Washington University in St. Louis
OLIN BUSINESS SCHOOL

Master of Science in Business Analytics (MSA)
Supply Chain Analytics Track 2020–2021 Academic Year

39 credits as follows:
18 common core credits
18 track required credits – as indicated by **
3 elective credits

April 2020 (subject to change)

MSA – Supply Chain 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.

DAT 500V Basics of R Programming (0.5)
OMM 510 Operations Management Foundations (2)

Fall Semester (12 core + 1.5 track required = 13.5 credits)

Fall A	Fall B
Required: DAT 560G Database Design & SQL (1.5) Track Required: OMM 576 Foundations of Supply Chain Management (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)

Spring Semester (6 core + 6 track required = 12 credits + electives)

Spring A	Spring B
Track Required: OMM 500M Stochastic Models (1.5)** OMM 531 Supply Chain Finance (1.5)**	Required: DAT 560E Data Visualization for Business Insights (1.5) DAT 562 Text Mining (1.5)

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

Track Required:
OMM 554 Operations Analytics (3)**
Required experiential course: MGT 551 Summer CPT course (1.5) or OMM 501P Boeing Center Supply Chain Practicum (1.5) (spring or fall)

Electives (choose 3 or more credits from the following or other analytics courses proposed by the other tracks):

OMM 500E Supply Chain Risk Management (1.5) OMM 573 Operations Management in the Service Industry (1.5)	DAT 560N Introduction to Cybersecurity (1.5)

OMM 500D Project Management (3)
L24 MATH 420 Experimental Design (3)
T81 INFO 558 Applications of Deep Neural Networks (3)
E81 CSE 417A Introduction to Machine Learning (3) (or E81 CSE 517A Machine Learning (3))
E81 CSE 501N Introduction to Computer Science (3)
E81 CSE 502N Data Structures and Algorithms (3)
E81 CSE 503S Rapid Prototype Development and Creative Programming (3)
E81 CSE 514A Data Mining (3)

Second Fall Semester (9 track required + electives)

Track Required:

OMM 520 Revenue Management (3)**
OMM 530 Supply Chain Analytics Capstone (3)**
OMM 558 Advanced Operations Strategy (3)**
Required experiential course: MGT 551 Summer CPT course (1.5) or OMM 501P Boeing Center Supply Chain Practicum (1.5) (spring or fall)

Electives (choose 3 or more credits from the following or other analytics courses proposed by the other tracks):

Fall A	Fall B
	OMM 577 IT and Supply Chain Management (1.5) DAT 565E Deep Learning for Business Analytics (1.5)

DAT 537 Data Analysis, Forecasting and Risk Analysis (3)
OMM 500D Project Management (3)
OMM 577 Information Technology and Supply Chain Management (1.5)
L24 MATH 475 Statistical Computation (3)
M21 MSB 550 Introduction to Bioinformatics (3)
T81 INFO 558 Applications of Deep Neural Networks (3)
E81 CSE 222S Internet of Things (3)
E81 CSE 417A Introduction to Machine Learning (3)
E81 CSE 427 Cloud Computing with Big Data Applications (3)
E81 CSE 501N Introduction to Computer Science (3)
E81 CSE 502N Data Structures and Algorithms (3)
E81 CSE 503S Rapid Prototype Development and Creative Programming (3)
E81 CSE 514A Data Mining (3)
E81 CSE 515T Bayesian Methods in Machine Learning (3)
E81 CSE 530S Database Management Systems (3)
3 credits of experiential coursework: OMM 501P Boeing Center Supply Chain Practicum (1.5) ***strongly recommended***

Total: 39 credits (18 common core credits, 18 track required credits, 3 elective credits)

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 – Supply Chain Analytics Course Descriptions

Summer Foundations Workshops

DAT 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 MSCA 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.

OMM 510 Operations Management Foundations
This required course discusses the main principles and concepts in managing operations for competitive success. Among the topics covered are: Operations strategy, capacity analysis and organization, queuing theory, service management, quality management, inventory management, and a brief introduction to supply chain management. Students learn the basics of how to manage the operations of a firm, with the main goal of this course being to prepare students for advanced coursework in operations and supply chain management, beginning in the Fall A term. Most sessions consist of in-depth case discussion, integrated with theory. Letter-graded. 2 credits.

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 and 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.

Required Track Courses

OMM 576 Foundations of Supply Chain Management
Examines how companies manage effectively the entire set of activities involved in the production and delivery of goods and services to their customers. Supply chain management (SCM) deals with the management of materials, information, and financial flows in networks consisting of suppliers, manufacturers, distributors, and customers. Recent trends in communication technology, sophisticated information systems, globalization of operations and markets, increased demand for mass customization, and increasing customer expectations have made the coordination and integration of these flows within and across companies critical to the success of businesses. This course focuses primarily on the foundations of SCM, touching topics such as: 1) matching supply with uncertain demand, 2) inventory management, 3) logistics, 4) design for variety, 5) global issues in SCM, 6) Quick/Accurate Response,7) collaborative processes. 1.5 credits.

OMM 531 Supply Chain Finance

This course focuses on understanding ways to better integrate operational and financial decisions within a supply chain. Our studied firms and world-class practices better integrate physical and financial flows by endogenizing not only the operational choices of the firm and its agents but also their financial decisions. Students will better understand how to make informed decisions using all relevant analytics tools at the interface of operations, finance and risk management. There are three main topics the course will explore: Supply Chain Financing: Understand how capital constraints of firms in a supply chain affect their operational choices, and what are better ways to finance working capital needs of a firm in a supply chain, when fully accounting for the operational and risk management implications of such solutions. The financing solutions that will be explored are divided into "supplier led" (e.g., trade credit) and "buyer led" (e.g., reverse factoring). Supply Chain Contracting in the presence of Financial Frictions: Study the effect of financial frictions (e.g. limited working capital, transaction costs, taxes, bankruptcy costs) on contracts and the implementation of operational strategies. The contracting issues to be explored within a supply chain finance setting are incentive coordination among firms in the chain, information asymmetries, and moral hazard issues. Integrated Operational and Financial Risk Hedging: Understand how operational and financial risks in global supply chains interact (e.g, exchange rates, commodity procurement risks, etc.), and what combination of operational and financial tools can be used to effectively manage those risks. PREREQ: OMM 510; OMM 5704. 1.5 credits.

OMM 500M Supply Chain Analytics: 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 554 Operations Analytics

Examines approaches to problems of operations planning and control in various organizational settings. Topics include demand forecasting (data analysis, forecasting techniques, and control of forecasting systems), end-item inventory control (lot sizing, safety stock, and evaluation of systems), and materials requirements planning (master scheduling, shop scheduling, aggregate capacity planning, and systems implementation). 3 credits.

OMM 520 Revenue Management

This course examines the core concepts of revenue management: how to accurately align product pricing, placement, and availability with a retailer?s perception of consumer demand. Students will be introduced to linear and dynamic programming as a means to model a variety of capacity allocation and pricing problems that are relevant to airline, hotel, or restaurant industries. Specifically, most problems will be framed within the context of the single resource and network level revenue management problems. For the single resource problem, we will derive efficient exact solution methods and also consider a variety of extensions to the original model which incorporate overbooking and no-show behavior. For the network problem, we will learn how to extract near-optimal, and easily implementable policies from deterministic approximations. While the main goal of this course is to provide insight into industry specific problems, another central objective is to introduce students to concepts such as robust optimization and approximate dynamic programming to expand their breadth of modeling tools. Moreover, students will learn how to use Python to solve complex and industry-level optimization problems with data. At the successful completion of this course, students should feel confident modeling and analyzing a broad series of stochastic optimization problems. Students should also feel comfortable with using Python to make revenue management decisions with data. Beyond studying and analyzing classical RMP problems the students will gain valuable computational skills. Students will be asked to code up dynamic programming formulations, solve large scale linear programs with Python (coupled with Gurobi) and use machine learning techniques for demand estimation and forecasting. 3 credits.

OMM 558 Advanced Operation Strategy

This course deals with operations issues having a long-term impact on the corporate strategy, and on the competitive viability of a firm. We develop a general framework for creating and analyzing strategies for managing domestic and international manufacturing and service operations. The strategic decision categories to be examined include product-process technology strategies, facilities, and capacity management, performance measurement, managing quality and productivity, and system design. The course covers productivity measurement, process choice, product profiling, interfaces with marketing, experience costs, process positioning, accounting and financial perspectives, and international operations. It gives equal attention to service operations and manufacturing operations. Emphasis is on the application of systems thinking to case studies and the design of world class operations. It is valuable for students with an operations or general management focus, as well as for finance and marketing students. 3 credits.

OMM 530 Supply Chain Analytics Capstone
This capstone course offers opportunities for students to apply various analytics techniques learned from different courses to large-scale real-world datasets and problems. Students will work on several projects, each involving (1) exploring dataset to identify problems, (2) defining project scopes, (3) conducting data analysis (prediction models, forecasting), (4) setting up decision making models (real-time, large-scale optimization models, simulation models), (5) prescribing decision recommendations. By applying relevant analytic tools and going through a complete problem solving process, students will gain confidence in applying theories and techniques to solve real-world problems. 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.

OMM 500D Project Management
Change management has become synonymous with project management, since organizations that want to change their focus or direction increasingly recognize that introducing new products, processes, or programs in a timely and cost effective manner requires professional project management. This course analyzes complex projects and discusses available tools for managing them. Some of the topics covered include life cycle models, project selection, project monitoring and control, planning with uncertainty, project risk management, the critical chain method, and managing multiple projects. It also discusses commercial project management software and how to overcome its limited functionality to address the requirements of managing risky complex projects in practice. Students learn project management skills that will be useful throughout their careers. As such, this course is essential for current or future managers regardless of their career concentration. 3 credits.

OMM 500E Supply Chain Risk Management
Many events in the last few years made supply chain managers keenly aware of the multiplicity and diversity of risks affecting them, from fluctuating commodity prices, unstable currencies, hurricanes and earthquakes, fires, terrorist attacks, contaminated material sourced from developing countries, and suppliers going bankrupt in tight financial credit environments. Building a functional supply chain requires careful planning and consideration of a variety of disruption risks, and it is of paramount importance to integrate management of physical flows and financial hedges when dealing with such risks. Companies that effectively manage their supply chain risks enjoy a level of robustness (flexibility) and resilience disruption-"proof-ness") that affords them significant competitive advantage. This course will develop a comprehensive risk management framework for complex supply chains and introduce students to all needed decision tools for supply management and risk hedging. In addition, it will outline a portfolio of proven strategies to assess, reduce, hedge, and mitigate supply chain risks. 1.5 credits.

OMM 501P Boeing Center Supply Chain Practicum
Students work in small teams on an operations and/or supply chain related consulting project for a client organization, applying insights from their course work to real-world business problems under supervision of both a faculty advisor and a client project lead. Each student is expected to spend about 150 hours on the project. Grades are based on the quality of the project work and the final deliverables (e.g., written and oral reports), as determined by the faculty advisor and client project lead. 1.5 credits.

OMM 573 Operations Management in the Service Industry
The service industry is of vital importance to today's economy. Through a greater understanding of the design and operation of services, productivity improvements can be achieved which result in real growth. In this course we will analyze both the strategic issues in service management as well as the particular aspects of running firms. We will discuss important issues in the operations of major service providers such as hotels and restaurants, airlines, retailers, financial services, and health care providers. We cover such topics as: service design, capacity and demand management, quality in services, variability and bottlenecks, and revenue management. The course will approach services from an operations management viewpoint, though related aspects of strategy, marketing, technology management and organizations will be discussed. Much of the discussion will focus on case studies and articles. Students will be required to write-up several cases, complete other written assignments, and may be required to take part in a term project. 1.5 credits.

OMM 577 IT & Supply Chain Management
Recent developments and breakthroughs in information technology have radically changed the business world, offering opportunities not only for new products and services also for reengineering supply chains and improving supply chain performance. The course will study how the innovations in information technology affect the ways information flows through the supply chain, which in turns provide opportunities to better coordinate the material and financial flows. The course will review business cases in which companies use supply chain management concepts and emerging technologies to improve business processes as well as creating values. 1.5 credits.

L24 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. Prerequisite: CSE 131 or 200, Math 3200, or permission of instructor. 3 credits.

L24 MATH 475 Statistical Computation
Introduction to modern computational statistics. Pseudo-random number generators; inverse transform and rejection sampling. Monte Carlo approximation. Nonparametric bootstrap procedures for bias and variance estimation; bootstrap confidence intervals. Markov chain Monte Carlo methods; Gibbs and Metropolis-Hastings sampling; tuning and convergence diagnostics. Cross-validation. Time permitting, optional topics include numerical analysis in R, density estimation, permutation tests, subsampling, and graphical models. Prior knowledge of R at the level used in Math 494 is required. Prereqs: Math 233, 309, 493, 494 (not concurrently); acquaintance with fundamentals of programming in R. 3 credits.

M21 MSB 550 Introduction to Bioinformatics
Provide a broad exposure to the basic concepts, methodology and application of bioinformatics to solve biological problems. Specifically, the students will learn the basics of online genomic/protein 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 in the protein microarray technology. Prerequisite: R Primer. 3 credits.

T81 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.

E81 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.

E81 CSE 417A 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, Math 233, and Math 309 (can be taken concurrently). 3 credits.

E81 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.

E81 CSE 501N Programming Concepts and Practice

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.

E81 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.

E81 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.

E81 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). 3 credits.

E81 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.

E81 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.

E81 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.