework. They build real-time application servers, backend databases, and front-end interfaces. They create microservices that deploy machine learning algorithms. The course shows how to extract information from online resources. Graph theory, information retrieval, social media, and text analytics are discussed and employed in real-world applications. Students also learn design principles for implementing relational, document, and graph databases. This is a project-based course with a strong programming component. (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 442-DL Data Pipelines and Stream Processing (1 Unit)
This application engineering and analytics course introduces stream processing and the end-to-end data pipeline. Real-time data sources include electronic monitoring of continuous processes, observing digital communications and social interaction, and tracing the movement of goods through production lines, warehouses, and distribution channels. The course demonstrates a stream-processing technology stack designed for high throughput and low latency. Students analyze business transactions and processes, event logs, workflows, and consumer behavior. They learn about operations, logistics, and supply chain management. This is a case study and project-based course with a strong programming component. (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 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 Machine Learning (1 Unit)
This course introduces applications of machine learning techniques to finance. Financial data presents special challenges to standard machine learning techniques, engendering significant adaptations. Topics include a basic introduction to finance, nuances of financial features engineering, techniques to avoid various biases during model training, and example applications such as meta-labeling. Recommended prior course: MSDS 413-DL. (Required: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.)

MSDS 452-DL Web and Network Data Science (1 Unit)
This course shows how to acquire and analyze information from the web and reviews web analytics and search performance metrics. It introduces the mathematics of network science, including random graph, small world, and preferential attachment models. Students compute network metrics, analyzing structure and connections in information and social networks. They study user interactions through electronic communications and social media. They work with graph algorithms and graph databases. This is a case study and project-based course with a strong programming component. (Required: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.)

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 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-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. 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.