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 will 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.

Global Sports Communication, Graduate Certificate

The Graduate Certificate in Global Sports Communication (https://catalogs.northwestern.edu/sps/certificates/graduate/sports-administration/global-sports-communication-graduate-certificate/) offered on Northwestern’s Doha, Qatar campus, prepares students to work in the growing global sports industry, focusing on strategic communication, media marketing, and leadership. Graduates of the program will build communication skills specific to the sports industry and will be well-prepared for communication, marketing, and promotional roles in the Middle East sports industry.

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 multifaceted 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/)
• Global Sports Communication, Graduate Certificate (https://catalogs.northwestern.edu/sps/certificates/graduate/sports-administration/global-sports-communication-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 reflects 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)**
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**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 relates 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.

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**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.

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**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)**
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**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 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 406-0 Sports Public Relations and Crisis Management (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.

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understand the global business dynamics of the Olympic marketing

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 Sponsorships 2.0: Adding Value to Sports, Brands, Fans, and Communities (1 Unit)
In this class, we will deconstruct some of the world’s most innovative partnerships from the inside out. You will learn how to think like a sponsor, including how to set measurable objectives and how to bullet proof sponsorship selection to linking activation to business goals and how to measure return on investment. Participants will also learn sponsorship through the lens of the sports rightsholder, gaining the skills and tools to sell sponsorship to team, league, event, venue, athlete or program. Also covered: pricing, negotiating, servicing and licensing.

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 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 with 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
MSA 453-DL Globalization in Sports (1 Unit)
This course will examine 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 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 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.

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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.

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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-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-DL Globalization of Sport (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 463-0 Globalization in Sports (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 475-DL Global Sports Communication (1 Unit)**
This course provides an understanding of the sports communications industry at both the collegiate and professional levels. Topics include the role of communications in management, news release writing, working with and using various forms of media, crisis management, pitching stories, interviews, and ethics.

**MSA 476-DL Principles and Practice of Strategic Communication and Public Relations (1 Unit)**
This course looks at the broad range of theoretical perspectives applied to strategic communication and public relations. It explores normative theories underpinning organizational understanding of strategic communication and PR by considering approaches, practices, and strategies in this field. Participants will gain a working knowledge of PR industry conventions, structure, and operations; strategic communication audiences and public opinion; stakeholders theory; issues management, and crisis management. The course pays particular attention to public relations strategies for communication with internal and external constituencies.

**MSA 477-DL Media Literacy in Sports (1 Unit)**
Media literacy is a competence that sports administrators often use to shape the array of messages that relate to the sports venture they administer, but more importantly, to engage with the media in the narratives that could benefit or damage the reputation of their clients. This course has three primary goals: (a) Provide students with the media literacy tools needed to uncover the power of the media in controlling images and stories, (b) Help students to understand the role of the media in the construction of beliefs, the mobilization of publics, and the fostering of emotions. (c) Provide participants with the necessary lexicon to engage with media professionals and understand media production basics.

**MSA 479-DL Practical Experience in Global Sports Communication (1 Unit)**
The Practical Experience in Global Sports Communication course is an opportunity for students to demonstrate their mastery of the global sports communication certificate curriculum and a firm understanding of the fundamental principles of strategic communication, media marketing, and leadership that guide the diverse and growing global sports industry. This course will combine theories taught in the previous certificate courses with practical, hands-on applications allowing students to bring their unique experiences to the classroom.

**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-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.

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

**MSDS 401-DL Applied Statistics with R (1 Unit)**
This course teaches fundamentals of statistical analysis. This includes evaluating statistical information, performing data analyses, and interpreting and communicating analytical results. Students will learn to use the R language for statistical analysis, data visualization, and report generation. Topics covered include descriptive statistics, central tendency, exploratory data analysis, probability theory, discrete and continuous distributions, statistical inference, correlation, multiple linear regression, contingency tables, and chi-square tests. Selected contemporary statistical concepts, such as bootstrapping, are introduced to supplement traditional statistical methods. Recommended prior course: MSDS 400-DL.

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

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

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

MSDS 411-DL Unsupervised Learning Methods (1 Unit)
This course introduces data modeling for studies in which there is no clear distinction between explanatory and response variables. 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. Prerequisite: 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.

Prerequisite: (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

MSDS 420-DL Database Systems and Data Preparation (1 Unit)
This course introduces data management and data preparation with a focus on applications in large-scale analytics projects. Students learn about relational databases, the relational model, the normalization process, and 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.

Prerequisite: MSDS 402-DL or MSDS 403-DL.

MSDS 422-DL Practical Machine Learning (1 Unit)
The course introduces machine learning with business applications. It provides a survey of 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. Prerequisite: MSDS 400-DL, MSDS 401-DL, and MSDS 402-DL or MSDS 403-DL.

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

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

**Prerequisite:** (1) MSDS 400-DL or (2) MSDS 420-DL or CIS 417-DL.

**MSDS 434-DL Analytics Application Engineering (1 Unit)**

This course covers programming components essential to the development of analytics applications. The focus is analytics software engineering. Students learn to develop desktop and client-server solutions. They learn about web-based solutions employing a variety of front-end and back-end system components. The course introduces machine learning operations and engineering. Students use cloud systems to package and distribute containerized computer software. They develop software, working on open-source programming, database, and systems integration projects. They employ best practices in software development. Recommended prior courses: MSDS 432-DL.

**Prerequisite:** 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 computer architecture and scalable systems for data science. They evaluate performance and resource utilization in batch, interactive, and streaming environments. Students review protocols for application programming interfaces. They compare data models, resource requirements, and performance of applications implemented with relational versus graph database systems. Recommended prior course: MSDS 432-DL.

**Prerequisite:** (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

**MSDS 440-DL Real-Time Interactive Processing and Analytics (1 Unit)**

This course introduces application engineering and analytics within an integrated environment and full-stack development process. Students implement client-side, web-based applications using a model-view-controller framework. They use server-side systems for responding to website requests and database queries. They prepare indices for efficient, relevant search across large document collections. They find information in databases and document collections, make service and product recommendations, and detect anomalies or security violations. This is a case study and project-based course with a strong programming component.

**Prerequisite:** (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

**MSDS 442-DL Real-Time Stream Processing and Analytics (1 Unit)**

This course introduces application engineering and analytics within stream and event processing environments. Students learn how to work with various data feeds and sources, including electronic sensors, monitoring continuous processes, observing communication traffic and social interaction, and tracking goods through production and distribution. Students implement stream processing solutions, providing high throughput and low latency. They use relational and graph databases. They analyze event logs and business processes. This is a case study and project-based course with a strong programming component.

**Prerequisite:** (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

**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.

**Prerequisite:** (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.

**Prerequisite:** (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.

**Prerequisite:** (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 reviews natural language processing with a focus on recent developments in computational linguistics and machine learning. Students work with unstructured and semi-structured text from online sources, document collections, and databases. Students learn how to parse text into numeric vectors and to convert higher dimensional vectors into lower dimensional vectors for subsequent analysis and modeling. Applications include speech recognition, semantic processing, text classification, search, recommendation systems, sentiment analysis, and topic modeling. This is a project-based course with extensive programming assignments.

**Prerequisite:** (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

**MSDS 454-DL 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.

**Prerequisite:** (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.

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

**MSDS 456-DL Sports Performance Analytics (1 Unit)**
An introduction to sports performance measurement and analytics, this course reviews roles of athletes at each position in sports selected by the instructor. With a focus on the individual athlete, the course discusses the development and use of accurate assessments and variability due to factors such as body type, climate, and training regimen. The course reviews athletic performance measurements, including jumping ability, running speed, agility, and strength. Students work with player on-field and on-court performance measures. The course utilizes exploratory data analysis, predictive modeling, and presentation graphics, showing real-world implications for athletes, coaches, team managers, and the sports industry.

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

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

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

**MSDS 458-DL Artificial Intelligence and Deep Learning (1 Unit)**
An introduction to 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.

**Prerequisite:** (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

**MSDS 459-DL Knowledge Engineering (1 Unit)**
This course reviews methods for developing knowledge-based systems, providing examples of their use in intelligent applications and conversational agents. It uses of relational, document, and graph databases for storing information about relationships among words, people, places, events, and things. Students learn about knowledge representation and automated reasoning. They draw on logic programming and machine learning to build end-to-end knowledge-based applications for information extraction and question answering. Recommended prior courses: MSDS 453-DL and MSDS 458-DL.

**Prerequisite:** (1) MSDS 420-DL or CIS 417-DL and (2) MSDS 422-DL or CIS 435-DL.

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

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

**MSDS 467-DL Analytics Entrepreneurship (1 Unit)**
This course prepares students for establishing and running a data-sciences-oriented entrepreneurial organization. Students learn how to transform an idea into a running organization, identifying the right data, analytics tools, and resources, and aligning with unmet market demands. Students 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. Analytic product and consulting services opportunities are reviewed. Students develop business plans and make presentations for starting entrepreneurial data science ventures.

**Prerequisite:** MSDS 400-DL, MSDS 401-DL, and MSDS 402-DL or MSDS 403-DL.

**MSDS 472-DL Analytics Consulting (1 Unit)**
This 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.

**Prerequisite:** MSDS 400-DL, MSDS 401-DL, and MSDS 402-DL or MSDS 403-DL.

**MSDS 474-DL Accounting and Finance for Analytics Managers (1 Unit)**
This course reviews corporate finance and managerial accounting with a focus on analytics management. Analytics managers are often responsible for the profit-and-loss of their projects and divisions which have special needs in terms of workflow, coordination with other businesses, satisfying multiple stakeholders, and employing highly specialized knowledge professionals. Students learn how to conduct break-even and investment analyses. They learn how to read balance sheets, income statements, and cash flow statements and infer risks related to companies. The course provides in-depth coverage of spreadsheet programming methods, setting the stage for subsequent financial modeling work.

**Prerequisite:** MSDS 402-DL or MSDS 403-DL.

**MSDS 475-DL Project Management (1 Unit)**
This course introduces best practices in project management, covering the full project life cycle with a focus on globally accepted standards. It reviews traditional methods, including integration, portfolio and stakeholder management, chartering, scope definition, estimation, the Delphi method, project evaluation and review technique, precedence diagrams, and the critical path method. It 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 should be able to execute information systems and data science projects more effectively.

**Prerequisite:** None.

**MSDS 480-0 Business Leadership and Communication (1 Unit)**
This course introduces fundamental leadership theory and associated behaviors to enable students to excel in their analytics careers. The course examines the theory and practice of leadership at the individual and organizational levels, and discusses how to drive effective change at various stages in an enterprise analytics transformation process. Students spend three weeks on analytics-specific project management, in which they design an analytics project plan using an agile approach. Leadership challenges unique to analytics departments are addressed through the use of case studies and theory-based assignments. The course focuses on developing effective communication strategies and presentations that resonate across business and technical teams.

**Prerequisite:** None.

**MSDS 480-DL Business Leadership and Communications (1 Unit)**
This course introduces 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.

**Prerequisite:** None.

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

**Prerequisite:** 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-Analytics and Modeling (1 Unit)**
Topics vary from term to term.

**Prerequisite:** Vary by topic.

**MSDS 492-DL Special Topics in Data Science-Data Engineering (1 Unit)**
Topics vary from term to term.

**Prerequisite:** Vary by topic.

**MSDS 493-DL Special Topics in Data Science-Analytics Management (1 Unit)**
Topics vary from term to term.

**Prerequisite:** Vary by topic.

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

**Prerequisite:** Completion of all core courses in the student’s graduate program and specialization.

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

**Prerequisite:** Completion of all core courses in the student’s graduate program and specialization.

**MSDS 499-DL Independent Study (1 Unit)**
Topics vary from term to term.

**Prerequisite:** Vary by topic.

**MSDS 579-0 Practicum (1 Unit)**

**MSDS 590-DL Thesis Research (1 Unit)**
This final project is meant to represent the culmination of students’ experience in the program and must demonstrate mastery of the curriculum and ability to conduct sustained independent research and analysis. The project may be applied or may be a traditional scholarly paper; in both cases a write-up following the paper's program-specific guidelines is required. Students must submit a proposal and secure a first reader in order to register; for further details students are advised to review the student handbook and contact their academic adviser.