Washington University in St. Louis
OLIN BUSINESS SCHOOL

Master of Science in Business Analytics (MSA) – Customer Analytics track
2020–2021 Academic Year

39 credits as follows: May 2020 (subject to change)
18 common core credits
13.5 customer analytics required credits – as indicated by **
7.5 elective credits

MSA – Customer Analytics Three-Semester Course Plan

Preprogram Foundations Requirements
Preparatory work begins in July/August, is in addition to required credits, and does not affect GPA.
MKT 500V Basics of R Programming (0.5)
Online Introduction to Marketing course

Fall Semester (12 core + 3 track required = 15 credits)

Fall A	Fall B
Required: DAT 560G Database Design & SQL (1.5)	Required: DAT 500N Prescriptive Analytics (1.5) DAT 560M Big Data & Cloud Computing (1.5)

Required:
MGT 560F Professional Business Communication (1.5)
DAT 500S Machine Learning Tools for Prediction of Business Outcomes (3)
DAT 561 Introduction to Python and Data Science (3)

Track Required:
MKT 580 Marketing Research Analytics (3)**

Spring Semester (6 core + 7.5+ track required + 3 electives = 13.5-16.5 credits)

Spring A	Spring B
Track Required: MKT 555A Data Analysis for Brand Management (1.5)** MKT 500U Digital Marketing (1.5)**	Required: DAT 560E Data Visualization for Business Insights (1.5) DAT 562 Text Mining (1.5) Track Required: MKT 555 Analytics-Driven Brand Management (1.5)**

Required:
DAT 500W A/B Testing in Business and Social Science (3)

Track Required:
MKT 500T Customer Analytics (3)**
Required experiential course: MGT 551 Summer CPT course (1.5) or MKT 501P CABI Practicum (3) in spring or fall semesters

Electives:

OB 500E Talent Analytics (1.5)	DAT 560N Introduction to Cybersecurity (1.5) OB 535 People Metrics (1.5)

MGT 566 Research in Healthcare Management (3)
MATH 420 Experimental Design (3)
INFO 5500 Enterprise Resource Planning (3)
INFO 558 Applications of Deep Neural Networks (3)
CSE 501N Introduction to Computer Science (3)
CSE 502N Data Structures and Algorithms (3)
CSE 503S Rapid Prototype Development and Creative Programming (3)
CSE 514A Data Mining (3)
CSE 417T Intro to Machine Learning (3) or CSE 517A Machine Learning (3)
CSE 515T Bayesian Methods in Machine Learning (3)
CSE 530S Database Management Systems (3)

<table>
<tr><th colspan="2">Second Fall Semester (3 track required + 4.5 - 7.5 electives = 7.5-10.5 credits)</th></tr>
<tr><td colspan="2">Track Required:
MKT 577 Marketing Strategy (3)**
Required experiential course: MGT 551 Summer CPT course (1.5) or MKT 501P CABI Practicum (3) in spring or fall semesters</td></tr>
<tr><td colspan="2">Electives:</td></tr>
<tr><th>Fall A</th><th>Fall B</th></tr>
<tr><td>MKT 558 Pricing Strategies (1.5)</td><td>DAT 565E Deep Learning for Prediction of Business Outcomes (1.5)
MKT 558B Pricing Decision Making & Implementation (1.5)
OMM 519E Introduction to Revenue Management (1.5)</td></tr>
<tr><td colspan="2">DAT 537 Data Analysis, Forecasting & Risk Analysis (3)
MGT 620 Empirical Methods in Business (3)
MGT XXX Introduction to Blockchain (1.5)
MSB 550 Introduction to Bioinformatics (3)
INFO 558 Applications of Deep Neural Networks (3)
MATH 475 Statistical Computation (3)
CSE 222S Internet of Things (3)
CSE 316A Social Network Analysis (3)
CSE 417A Introduction to Machine Learning (3) (or CSE 517A Machine Learning during Spring)
CSE 457A Introduction to Visualization (3)
CSE 501N Introduction to Computer Science (3)
CSE 502N Data Structures and Algorithms (3)
CSE 503S Rapid Prototype Development and Creative Programming (3)</td></tr>
<tr><th colspan="2">Total: 39 credits (18 common core credits, 13.5 track required credits, 7.5 elective credits)</th></tr>
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All letter graded courses count toward degree and GPA calculation. Math and CSE courses can be taken P/F and count toward degree.

Under the flat tuition rate, students may take up to 18 credits per semester. Additional courses are charged per-credit.

The degree requirements and policies in this document apply to students entering Washington University during the 2020–2021 academic year. Every effort is made to ensure that the information is accurate and correct as of the date of publication (9/9/20). Washington University reserves the right to make changes at any time without prior notice. Therefore, this curriculum document may change from time to time without notice. The governing document at any given time is the then-current version, as published online.

MSA - Customer Analytics Course Descriptions

Summer Foundations Workshop

MKT 500V Basics of R Programming

R has become the tool of choice for many data science and customer analytics professionals in every industry and field. It is not surprising to see a requirement for being familiar with R in job descriptions. R is very flexible in carry out data analysis. Part of the benefit of being open source is that many programmers/researchers are constantly introducing new statistical analysis tools into R through R packages. Given all the benefits, R does have a relatively steeper learning curve. To better prepare MSA students, we introduce this 2 day introduction to R programming course. This class will help you master the basics of R. We will start from the very beginning - installation of the program. No prior knowledge in programming is required. Through in class demonstration and lots of hands-on practice, by the end of the second day, you will have the chance to undertake your own data analysis and solve relevant business problems using R. 0.5 credits. Graded Pass/Fail.

Required Core Courses

DAT 500N Prescriptive Analytics

This course covers optimization models and tools as they apply to the design and analysis of supply chains. Production planning, distribution, network design, and revenue management problems are covered using the methods of linear, non-linear, and integer programming. Upon successful completion of this course, students will demonstrate competency in formulating and solving supply chain optimization models of real-life complexity using state-of-the-art software. They will become proficient with industrial strength software tools like AMPL and Gurobi alongside Excel's Solver. The course emphasizes proficiency in model-building and using software tools rather than theory. 1.5 credits

DAT 500S Machine Learning Tools for Prediction of Business Outcomes

Predictive Analytics deals with the employment of formal learning from business experience, using business data, to predict the future behavior of customers or other critical organizational elements in order to drive better business decisions. This course emphasizes data situations that students are likely to face in marketing, finance, manufacturing and consulting jobs. Students will analyze real-world business datasets using various advanced analytic techniques such as logistic regression, decision trees, neural networks, stochastic gradient boosting, MARSplines, Ensembles, Clustering, Associations etc. The focus of the course lies in the conversion of raw and messy business data in to robust actionable predictions for decision-making. 3 credits.

DAT 500W A/B Testing in Business and Social Science

This course introduces students to causal methods that are used to measure the impact of business and policy decisions. The key insight of the course is that correlation does not imply causation and therefore cannot measure impact. In this class, we will learn about A/B testing and other causal methods, as well as how to implement them in business, economic, and policy situations. 3 credits.

DAT 560E Data Visualization for Business Insights

Data Visualization has become a core skill set to derive business insights in the data rich business world. Organizations are expecting Business Analysts and Managers to create and disseminate insightful visualizations about the business. This course teaches students the necessary skill set to create insightful visualizations using Tableau to understand patterns prevalent in large datasets which are otherwise difficult to comprehend. In particular, students will learn how to choose and create appropriate visualization based on the following three criteria: 1. Who's the audience looking at the visualization? 2. What is the nature of the business goal (Descriptive, Predictive, or Prescriptive)? 3. What is the data (Categorical, Numerical, Time Series, etc.)? The course will expose students to prevalent business applications of data visualization in different domains (Customer Analytics, Supply Chain Analytics, Healthcare Analytics, Financial Technology Analytics, Accounting Analytics, Talent Analytics etc.). Upon completing this course, students will know how to create insightful dashboards and other visualizations for different audiences from the given data according to the specified goal. 1.5 credits.

DAT 560G Database Design and SQL
Databases are at the foundation of every organization's information strategy. Understanding the structure of databases and mastering the tools to analyze data are essential skills in any role. The tools developed in this course assist students in implementing a company's data management strategy and developing well-grounded analytical recommendations. In this course we focus on understanding how data is structured in relational databases. With vast amounts of data available, from disparate sources, effective organization of the data is essential to its utilization. To complement this, we utilize SQL (Structured Query Language) as the primary tool to extract data for managerial reports and for advanced analytical models. Practical experience with current relational database software is developed throughout the course. This course is required for MS/CA students and priority will be given to SMP students. 1.5 credits.

DAT 560M Big Data & Cloud Computing
The growth in available data is a challenge to many companies. This presents an opportunity for companies to conquer the vast and various data available to them. The growth in data includes traditional structured data, as well as unstructured data created by both people and machines. It is essential for analysts to be comfortable in the new technologies and tools that are being developed to store, retrieve, analyze, and report, using the vast data resources available. This course introduces students to the technologies currently deployed to overcome the challenges of Big Data. Prerequisite: MGT 560G. 1.5 credits.

DAT 561 Introduction to Python and Data Science
This is a 3-credit course offered to MSBA students. It provides students the necessary skill set to extract reliable insights from large datasets prevalent in various business applications, such as supply chain management, marketplace operations, healthcare analytics and financial engineering, using Python. In this course, students will develop basic tools to understand Python programs and implement data processing pipelines using Python. In particular, students will learn how to acquire, clean, analyze and visualize data in Python, which they will then use to improve decision-making processes. Throughout the course, students will use the Python programming language, which is very effective for data manipulation, reporting, and complex optimization. Topics covered include introduction to Python programming, data acquisition and cleaning, data manipulation, current multi-source data collection technology used in practice, basic data visualization using Matplotlib, ggplot2 and Bokeh. 3 credits.

DAT 562 Text Mining
Consumers and companies constantly generate large amounts of unstructured or lightly structured texts on the web and offline: exchanges of consumer opinions on products and services on social media, transcripts of phone conversations with customer representatives, open-ended surveys, etc. By employing text analytics, businesses can derive at scale valuable insights into consumer attitudes to brands, competitive landscape, and customer relationships, among other applications. This course introduces students to the methods of mining, organizing, summarizing, and analyzing textual data with the objective of driving business decision-making. 1.5 credits.

MGT 560F Professional Business Communication
Communication is the process of sending and receiving messages, however, communication is effective only when the message is understood and when it stimulates action or encourages the receiver to think in a new way. This course will introduce students to fundamental best practices in business writing and business speaking that will ensure effective communication. Students will participate in activities that will develop professional business communication skills in both writing and speaking. These will include: preparing, writing and delivering presentations, composing clear concise business messages in a variety of formats, understanding emotional intelligence to reach the audience and utilizing critical thinking as a basis for communication strategies. 1.5 credits.

MKT 577 Marketing Strategy
Marketing strategic decisions require long-term planning and are often costly to change once implemented. They often involve more than one marketing mix variable (price, advertising and other promotions) that have to be consistent with a firm's core competencies, with the objective of establishing sustainable competitive advantages. A good strategic planning requires careful analysis of customers and competitors in the industry, identifying a feasible set of options and deciding on a course of actions. With the development of the information technology nowadays, firms have collected valuable market data, either by themselves or from third-party data providers. The biggest question for most firms, however, is how to use these data to help make strategic decisions. The objective of this capstone course is to develop a comprehensive framework to help understand the strategic situations of firms and the trade-off involved in decision-making. It will also provide students a comprehensive knowledge of using analytical skills to solve business problems. We will explore the importance of CRM and how to use customer analysis to make marketing decisions. Other topics including competitor analysis, STP, price competition, product and entry strategies will also be covered. 3 credits.

Track Required Courses

MKT 500T Customer Analytics Using Probability Models
Customer analytics is about using customer data to make business decisions and predict future behavior. This course will build and implement powerful and leading-edge models for customer acquisition, retention, behavioral patterns such as website visits, customer lifetime value and direct marketing responses. The course will provide a unifying framework for thinking about customer data analysis and develop hands-on experience in model building and estimation using Microsoft Excel. These models use basic building blocks from probability theory to offer behaviorally plausible perspectives on what people buy, when they buy, and how much they buy. Anyone with interest in the revenues generated by customers (such as managers, consultants, analysts and investors) can benefit from deeper insights and more accurate forecasts that result when accounting for these patterns in their models. 3 credits.

MKT 500U Digital Marketing
The aim of this course is to provide a rigorous and comprehensive introduction to technology and methods of conducting marketing activities online. Specific objectives are to introduce students to: (1) Concepts and terminology of digital marketing; (2) Specifics of online consumer behavior and internet-based business models; (3) Hands-on experience in creating and running advertising campaigns in social media. 1.5 credits.

MKT 555 Analytics-Driven Brand Management
This course will cover decision support tools that can be effectively used by brand managers to improve the quality of their marketing decisions, such as pricing, advertising, promotions, etc. These decision-support tools typically rely on market-based estimates of demand and competitive conditions, which are often obtained by analyzing historical transactions data (which is the focus of MKT 555A: Data Analysis for Brand Management) and sometimes using consumer surveys (which is the focus of MKT 571A: Marketing Research I). The focus of this course will be on the optimization of marketing resources and budgets given such a quantitative understanding of the marketplace. While the focus will be on fast-moving packaged goods categories (coffee, laundry detergents, carbonated beverages, etc.), the course will also deal with durable goods (automobiles), entertainment products (movies), etc. Microsoft Excel will be used for analysis. 1.5 credits.

MKT 555A Data Analysis for Brand Management
Today's brand managers typically have access to large quantities of data. For example, managers of consumer packaged goods brands typically have access to supermarket scanner data that cover thousands of daily transactions in hundreds of product categories at the store. Careful analyses of such data lead to an improved understanding of the marketplace and, in turn, improve the quality of marketing decisions. This course will cover statistical models and techniques that can be effectively used by brand managers on large marketing datasets. While the focus will be on fast-moving packaged goods categories (coffee, laundry detergents, carbonated beverages, etc.), the course will also deal with durable goods (automobiles), entertainment products (movies), etc. Microsoft Excel will be used for analysis. 1.5 credits.

MKT 580 Marketing Research Analytics
This course is designed to provide you with an appreciation of the role of marketing research (MR) in the formulation and solution of marketing problems. In this course, you will be developing basic skills in conducting and evaluating marketing research design, alternative methods of data collection, and data analysis techniques. 3 credits.

Electives

DAT 537 Data Analysis, Forecasting and Risk Analysis
This course presents a modem and contemporary coverage of several econometric models that are used for the analysis and forecasting of business data. The basic building blocks for the analysis are regression time series models. Broad coverage of non-seasonal and seasonal ARIMA models is included. The important family of ARCH-GARCH models, used to represent changing volatility, are also covered in detail. These models are widely used in option pricing and in other financial applications. The course includes some extensions of these models to multivariable problems. Students are exposed to numerous real data sets in class and in assignments. All the models are analyzed with a popular econometrics software package that is employed in business. A group project is required. 3 credits.

DAT 560N Introduction to Cybersecurity
This course covers a broad range of cyber security terms, definitions, perspectives, concepts, and current trends with a focus on managing risk and the use of information and cyber security as business enablers. Students will complete a cybersecurity analytics-related project as part of the coursework. 1.5 credits.

DAT 565E Deep Learning for Business Analytics

Deep Learning has become a core skillset to solve business problems in the unstructured, data-rich business world. Experts estimate approximately that 90% of the data in organizations is unstructured datasets (including images, texts, customer reviews, videos, etc.). Organizations would like to use these datasets to improve their business. Moreover, deep learning has a significant advantage over other machine learning algorithms, in that it does not require extracting "features" manually, prior to applying algorithms. Leading-edge organizations are also expecting business analysts and managers to be familiar with applying deep learning models to solve business problems using unstructured data. This course is a 1.5-credit required course offered to MS-Business Analytics (MSA) students in all tracks. The course will teach students to build deep learning models for solving business problems using python libraries (e.g., Keras, Tensorflow, etc.). We will cover a range of algorithms from neural networks foundations, to convolutional and recurrent network structures. These will be appied in domains such as marketing, customer behavior, and predicting finance risks. In the course, students will learn deep learning practically based on the following five questions: 1. How to visualize and analyze unstructured datasets? 2. What are neural networks and how to optimize them? 3. What is the deep learning model and how to use it in business? 4. Which deep learning structure should be usesd for a given business problem? 5. How to develop a deep learning model to solve business problems? In summary, the course will expose students to prevalent business applications of deep learning in different domains (Customer Analytics, Supply Chain Analytics, Healthcare Analytics, Financial Technology Analytics, Accounting Analytics, Talent Analytics, etc.). Upon completing this course, students will know how to build and optimize deep learning models for different business applications. 1.5 credits.

MGT 566 Research in Healthcare Management

This is the capstone course for the Health Management major where students learn to apply rigorous statistical and analytical approaches to research questions in health services, but not limited to questions relating to management, finance and economics, operations, and policy. Faculty will identify several available research project options, and present these options in class. The goal is to capitalize on the strength of the university medical school and affiliated medical centers, in addition to capitalizing on existing relationships between Olin and healthcare firms to identify the student research projects. Students will also be encouraged to formulate their own research question and to identify potential data sources they could use to address these questions, if they so desire. Students will work in teams of 3-4, using the approach developed for the Practicum and Hatchery courses. 3 credits.

MGT 620 Empirical Methods in Business

3 credits.

MGT XXX Introduction to Blockchain

1.5 credits.

MKT 501P Center for Analytics & Business Insights Practicum

Students will work in teams on an analytics-driven client project, applying the tools that they learned in their Fall course work to the client's data-driven business problem under faculty and client supervision. Each student is expected to spend about 150 hours on the project. Grades are based on the quality of the final deliverables, i.e., written report and oral presentation. 3 credits.

MKT 558 Pricing Strategies

This course is designed to equip you with some essential concepts and techniques needed to make profitable decisions about one of the most important marketing variables—price. This course is structured around four fundamental factors that firms need to consider in their pricing decisions: costs, customers, competitors, and climate (legal environment). Through case studies, in-class discussions, and course project/presentations, this course will provide you with a conceptual framework, grounded in modem economics and consumer psychology, for analyzing a complex marketing environment and designing proactive pricing strategies that are most profitable for a business. 1.5 credits.

MKT 558B Pricing Decision Making & Implementation

The focus of this course is on pricing tactics and strategies that are proven to be profitable for firms. Through case studies, lectures, a pricing simulation game, and presentations, this course will help students gain insights in to successful pricing strategies in various industries and to develop skills that are necessary to make the most important business decision—pricing—in their organizations. Topics of discussion include pricing innovative products, pricing and market making on the internet, pricing of digital products, and dynamic and competitive pricing. 1.5 credits.

OB 500E Talent Analytics
Finding, developing, and retaining the best talent has always been the key to sustained success in business. Organizations today have potential access to far more useful information about people than ever before but most struggle to access and use it effectively. In a highly competitive global market, rigorously analyzing data to enable timely, strategic decisions about talent provides a critical edge. In this course you will learn how to use analytics to bring data and rigorous modelling to bear on people-related issues, such as recruiting, performance evaluation, leadership development and succession, job design, and compensation. Together, these can help organizations achieve long range strategic goals, rather than simply serving as an administrative support function. 1.5 credits.

OB 535 People Metrics
Metrics are at the core of people analytics. The purpose of this course is to introduce you to the foundations of assessing behavior in organizations using novel measurement approaches and large datasets. Through classroom discussions and real-world applications, this course will enable you to add value to organizations through the development, use, and interpretation of innovative people metrics. Specifically, after taking this course, you will be able to: Develop a clear and logical conceptual measurement model. A conceptual measurement model is the foundation of creating novel and useful new approaches for assessing intrapersonal characteristics (e.g., personality) and interpersonal behavior (e.g., knowledge sharing, teamwork). Identify novel sources of data for innovative people metrics. Organizations are awash in the traces of individual behavior and social interactions. Decoding how data that already exist in an organization can be used to understand behavior is an essential skill for adding value in the field of people analytics. Apply a rigorous process for validating new people metrics. Developing a measurement model and finding sources of data are necessary, but insufficient for adding value through people metrics. New measures must be validated. 1.5 credits.

OMM 500M Stochastic Models
This course covers the two key types of simulation models of uncertain events: Monte Carlo simulation and Discrete Event Simulation. The conceptual difference between these simulation methodologies is in their treatment of time. Discrete Event Simulation is used to model dynamic systems where events occur at specified, random, time. In Monte Carlo simulation the timing of events is typically inconsequential. Upon successful completion of this course, students will demonstrate competency in formulating and analyzing stochastic models using state-of-the-art simulation software. They will become proficient with software tools like **Arena** for Discrete Event Simulation and **Crystal Ball** for Monte Carlo simulation. The course emphasizes proficiency in using software tools to analyze models rather than theory. 1.5 credits.

OMM 519E Introduction to Revenue Management
Quantitative pricing and revenue analytics collectively refers to the set of practices and tools that firms in various industries use to quantitatively model consumer preferences, segment their market, and tactically optimize (often in micro targeted or personalized manner) their product assortment, pricing, and promotion strategies. The origins of this field, often referred to as revenue management as it is also called, are in the airline industry during the late 80s. The prototypical question is how a firm should set and update pricing and product availability decisions across its various selling channels in order to maximize its profitability. In the airline industry, as most of us know, tickets for the same flight may be sold at many different fares, the availability of which is changing as a function of purchase restrictions, the forecasted future demand, and the number of unsold seats. The adoption of such systems has transformed the transportation and hospitality industries, and is increasingly important in retail, telecommunications, entertainment, financial services, health care, manufacturing, as well as on-line advertising, online retailing, and online markets. In parallel, pricing and revenue optimization has become a rapidly expanding practice in consulting services, and a growing area of software and IT development. The ultimate goal is for students to learn to identify and exploit opportunities for revenue optimization in different business contexts. The topics covered in the course are either directly or indirectly related to customer segmentation, demand modeling, and tactical price optimization. Students can take either OMM 519E or 520, but not both. Prerequisites: DAT 561 (formerly OMM 561) and DAT 500N (formerly OMM 500N). 1.5 credits.

CSE 222S Internet of Things
For a very long time, the Things in our world have lived relatively lonely and single-purposed lives. With the advent of the Internet of Things, we can address, control, and interconnect these formerly isolated devices to create new and interesting applications. In this course we study Bluetooth Low Energy, one of the fundamental networking technologies behind Internet-of-Things devices, and Appcessories, which include smart watches, health monitors, toys, and appliances. In addition to learning about the Bluetooth Low Energy protocol and network stack, students gain hands-on experience developing multi-platform solutions that control and communicate with Things using an accompanying app on a mobile device. Students apply their knowledge and skill to develop a project of their choosing using topics from the course. Prerequisite: CSE 132. 3 credits.

CSE 316A Social Network Analysis
This course looks at social networks and markets through the eyes of a computer scientist. We will look at questions including, "Why are acquaintances rather than friends more likely to get us job opportunities?" and, "Why do the rich get richer?" We begin by studying graph theory (allowing us to study the structure) and game theory (allowing us to study the interactions) of social networks and market behavior at the introductory level. Among other topics, we will study auctions, epidemics, and the structure of the Internet (including web searches). This course examines the intersection of computer science, economics, sociology, and applied mathematics. 3 credits.

CSE 417T Introduction to Machine Learning
The field of machine learning is concerned with the question of how to construct computer programs that automatically improve with experience. This course is a broad introduction to machine learning, covering the foundations of supervised learning and important supervised learning algorithms. Topics to be covered are the theory of generalization (including VC-dimension, the bias-variance tradeoff, validation, and regularization) and linear and non-linear learning models (including linear and logistic regression, decision trees, ensemble methods, neural networks, nearest-neighbor methods, and support vector machines). Prerequisites: CSE 502N, ESE 326 or Math 3200, Math 233, and Math 309 (can be taken concurrently). 3 credits.

CSE 427S Cloud Computing with Big Data Applications
This course provides a comprehensive introduction to applied parallel computing using the MapReduce programming model facilitating large scale data management and processing. There will be an emphasis on hands-on experience working with the Hadoop architecture, an open-source software framework written in Java for distributed storage and processing of very large data sets on computer clusters. Further, we will make use of related big data technologies from the Hadoop ecosystem of tools, such as Hive, Impala, and Pig in developing analytics and solving problems faced by enterprises today. Prerequisites: CSE 501N, CSE 502N, and CSE 503S. 3 credits.

CSE 501N Introduction to Computer Science
An introduction to software concepts and implementation, emphasizing problem solving through abstraction and decomposition. Introduces processes and algorithms, procedural abstraction, data abstraction, encapsulation, and object-oriented programming. Recursion, iteration, and simple data structures are covered. Concepts and skills are mastered through programming projects, many of which employ graphics to enhance conceptual understanding. Java, an object-oriented programming language, is the vehicle of exploration. Active-learning sessions are conducted in a studio setting in which students interact with each other and the professor to solve problems collaboratively. Prerequisites: Comfort with algebra and geometry at the high school level is assumed. Patience, good planning, and organization will promote success. This course assumes no prior experience with programming. 3 credits.

CSE 502N Data Structures and Algorithms
Study of fundamental algorithms, data structures, and their effective use in a variety of applications. Emphasizes importance of data structure choice and implementation for obtaining the most efficient algorithm for solving a given problem. A key component of this course is worst-case asymptotic analysis, which provides a quick and simple method for determining the scalability and effectiveness of an algorithm. Prerequisite: CSE 501N. 3 credits.

CSE 503S Rapid Prototype Development and Creative Programming
This course uses web development as a vehicle for developing skills in rapid prototyping. Students acquire the skills to build a Linux web server in Apache, to write a web site from scratch in PHP, to run an SQL database, to perform scripting in Python, to employ the AngularJS web framework, and to develop modern web applications in client-side and server-side JavaScript. The course culminates with a creative project in which students are able to synthesize the course material into a project of their own interest. The course implements an interactive studio format: after a formal presentation of a topic, students develop a related project under the supervision of the instructor. Prerequisite: CSE 501N. 3 credits.

CSE 514A Data Mining
With the vast advancement in science and technology, data acquisition in large quantities are routinely done in many fields. Examples of large data include various types of data on the internet, high-throughput sequencing data in biology and medicine, extraterrestrial data from telescopes in astronomy, and images from surveillance camera in security. Mining a large amount of data through data mining has become an effective means to extracting knowledge from data. This course introduces the basic concepts and methods for data mining and provides hands-on experience for processing, analyzing and modeling structured and unstructured data. Homework problems, examines and programming assignments will be administrated throughout the course to enhance the learning. Prerequisites: CSE 502N and ESE 326 or Math 320 (or their equivalent), or permission of the instructor. 3 credits.

CSE 515T Bayesian Methods in Machine Learning
This course will cover machine learning from a Bayesian probabilistic perspective. Bayesian probability allows us to model and reason about all types of uncertainty. The result is a powerful, consistent framework for approaching many problems that arise in machine learning, including parameter estimation, model comparison, and decision making. We will begin with a high-level introduction to Bayesian inference, then proceed to cover more-advanced topics. These will include inference techniques (exact, MAP, sampling methods, the Laplace approximation, etc.), Bayesian decision theory, Bayesian model comparison, Bayesian nonparametrics, and Bayesian optimization. Prerequisites: CSE 417T, ESE 326. 3 credits.

CSE 517A Machine Learning
This course assumes a basic understanding of machine learning and covers advanced topics at the frontier of the field in-depth. Topics to be covered include kernel methods (support vector machines, Gaussian processes), neural networks (deep learning), and unsupervised learning. Depending on developments in the field, the course will also cover some advanced topics, which may include learning from structured data, active learning, and practical machine learning (feature selection, dimensionality reduction). Prerequisites: CSE 502N, CSE 417T, ESE 326, Math 233, and Math 309. 3 credits.

CSE 530S Database Management Systems
A study of data models and the database management systems that support these data models. The design theory for databases is developed and various tools are utilized to apply the theory. General query languages are studied and techniques for query optimization are investigated. Integrity and security requirements are studied in the context of concurrent operations on a database, where the database may be distributed over one or more locations. The unique requirements for engineering design databases, image databases, and long transaction systems are analyzed. Prerequisite: CSE 502N. 3 credits.

CSE 557A Advanced Visualization
We are in an era where it is possible to have all of the world's information at our fingertips. However, the more information we can access, the more difficult it is to obtain a holistic view of the data or to determine what's important to make decisions. Computer-based visualization systems provide the opportunity to represent large or complex data visually to aid comprehension and cognition. In this course, we learn about the state-of-the-art in visualization research and gain hands-on experience with the research pipeline. We also learn how to critique existing work and how to formulate and explore sound research questions. We will cover advanced Visualization topics including User Modeling, Adaptation, Personalization, Perception, and Visual Analytics for Non-Experts. 3 credits.

INFO 5500 Enterprise Resource Planning
This course introduces participants to integrated business processes through the application of SAP modules supporting Sales and Distribution (SD), Materials Management (MM), Financial Accounting (FI), Production Planning (PP), and Controlling (CO) as components of the SAP integrated business solution. During the course, each student will complete exercises to construct a functioning company operating in an integrated SAP environment. The exercises provide a guide through the concepts and creation of applications supporting the business functions of the company. 3 credits.

INFO 558 Applications of Deep Neural Networks
Deep learning is a group of exciting new technologies for neural networks. Through a combination of advanced training techniques and neural network architectural components, it is now possible to create neural networks of much greater complexity. Deep learning allows a neural network to learn hierarchies of information in a way that is like the function of the human brain. This course will introduce the student to computer vision with Convolution Neural Networks (CNN), time series analysis with Long Short-Term Memory (LSTM), classic neural network structures and application to computer security. High Performance Computing (HPC) aspects will demonstrate how deep learning can be leveraged both on graphical processing units (GPUs), as well as grids. Focus is primarily upon the application of deep learning to problems, with some introduction mathematical foundations. Students will use the Python programming language to implement deep learning using Google TensorFlow and Keras. It is not necessary to know Python prior to this course; however, familiarity of at least one programming language is assumed. This course will be delivered in a hybrid format that includes both classroom and online instruction. 3 credits.

MATH 420 Experimental Design
A first course in the design and analysis of experiments, from the point of view of regression. Factorial, randomized block, split-plot, Latin square, and similar design. 3 credits.

MATH 475 Statistical Computation
Applied statistics using SAS. An introduction to SAS and SAS programming; contingency tables and Mantel-Haenszel tests; general linear models and matrix operations; simple, multilinear, and stepwise regressions; ANOVAs with nested and crossed interactions; ANOVAs and regressions with vector-valued data (MANOVAs). Topics chosen from discriminant analysis, principal components analysis, logistic regression, survival analysis, and generalized linear models. Prior acquaintance with SAS at the level introduced in Math 3200 is assumed. 3 credits.

MSB 550 Introduction to Bioinformatics
This course is designed to provide broad exposure to the basic concepts, methodology and application of bioinformatics to solve biological problems. Specifically, students will learn the basics of online genomic databases and database mining tools, and acquire understanding of mathematical algorithms in genome sequence analysis (alignment analysis, gene finding/predicting), gene expression microarray (genechip) analysis, and of the impact of recent developments such as protein microarrays or whole-genome DNA chips for genome-wide association studies. Students will also take computer labs and learn basics of bioinformatics tools and databases (BLAST/WUBLAST, Prospector, etc.), practice basics of R/Bioconductor programming, and apply specialized R packages to solve bioinformatics problems pertinent to real medical research of human diseases. Auditors will not have access to the computer lab sessions. 3 credits.