COMPUTER SCIENCE AND SOFTWARE ENGINEERING

Chair: Ling Zheng, Department of Computer Science and Software Engineering

UNIX Administrator and Teacher: Joseph Chung

Master of Science in Computer Science (M.S.C.S.)

The Master of Science in Computer Science provides a broad background in graduate-level computer science study. The thirty- to forty two-credit program allows the student to choose a thesis option or a non-thesis option. Students may also choose to specialize in Computer Networks, Databases and Intelligent Information Systems, or Security of Computer Systems and Networks. When the applicant has a strong background in computer science, such as a bachelor's degree in computer science with excellent standing, up to twelve credits (CS-501B Program Development (3 cr.)-CS-505 Operating Systems Concepts (3 cr.)) may be waived. Other majors may be required to take some or all of these courses. These foundation courses must be completed with a minimum GPA of 3.0, and all prerequisite courses must be passed with a grade of "B-" or better.

Master of Science in Data Science (M.S.D.S.)

The Master of Science in Data Science provides a nice complement to our current advanced degree programs, and offers an attractive option for students with or without a strong background in computer science to gain the skills to enter this highly attractive job market for data scientists/data analysts. The emphasis of this program is on projects that will provide students with experience in working with real-world data from a variety of different disciplines. Students will engage in three or four semester-long projects, working with external partners to address questions that can be answered with a variety of data science techniques. Students graduated from this program will be well positioned to compete in the marketplace for positions in a range of fields by having broad experience with many data analysis techniques and experience with data visualization and communication in both written and oral forms.

Master of Science in Information Systems (M.S.I.S.)

The M.S.I.S. is a unique degree program that educates students about how to apply computing technology to business programs. With courses offered through the School of Science and the Leon Hess Business School, the M.S.I.S. prepares students for employment in the Information Technology (IT) sector at a management level. The program benefits are:

- Focus on the technology or management side of information systems by choosing one of two distinct tracks;
- Become an effective team member, including teams that are international and geographically distributed;
- Excel at project management and management and improve business decision-making;
- Learn how to reconcile conflicting project objectives;
- Be eligible to apply for positions such as business systems analyst, software project manager, software requirements developer, information technology operations manager, and customer support specialist.

The M.S.I.S. also allows students to gain **full and thorough** training in information systems, which can be used as a basis for pursuing certifications such as the Certified Information Systems Security Professional (CISSP), Project Management Professional (PMP), and the Certified Software Development Professional (CSDP).

Master of Science in Software Engineering (M.S.S.E.)

Monmouth University was one of the first institutions in the United States to recognize the newly emerging discipline of Software Engineering by establishing a separate department to specialize in this strategic engineering discipline. The Department of Computer Science and Software Engineering offers a Master of Science Degree in Software Engineering.

The objective of the master's degree program is for the student to master the necessary skills and knowledge that allow him or her to be an effective member of a software development team. The program's educational objectives are to prepare students so that upon graduation they will:

1. Show mastery of the software engineering knowledge and skills and professional issues necessary to practice as a software engineer in a variety of application domains with demonstrated performance in at least one application domain;
2. Understand the relationship between software engineering and systems engineering and be able to apply systems engineering principles and practices in the engineering of software;
3. Show mastery of software engineering in at least one specialty, such as networked software systems, information systems, real-time systems, or software systems security.
4. Work effectively as part of a team, including teams that may be international and geographically distributed, to develop quality software artifacts, and to lead in one area of project development, such as project management, requirements analysis, architecture, construction, or quality assurance;
5. Reconcile conflicting project objectives, finding acceptable compromises within limitations of cost, time, knowledge, existing systems, and organizations;
6. Design appropriate software engineering solutions that address ethical, social, legal, and economic concerns;
7. Understand and appreciate the importance of feasibility analysis, negotiation, effective work habits, leadership, and good communication with stakeholders in a typical software development environment;
8. Learn new models, techniques, and technologies as they emerge, and appreciate the necessity of such continuing professional development;
9. Analyze a current significant software technology, be able to articulate its strengths and weaknesses, and be able to specify and promote improvements or extensions to that knowledge.

Classes are scheduled to support working professionals and many of our students are from New Jersey's premier software industries. The department offers the entire program at the main campus of Monmouth University. The Master of Science in Software Engineering degree is a thirty-credit curriculum, with four core courses, four advanced elective

courses, and a six-credit thesis or practicum. The core courses provide the student with the foundations of modern software engineering. When the applicant has a background other than computer science or software engineering, up to twelve credits of foundation courses may be required before registering for the core courses. These foundation courses must be passed with a grade of "B-" or better. Students can opt for writing a thesis or participating in a group practicum for two semesters as their capstone experience before graduation.

For students who have already completed a bachelor's degree in software engineering, the department offers an advanced track, which gives students the opportunity to earn a master's degree after completion of a thirty-credit curriculum. In addition, students may choose between two paths within this track, the thesis or non-thesis option. If students choose the thesis option, they will complete the core courses, research and write a thesis over two semesters, and choose and complete two pairs of advanced elective courses. Students who choose the non-thesis option will complete the core courses and choose and complete three pairs of advanced elective courses. Finally, all students will take one advanced elective course from the list of non-paired courses.

Programs
Masters

- M.S. in Computer Science, Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/computer-science-ms-thesis-track/)
- M.S. in Computer Science, Non-Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/computer-science-ms-non-thesis-track/)
- M.S. in Computer Science, Computer Networks, Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/computer-science-ms-computer-networks-thesis-track/)
- M.S. in Computer Science, Computer Networks, Non-Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/computer-science-ms-computer-networks-non-thesis-track/)
- M.S. in Computer Science, Databases and Intelligent Information Systems, Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/computer-science-ms-databases-intelligent-information-systems-thesis-track/)
- M.S. in Computer Science, Databases and Intelligent Information Systems, Non-Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/computer-science-ms-databases-intelligent-information-systems-non-thesis-track/)
- M.S. in Computer Science, Cybersecurity, Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/computer-science-ms-security-computer-systems-networks-thesis-track/)
- M.S. in Computer Science, Cybersecurity, Non-Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/computer-science-ms-security-computer-systems-networks-non-thesis-track/)
- M.S. in Data Science (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/ms-data-science/)
- M.S. in Information Systems, Management Track, Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/information-systems-msis-management-track-thesis-track/)
- M.S. in Information Systems, Management Track, Non-Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/information-systems-msis-management-track-non-thesis-track/)
- M.S. in Information Systems, Technology Track, Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/information-systems-msis-technology-track-thesis-track/)
- M.S. in Information Systems, Technology Track, Non-Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/information-systems-msis-technology-track-non-thesis-track/)
- M.S. in Software Engineering, Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/software-engineering-ms-thesis-track/)
- M.S. in Software Engineering, Non-Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/software-engineering-ms-non-thesis-track/)
- M.S. in Software Engineering, Advanced Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/software-engineering-ms-advanced-thesis-track/)
- M.S. in Software Engineering, Advanced Non-Thesis Track (https://catalog.monmouth.edu/graduate-catalog/science/computer-science-software-engineering/software-engineering-ms-advanced-non-thesis-track/)

Faculty

Rolf Kamp, Specialist Professor (Graduate Faculty). B.S., B.A., Stockton University; M.B.A., Monmouth University; M.S., New Jersey Institute of Technology. Interests include computer science education, networking technologies, and ethics and professionalism for scientists and engineers. rkamp@monmouth.edu

Raman Lakshmanan, Specialist Professor (Graduate Faculty). B.S., University of Madras; Ph.D., Oakland University. Interests include web technologies and applications, Cloud computing architectures, SQL and noSQL databases, machine learning, and enterprise iOS apps. rlakshma@monmouth.edu

Jiacun Wang, Professor and Graduate Program Director (Graduate Faculty). B.S., Jiangsu University of Science and Technology; Ph.D., Nanjing University of Science and Technology, China. Interests include software architecture, Petri nets, real-time systems, discrete event systems, telecommunications, and networking. jwang@monmouth.edu

Cui Yu, Associate Professor (Graduate Faculty). B.S., Nanjing University of Aeronautics and Astronautics; Ph.D., University of Singapore, Singapore. Interests include database management systems, spatial databases, and information storage and retrieval. cyu@monmouth.edu

Ling Zheng, Associate Professor and Chair (Graduate Faculty). B.S., Southern Medical University, Guangzhou, China; M.S., Zhejiang University, Hangzhou, China; Ph.D., New Jersey Institute of Technology. Healthcare information systems, translational

bioinformatics, biomedical ontologies/terminologies, and biomedical knowledge representation and discovery. lzheng@monmouth.edu

Courses

CS-501A   Computer Programming Essentials   **Credits: 3**
Term Offered: All Terms
Course Type(s): TPS
An introduction in computer programming for newly admitted graduate students. Students will learn basic concepts in modern computer programming. Students will complete all the programming exercises and assignments in the modern objected-oriented language.

CS-501B   Program Development   **Credits: 3**
Prerequisite(s): CS-501A passed with a grade of B- or higher
Term Offered: All Terms
Course Type(s): None
Continuation at the coverage of the same modern object-oriented language introduced in CS-501A. More advanced object-oriented design, including inheritance and polymorphism.

CS-502   Theoretical Foundations of Computer Science   **Credits: 3**
Term Offered: All Terms
Course Type(s): None
Concepts, methods, models, and associated computer exercises for important topics in discrete mathematics and probability. Includes: logic and mathematical reasoning, functions, sets, summations, asymptotic notation, algorithms and complexity, number theory, cryptography, matrix algebra, induction and recursion, counting techniques, combinatorial objects, discrete structures, discrete probability theory, relations, graph theory, moments, random variables, and graph algorithms. Limited to Computer Science majors.

CS-503   Data Structures and Algorithms   **Credits: 3**
Prerequisite(s): CS-501B passed with a grade of B- or higher
Term Offered: All Terms
Course Type(s): None
Design and implementation of fundamental data structures and algorithms, including: linked lists, hashing, sorting, trees, stacks, queues, sets and bags, and recursion. Application to problem solving and object-oriented design of moderate-sized programs.

CS-505   Operating Systems Concepts   **Credits: 3**
Prerequisite(s): CS-503 passed with a grade of B- or higher
Term Offered: All Terms
Course Type(s): None
The basic concepts of operating systems from the point of view of an advanced user: the interaction of the kernel, the command interpreter, and user processes. Focus is on process and resource management, concurrency control, and inter-process communication. Examples and projects are based mainly on Unix. The course also includes an introduction to computer architecture from an operating-systems perspective (processors, devices, interrupts, clocks, etc.).

CS-509   Advanced Object-Oriented Programming and Design   **Credits: 3**
Prerequisite(s): CS-501B passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): None
Object-oriented programming and design, using a language different from that used in CS 501B. Used in classes, inheritance, polymorphism, and libraries.

CS-512   Algorithm Design   **Credits: 3**
Prerequisite(s): CS-502 and CS-503 both passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): CISEL
Design and analysis of algorithms; dependence of algorithm efficiency on data structure choice; correctness of algorithm implementation and basic design techniques and their applications to programming with fundamental data structures.

CS-514   Networks   **Credits: 3**
Prerequisite(s): CS-501A
Term Offered: All Terms
Course Type(s): CISEL
An introductory-level course on the hierarchy of networking software and hardware. Particular emphasis on Medium Access Control, Network layer, Transport layer, and Session layer. Several MAC-layer protocols, TCP/IP. Also listed as MIS-514. Prerequisite: CS-501A

CS-517   Database Design and Management   **Credits: 3**
Prerequisite(s): CS-503 passed with a grade of B or higher
Term Offered: All Terms
Course Type(s): CISEL
Introduction to database systems, data modeling, design theory and methodologies, query languages and query processing. Coverage of relational database model and design, normalization process, SQL, hands-on database design and application development. Also listed as MIS-517.

CS-518   Fundamentals of Computer Security and Cryptography   **Credits: 3**
Prerequisite(s): CS-514 or MIS-514 passed with a grade of B- or higher
Term Offered: Fall Term
Course Type(s): CISEL
An introduction to computer security and its related issues, including cryptography. It covers threats assessment, security policies, basic cryptography, security mechanisms, and assurance. Also includes several case studies on enhancing the security level of specific systems by integrating different security mechanisms and techniques. Both theoretical and practical issues are addressed in the course. Students who successfully complete this course will be capable of assessing the threats, enhancing the security, and evaluating the assurance level of specific computer systems.

CS-520   Introduction to Intelligent Systems   **Credits: 3**
Prerequisite(s): CS-502 and CS-503 both passed with a grade of B- or higher
Term Offered: All Terms
Course Type(s): CISEL
Introduction to methods and algorithms used to incorporate intelligence into computer programs. Topics include search techniques, representation and reasoning, and machine learning. Applications of these methods are stressed. Also covers implementation of some of the fundamental algorithms.

CS-521   Artificial Intelligence   **Credits: 3**
Prerequisite(s): CS-503 and CS-520 both passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): None
Basic and advanced methods in symbolic and quantitative artificial intelligence through Lisp programming techniques. Current issues concerning rule-based vs. statistical methods via applications.

CS-522   Knowledge Fusion   **Credits: 3**
Prerequisite(s): CS-517 or CS-520 passed with a grade of B- or higher.
Course Type(s): CISEL
Coverage of the fundamental techniques for integrating information from heterogeneous sources to obtain actionable knowledge. The sources of information include databases, files, and Web pages. Covered techniques include both those based upon logic and also approaches based on probabilistic reasoning.

CS-525   Simulation   **Credits: 3**
Prerequisite(s): CS-502, CS-503, and CS-514 all passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): None
Formal models of discrete event systems, computer simulation of models, and analysis of simulation results. Discrete event simulation is applied to studying the performance of computer and communication systems. Object-oriented design and programming in C++.

CS-529   Web Services and .NET   **Credits: 3**
Prerequisite(s): CS-503 passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): CISEL
Introduction to Web services. Theoretical and practical coverage of client-server architecture, communication protocols, and messaging, including XML and SOAP transactions. .NET Framework architecture is used for the applications. We contrast with other platforms, e.g., Java-based Web services. Students implement Web services and simple clients on PCs or mobile devices.

CS-532   Compiler Design   **Credits: 3**
Prerequisite(s): CS-512 passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): CISEL
The major techniques used in compiler writing, lexical analysis, syntax analysis, storage management, error detection and recovery, and code generation. Tools for compiler writing (LEX, YACC, etc.).

CS-533   Database System Implementation   **Credits: 3**
Prerequisite(s): CS-502 and CS-503 both passed with a grade of B- or higher
Term Offered: Fall Term
Course Type(s): CISEL
DBMS architecture, data storage and indexing, query processing and optimization, transaction management and recovery, and some issues related to advanced database applications.

CS-535   Telecommunications   **Credits: 3**
Prerequisite(s): CS-502, CS-505, and CS-514 all passed with a grade of B- or higher
Term Offered: Fall Term
Course Type(s): None
In-depth coverage of the lower layers of the network hierarchy: Physical layer, Data Link layer, Network layer, and Transport layer.

CS-536   File Management and Query Strategies   **Credits: 3**
Prerequisite(s): CS-503 passed with a grade of B or higher
Term Offered: Summer Term
Course Type(s): None
Addresses data storage and organization, file management principles, and query processing and applications. Students will gain hands-on experience in file processing and application development.

CS-550   Computer System Architecture   **Credits: 3**
Prerequisite(s): CS-502 and CS-503 both passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): None
Computer system interconnection structures, central processing unit, control unit, microprogrammed control, memory organization, cache and virtual memory, computer arithmetic, RISC processors, introduction to parallel processing, and case studies.

CS-588   Computer Science Practice and Experiences   **Credits: 1**
Prerequisite(s): 18 credits in Computer Science or Software Engineering
Term Offered: All Terms
Course Type(s): None
Provides opportunity for Computer Science graduate students to obtain related experience in employment at a local company or institution with Monmouth University sponsorship. Available to Computer Science graduate students who have completed at least eighteen credit hours of graduate courses (500 level), with a minimum GPA of 3.00. Does not satisfy elective requirements. Students may take the course a maximum of two times. This is a pass/fail course. Departmental approval is required to take this course.

CS-598   Special Topics in Computer Science   **Credits: 3**
Term Offered: All Terms
Course Type(s): CISEL
Subject matter varies with the interest of the students and of the professor teaching the course. The exact nature of the topic covered in any given semester is indicated in the student's transcript.

CS-599   Independent Study in Computer Science   **Credits: 3**
Term Offered: All Terms
Course Type(s): None
Independent study in a topic not substantially treated in a regular graduate course, for students with superior ability; weekly consultation. Prior permission of directing professor and the graduate program director is required to take this course. This course can only be taken once for credit. Completion of all foundation and core courses and a minimum G.P.A. of 3.50 is required to take this course.

CS-611   Secure Web Services Design   **Credits: 3**
Prerequisite(s): CS-501B passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): CISEL
Web applications present a complex set of security issues for architects, designers, and developers. The most secure and hack-resilient Web applications are those that have been built from the ground up with security in mind. This course focuses on principles of secure Web applications design. Topics include threats and counter measures, security in Web service frameworks, session control, access control, and data protection. Also listed as SE-611.

CS-612   Ethical Hacking   **Credits: 3**
Prerequisite(s): CS-518
Course Type(s): CISEL
Introduce penetration testing methodologies and ethical hacking tools. Discuss the importance of protecting corporate and government data from cyber-attacks. Learn advanced computer security resources that address new vulnerabilities and innovative methods to protect networks.

CS-613   Digital Forensics   **Credits: 3**
Prerequisite(s): CS-518
Term Offered: Spring Term
Course Type(s): CISEL
Introduce digital forensic fundamentals. Focus on discovering, authenticating, and analyzing digital evidence.

CS-618   Data Mining   **Credits: 3**
Prerequisite(s): CS--517 and CS-520 both passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): CISEL
An introduction to the fundamental concepts, algorithms, and techniques of data mining. Topics include: data preprocessing, classification algorithms and techniques, anomaly detection, and the design of data warehousing and OLAP systems.

CS-620   Applied Machine Learning   **Credits: 3**
Prerequisite(s): CS-503
Term Offered: All Terms
Course Type(s): CISEL
This course introduces basic and advanced machine learning techniques via various applications in finance, healthcare, image recognition and other fields. Topics include classification and regression supervised learning algorithms, unsupervised learning algorithms, and algorithm performance evaluation and validation.

CS-625   Internet Crawler   **Credits: 3**
Prerequisite(s): CS-529 passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): CISEL
In-depth coverage of the crawler component of modern search engines. Examination of the architecture of crawlers; algorithms for visitation, retrieval and processing of Web pages, and link analysis (e.g., PageRank computation). Coverage of ethical and legal issues of customized Web robots. Students build automatic Internet crawlers.

CS-628   Security of E-Systems and Networks   **Credits: 3**
Prerequisite(s): CS-518 passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): CISEL
The fundamental techniques in security of e-based Systems and Computer Networks. E-based systems are ubiquitous in the modern world with applications spanning e-commerce, e-government, e-services, Virtual Private Networks (VPNs), health care, and government organizations. Deals with the fundamental concepts and tools of security of e-based systems and computer networks and its range of applications. The topics to be covered include: authentication of users, system integrity, confidentiality of communication, availability of business service, non-repudiation of transactions, public key cryptosystems, authentication and digital signature, e-security tools such as Public Key Infrastructure (PKI) systems, biometric-based security systems, trust management systems in communication networks, intrusion detection systems, protecting against malware, and computer network security risk management. Intended for graduate students in computer science, software engineering, and electrical engineering who have some background in computer networks and fundamentals of computer security.

CS-635   Wireless Network Systems and Security   **Credits: 3**
Prerequisite(s): CS-514 passed with a grade of B- or higher
Term Offered: Spring Term
Course Type(s): CISEL
Fundamental techniques in the design, operation, performance evaluation, and security of wireless network systems. Among the topics covered are first, second, third, and fourth generation wireless systems, cellular wireless networks, medium access techniques, physical layer, protocols (AMPS, IS-95, IS-136, GSM, GPRS, EDGE, WCDMA, cdma2000, etc.), fixed wireless systems, personal area networks (PANs) including Bluetooth and Home RF systems, wireless local area network(WLAN) technologies, architectures, protocols, and standards, and advanced topics. Security of WLANs, wireless sensor networks (WSNs), cellular systems, and Bluetooth and Home RF networks will be dealt with as well. Intended for graduate students in computer science, software engineering, and electrical engineering who have some background in computer networks.

CS-655   Cloud Computing - Concepts, Technology and Architecture
                                                                  Credits: 3
Prerequisite(s): CS-503
Term Offered: Summer Term
Course Type(s): CISEL
This course will introduce students to proven and mature cloud computing technologies and practices into a series of well-defined concepts, models, and technology mechanisms and architectures. Case studies will be presented to applying the concepts to practical applications. Also listed as SE-655.

CS-661   Computer Science Advanced Project   **Credits: 3**
Term Offered: All Terms
Course Type(s): CISEL
A challenging project, such as the development of a large, complex program, done under the supervision of a faculty member.

CS-691   Computer Science Thesis I   **Credits: 3**
Term Offered: All Terms
Course Type(s): None
Independent investigation of special topics reflecting the research interests of the sponsoring professor. Provides students with an opportunity to do extended relevant research in collaboration with, or under the supervision of, a faculty member. Sequential registration of one or more credits is required until successful completion. (Minimum of six credits must be accumulated.) Completion of all foundation and core courses and departmental approval is required to take this course.

CS-692   Computer Science Thesis II   **Credits: 3**
Prerequisite(s): CS-691
Term Offered: All Terms
Course Type(s): None
Independent investigation of special topics reflecting the research interests of the sponsoring professor. Provides students with an opportunity to do extended relevant research in collaboration with, or under the supervision of, a faculty member. Sequential registration of one or more credits is required until successful completion. (Minimum of six credits must be accumulated.)

CS-698   Advanced Special Topics   **Credits: 3**
Prerequisite(s): CS-503 passed with a grade of B- or higher or as
announced in the course schedule
Course Type(s): CISEL
The advanced subject matter varies with the interest of the students
and of the professor. The full syllabus for a specific offering will be filed
with the STE and Graduate School Deans when it is scheduled. The exact
nature of the topic covered in any given semester is indicated in the
student's transcript.

CS-699   Independent Study in Computer Science   **Credits: 3**
Term Offered: All Terms
Course Type(s): CISEL
Independent study of a subject not substantially treated in a regular
graduate course. Designed for students with superior abilities who, with
guidance and direction from the supervising faculty member, can master
a new subject. (Limited to students who have not yet taken CS-699.) A
minimum G.P.A. of 3.50, completion of all foundation and core courses
and departmental approval are required to take the course.

DS-501   Probability and Statistics for Data Science   **Credits: 3**
Term Offered: Fall Term
Course Type(s): None
This course covers the process of statistical analysis from beginning
to end. That process, in broad strokes, involves: posing a question,
determining what experiments or observations might provide data
for answering that question, developing data collection procedures,
exploring and summarizing the resulting data, and deriving inferences
from the data relevant to the original scientific question. Each of these
steps involves one or more of the following topics that will be covered
in this course: experimental design, descriptive statistics, probability
models, inferential statistics, confidence intervals, hypothesis tests,
and prediction. A special emphasis will be given to common pitfalls
in statistical analyses in a data-science context, including common
misinterpretations of statistical procedures, the confusion of association
and causation, and the reproducibility crisis in science.

DS-502   Introduction to Computer Programming for Data Science I
                                                              Credits: 3
Term Offered: All Terms
Course Type(s): None
Introduction to the basic concepts of program development using
Python; problem-solving methods and algorithm development; basic data
types; language syntax; style and documentation; and coding and testing
of programs.

DS-503   Introduction to Computer Programming for Data Science II
                                                              Credits: 3
Prerequisite(s): DS-502
Course Type(s): None
This course introduces the most important data structures available
in R and Python and their application to several real-world domains.
Methodologies to import data from external sources (files, databases,
on-line resources), to manipulate and transform data, and to save\export
data to data repositories are described. The course also describes how
to compute descriptive statistics and how to build charts for effective
data visualization tasks. The students will become familiar in using R and
Python data analysis libraries.

DS-504   Database Management   **Credits: 3**
Term Offered: All Terms
Course Type(s): None
Overview of database system concepts; data modeling; entity-
relationship diagrams; relational database schema definition; database
design; query languages; introduction to NoSQL and comparison between
relational and non-relational databases; hands-on experience of SQL,
Oracle, and NoSQL.

DS-510   Experimental Design and Causal Inference   **Credits: 3**
Prerequisite(s): DS-501
Course Type(s): None
This course introduces a rigorous, statistical definition of a causal effect,
and methods for inferring causal effects from both experimental and
observational data. Case studies and projects will be used to introduce
students to real-world applications of experimental design and causal
inference. Topics include randomized experiments (A/B testing, and
its generalizations), methods for subgroup analysis in randomized
experiments, graphical models for reasoning about causality, and
methods for deriving causal inferences from observational data with
confounders. Practical considerations (statistical power, sample size
determination, design and use of pilot studies, etc.) and common pitfalls
of applying these methods to real-world data will be emphasized.

DS-512   Data Analysis Solutions Using Low Code No Code   **Credits: 3**
Prerequisite(s): DS-501.
Term Offered: All Terms
Course Type(s): None
This course is designed for students across various disciplines who want
to develop practical AI/ML and analytics skills using low-code, no-code
software platforms. The course will provide the foundation for becoming
an AI&ML analyst by utilizing powerful and user-friendly AI&ML software
like Orange Data Mining and Dataiku.

DS-517   Ethics and Bias in AI   **Credits: 3**
Prerequisite(s): DS-502
Term Offered: All Terms
Course Type(s): CISEL
This course examines the full range of issues around BIAS and Ethics
implications in AI/ML-enabled systems. Important topics include
AI transparency, Fairness, BIAS, and Privacy & Security principles.
Additionally, the course will cover a wide range of global AI regulatory
proposed frameworks, including explainable AI techniques using SHAP
and LIME techniques.

DS-520   Data Analytics: Concepts and Techniques   **Credits: 3**
Prerequisite(s): DS-501, DS-502, and DS-504
Term Offered: Fall Term
Course Type(s): None
This course is designed to introduce students to the discipline of
data analytics and teach them basic algorithms, methodologies and
techniques for data analysis. The course introduces the main steps
of a data analysis process, including data gathering and collection,
exploratory data analysis, data mining algorithms and methodologies
for evaluating results. The most important data mining techniques,
i.e. classification, regression, association and clustering analysis, are
introduced. The students will gain familiarity with R and Python data
analysis libraries.

DS-525   Interactive Storytelling with Data   **Credits: 3**
Term Offered: Fall Term
Course Type(s): IM, TPS, CORTP
Designed to introduce students to the world of data journalism and teach them to tell interactive stories using raw data. We will start from asking what is data journalism and how we find stories in the data. Students will learn how to acquire data from the web, normalize the data into databases and finally use software to tell engaging, interactive stories with collected data. Students will also learn how to collect data from traditional sources that aren't necessarily found online. Students are expected to complete a data-driven journalism project as part of the course. Also offered as a undergraduate course, CO-492. Also listed as CO-592.

DS-530   Big Data Analysis, Methodologies and Infrastructures Credits: 3
Prerequisite(s): DS-520
Course Type(s): None
This course introduces the most important algorithms and frameworks for Big Data analysis. The course will introduce fundamentals concepts of Big Data, parallel and distributed data analysis models and the most important Big Data processing frameworks currently in use. Each topic will be illustrated by examples from a different application area. The students will become familiar in using Hadoop MapReduce and Spark, which have been emerging as the most important Big Data processing frameworks currently used in research and commercial tasks. Students are expected to complete a Big Data analysis project as part of the course.

DS-535   Data Science Consulting   **Credits: 1.5**
Prerequisite(s): DS-501
Term Offered: Spring Term
Course Type(s): None
This course introduces the roles and responsibilities of a data scientist working with teams of non-data scientists or non-technical clients, with an emphasis on verbal, non-verbal, and written communication between the data scientist and the client throughout the entire consulting process. The unique responsibilities of a data scientist in terms of accurately conveying the limitations of a data set and data analysis technique in the context of the client's original problem will be a central topic. The course will proceed through a series of case studies which will be used to practice interviewing, writing reports, and presenting results to a client.

DS-588   Data Science Practice and Experience   **Credits: 1**
Prerequisite(s): Completion of 9 credits from subject DS
Term Offered: All Terms
Course Type(s): OL
Provides opportunity for Data Science graduate students to obtain related experience in employment at a local company or institution with Monmouth University sponsorship. Available to Computer Science graduate students who have completed at least nine credit hours of graduate courses (500 level), with a minimum GPA of 3.00. Does not satisfy elective requirements. Students may take the course a maximum of two times. This is a pass/fail course. Departmental approval is required to take this course.

DS-615   Natural Language Processing for Data Science   **Credits: 3**
Prerequisite(s): DS-520.
Term Offered: All Terms
Course Type(s): None
Natural language processing, shortened to NLP, is the machine learning technique to derive insights from unstructured data. Theoretical foundation in understanding textual data, statistical analysis of text data using Machine Learning and hands-on python exercises using NLP techniques for Text classification, Topic modeling, Text summarization, and Sentiment analysis using data from Twitter, website scrapping, and Amazon product review.

DS-650   Applications for Data Science   **Credits: 3**
Prerequisite(s): DS-520
Term Offered: Spring Term
Course Type(s): None
This course provides students with a project to fully engage their data science skills. Projects will come from a real-world domain such as business applications (marketing, business analytics finance, insurance), health care analytics, bioinformatics, genomics, environmental analytics, social networks, data journalism, sports analytics, etc. Students will typically work with an external client to define the scope of the project, and then employ appropriate data science techniques to solve the established problems. The course will end with oral and written presentations of the project outcomes. This course is repeatable for credit.

DS-655   Advanced Data Science Techniques   **Credits: 3**
Prerequisite(s): DS-520 and DS-530.
Course Type(s): None
This course introduces advanced algorithms, methodologies and techniques for data analysis, with specific focus on classification, regression, clustering and association analysis. Among the most relevant algorithms, the course will cover advanced techniques, such as, deep learning, sequential pattern analysis, mixture models and grid-based clustering algorithms. Several examples, based on real-world datasets, will illustrate a variety of practical domains in which such techniques are used. Students will develop their exercises using R and Python data analysis libraries. Students are expected to complete a data-analysis project as part of the course.

DS-660   Management Science and Business Analytics   **Credits: 3**
Prerequisite(s): BM-518 and BM-519
Course Type(s): MBA.Q
Provides a graduate school introduction to the methodology and tools of Management Science and Business Analytics that are a necessity for all of today's managers. Students will learn how to model, design and analyze systems. Excel will be used for quantitative analysis and decision- making tools. Students will also learn how to organize, sort and sift through high levels of data in order to make a decision. Also listed as BM-620.

DS-691   Data Science Thesis I   **Credits: 3**
Term Offered: All Terms
Course Type(s): None
Independent investigation of special topics reflecting the research interests of the sponsoring professor. Provides students with an opportunity to do extended relevant research in collaboration with, or under the supervision of, a faculty member. Completion of all foundation and core courses and departmental approval is required to take this course.

DS-692   Data Science Thesis II   **Credits: 3**
Prerequisite(s): DS-691
Term Offered: All Terms
Course Type(s): None
Independent investigation of special topics reflecting the research interests of the sponsoring professor. Provides students with an opportunity to do extended relevant research in collaboration with, or under the supervision of, a faculty member. Sequential registration of one or more credits is required until successful completion. (Minimum of six credits must be accumulated.)

MIS-514   Networks   **Credits: 3**
Prerequisite(s): CS-501A
Term Offered: All Terms
Course Type(s): CISEL
An introductory-level course on the hierarchy of networking software and hardware. Particular emphasis on Medium Access Control, Network layer, Transport layer, and Session layer. Several MAC-layer protocols, TCP/IP. Also listed as CS-514.

MIS-517   Database Design and Management   **Credits: 3**
Prerequisite(s): CS-503 passed with a grade of B or higher
Term Offered: All Terms
Course Type(s): None
Introduction to database systems, data modeling, design theory and methodologies, query languages and query processing. Coverage of relational database model and design, normalization process, SQL, hands-on database design and application development. Also listed as CS-517.

MIS-525   Information System Architecture   **Credits: 3**
Prerequisite(s): MIS-565 or SE-565
Term Offered: All Terms
Course Type(s): None
Serves as an introduction to information systems architecture. The topics covered deal with an introduction to database systems, data models, the relational database model, the entity relation model, normalization, advanced data modeling, SQL, database design, transactions, performance, distributed database systems, and data warehouses. For MSIS students only. Also listed as SE-625.

MIS-550   Software Project Management   **Credits: 3**
Prerequisite(s): SE-505
Term Offered: Fall Term
Course Type(s): None
Project Management techniques and their application to the management of software projects. How to develop a software development plan and its associated tasks, milestones and deliverables. Software project scheduling and the establishment of relationships among the different tasks. Tasks, dependencies and conflict resolution. Resource management and allocation. Software project cost estimation. Algorithmic models for estimating costs: the COCOMO model and its derivatives. Risk assessment and its impact in the planning and scheduling of software projects. Software project measurement and tracking. Comparative review of software tools for software project management. Software configuration management and its importance in the management of large software projects. For MSIS students only. Also listed as SE-650.

MIS-551   Software Organization Management   **Credits: 3**
Prerequisite(s): SE-505
Term Offered: Spring Term
Course Type(s): None
Management issues regarding the software process. Authority and delegation. Leadership and leadership paradigms. Software team management organization, staffing and evaluation. Organizational alternatives. Centralized vs. decentralized organizations. Managing design, development and testing teams. Managing software support organizations. Strategies for staffing: minimal vs. redundant staffing. Combining generalists and specialists to achieve an optimal staff configuration. Staff development and growth. Fostering professional growth within the organization. Evaluation strategies and techniques. Compensation and reward issues. For MSIS students only. Also listed as SE-651.

MIS-565   Software System Requirements   **Credits: 3**
Prerequisite(s): CS-501A, SE-505, and SE-511
Term Offered: All Terms
Course Type(s): None
Students will learn advanced methods in software systems requirements. Ideally, these methods should be applied at the system, enterprise or global levels of software development. Methods in requirements elicitation, modeling of enterprises, prioritization and negotiation of requirements will be emphasized. Methods for including COTS into system applications and product families will be introduced. By the end of the course, students will master the standard documentation of system requirements. Many opportunities for hands-on experience with requirement tools will be provided throughout the course. For MSIS students only.

MIS-575   Software Verification, Validation and Maintenance   **Credits: 3**
Prerequisite(s): CS-501A and SE-505
Term Offered: All Terms
Course Type(s): None
Explores the techniques employed to insure quality in a software product developed in a controlled and disciplined environment. Detailed examination of software testing and inspection principles and methodologies. Provides specific methods for test case selection and inspection development leading to optimization of resource management in the software environment. For MSIS students only.

MIS-588   Information Systems Practice and Experience   **Credits: 1**
Term Offered: All Terms
Course Type(s): None
Provides opportunity for international Information Systems graduate students on an F1 student visa to obtain related experience via employment at a local company or institution, with Monmouth University sponsorship. Available only to Information Systems graduate students who have completed at least 18 credit hours of graduate courses (500-600 level), with a minimum G.P.A. of 3.00. This course does not satisfy elective requirements. Students may take this course a maximum of two times. Limited to MSIS students on an F1 Student Visa. This is a pass/fail course.

MIS-599   Independent Study in Management Information Systems
Credits: 3

Prerequisite(s): #12 credits in Management Information Systems
Term Offered: Fall Term
Course Type(s): None
The development and execution of a significant research project designed by the student in consultation with a management information systems professor. This is an experience meant to focus learning on an area of special interest to the student. Prior permission of the directing professor and department chair is required to take this course.

MIS-623   Management Information Systems
Credits: 3

Term Offered: Fall Term
Course Type(s): None
A survey of the concepts of management information systems and the information needs of management. A user-oriented introduction to the fundamentals of information systems and their integration into business organizations. Also listed as SE-623. Not open to students who have successfully completed BM-520.

MIS-691   Management Information System Thesis I
Credits: 3

Prerequisite(s): BM-520, MIS-525, MIS-565 and either MIS-517 and MIS-514 and MIS-575 or BM-565 and MIS-550 and MIS-551
Term Offered: All Terms
Course Type(s): None
First semester of independent research in management information systems, spanning a period of two consecutive semesters in an area not substantially covered in a regular course offering, under the supervision of a faculty member. A formal thesis is required. An oral defense of the thesis before a committee of two faculty members who teach MIS courses, plus the advising professor is required. Depending on the topic, a reviewer from outside the program faculty may be asked to serve as a committee member. For MSIS students only.

MIS-692   Management Information System Thesis II
Credits: 3

Prerequisite(s): MIS-691
Term Offered: All Terms
Course Type(s): None
Second semester of independent research in management information systems, spanning a period of two consecutive semesters in an area not substantially covered in a regular course offering, under the supervision of a software engineering faculty member. A formal thesis is required. An oral defense of the thesis before a committee of two faculty members who teach MIS courses, plus the advising professor is required. Depending on the topic, a reviewer from outside the program faculty may be asked to serve as a committee member. For MSIS students only.

MIS-695A   Management Information System Practicum I
Credits: 3

Prerequisite(s): BM-520 or MIS-623 and MIS-525 and MIS-565
Term Offered: All Terms
Course Type(s): None
A two-semester course sequence with major emphasis on a hands-on, team-oriented software development project. Students will be asked to form groups of three to five persons, which will work as a team whose purpose will be propose, plan, develop and market a software product. The teamwork exercise will be accompanied by readings, lectures and seminar discussions on economics, organizational behavior and management, managerial and financial accounting, finance, marketing, quantitative business modeling, electronic commerce, logistics, ethics, law and social responsibility. For MSIS students only.

MIS-695B   Management Information System Practicum II
Credits: 3

Prerequisite(s): MIS-695A
Term Offered: All Terms
Course Type(s): None
A two-semester course sequence with major emphasis on a hands-on, team-oriented software development project. Students will be asked to form groups of three to five persons, which will work as a team whose purpose will be to propose, plan, develop and market a software product. The teamwork exercise will be accompanied by readings, lectures and seminar discussions on economics, organizational behavior and management, managerial and financial accounting, finance, marketing, quantitative business modeling, electronic commerce, logistics, ethics, law and social responsibility. For MSIS students only.

MIS-699   Individual Research Project in Management Information Systems
Credits: 1-3

Term Offered: Spring Term
Course Type(s): None
The development and execution of a significant research project designed by the student in consultation with a Management Information Systems professor. An experience meant to focus learning on an area of special interest to the student. Prior permission of the directing professor and department chair is required to take this course.

SE-505   Principles of Software Engineering
Credits: 1.5

Term Offered: All Terms
Course Type(s): None
Basic introduction to software engineering. Justification that software engineering is an engineering discipline. The two main components of the software engineering discipline- the software product and software process-will be discussed in detail. For design and verification, there will be a focus on traditional Structured-Analysis method. Limited to Software Engineering students only.

SE-511   Object-Oriented Analysis
Credits: 1.5

Prerequisite(s): SE-505 passed with a grade of B- or higher
Term Offered: All Terms
Course Type(s): CISEL
Introduces the development of the requirements and analysis model for a software application. Uses object-oriented methodologies. This is not a programming course. Limited to Software Engineering students only.

SE-512   Object-Oriented Design
Credits: 1.5

Prerequisite(s): SE-511 passed with a grade of B- or higher
Term Offered: All Terms
Course Type(s): CISEL
Introduces the design of a software application. Uses object-oriented methodologies. This is not a programming course. Limited to Software Engineering majors only.

SE-517   Engineering Web-Based Systems
Credits: 3

Prerequisite(s): CS-501A
Term Offered: All Terms
Course Type(s): None
A practical introduction to the principles, methods and tools required to create high-quality software applications for the distributed, client-server context of the Web. The course emphasizes on architectural designs, and language and data access methods that are common in web-based systems.

SE-565   Software System Requirements   **Credits: 3**
Prerequisite(s): CS-501A, SE-505, and SE-511
Term Offered: All Terms
Course Type(s): CISEL
Students will learn advanced methods in software system requirements. Ideally, these methods should be applied at the system, enterprise or global levels of software development. Methods in requirements elicitation, modeling of enterprises, prioritization and negotiation of requirements will be emphasized. Methods for including Commercial Off-the Shelf (COTS) system applications and product families will be introduced. By the end of the course, students will master the standard documentation of system requirements. Many opportunities for hands-on experience with requirements tools will be provided throughout the course.

SE-571   Software Design and Systems Architecture   **Credits: 1.5**
Prerequisite(s): SE-565
Term Offered: Spring Term
Course Type(s): CISEL
Introduces software application design and system architecture in terms of the design process, design principles, design notations, design tools, design heuristics, and design patterns. Covers application and system design in detail concentrating on developing designs that are complete, correct, robust, implementable, and deployable. Limited to Software Engineering students only.

SE-572   Enterprise and Global Architecture   **Credits: 1.5**
Prerequisite(s): SE-571
Term Offered: All Terms
Course Type(s): CISEL
Introduces architectural design at the Enterprise and Global Architectural levels. Provides students with an understanding of how new systems are brought into an organization to interoperate with an existing system, how systems are maintained throughout their lifecycle, and how systems are retired at the end of their lifecycle. Also provides students with an understanding of how the computing capabilities of a company fits into the larger scope of the Internet. Limited to Software Engineering students only.

SE-575   Software Verification, Validation and Maintenance   **Credits: 3**
Prerequisite(s): CS-501A and SE-505
Term Offered: All Terms
Course Type(s): None
Covers software verification, validation and maintenance. The first half of the course includes inspections of requirements, design and code as well as testing. The second half addresses the handling of change requests, software evolution, code comprehension, and change management. It will include hands-on experience with a change management system and an automated testing tool.

SE-580   The Process of Engineering Software   **Credits: 3**
Prerequisite(s): CS-503 and SE-505
Term Offered: Spring Term
Course Type(s): None
Students will learn how to define, apply and improve a software process. The basic components of a software process will be introduced, as well as the most influential process models. Students will experiment with both plan-based and agile methods of software development. The need for continuous process quality assessment and improvement will be described. Models such as CMM, ISO9001 will be introduced as reference models for organizations process models.

SE-588   Software Practice and Experience   **Credits: 1**
Prerequisite(s): 18 credits from Computer Science or Software Engineering
Term Offered: All Terms
Course Type(s): None
Provides opportunity for Software Engineering graduate students to obtain related experience in employment at a local company or institution, with Monmouth University sponsorship. Available to Software Engineering graduate students who have completed at least eighteen credit hours of graduate courses (500-level), with a minimum G.P.A. of 3.00. Does not satisfy elective requirements. Students may take this course a maximum of two times. This is a pass/fail course.

SE-598   Special Topics in Software Engineering   **Credits: 1-3**
Course Type(s): None
The subject matter varies with the interest of the students and of the professor teaching the course. The exact nature of the topic covered in any given semester is indicated in the student's transcript.

SE-599   Independent Study in Software Engineering   **Credits: 1-3**
Prerequisite(s): Completion of at least 12 credits in Software Engineering
Term Offered: All Terms
Course Type(s): None
The development and execution of a significant research project designed by the student in consultation with a software engineering professor. This is an experience meant to focus learning on an area of special interest to the student. Prior permission of the directing professor and department chair is required to take this course.

SE-601   Outsourcing: Specifications and Strategies   **Credits: 3**
Prerequisite(s): SE-565
Term Offered: Spring Term
Course Type(s): CISEL
Covers issues associated with outsourcing software development in a fashion that assures delivery of acceptable products. The emphasis is on basic factors that determine the effectiveness of outsourcing, strategies for minimizing risk, project tracking, contract-specified breakpoints, and requirements.

SE-602   Technology Assessment   **Credits: 3**
Prerequisite(s): SE-565
Term Offered: Spring Term
Course Type(s): CISEL
Covers the practicalities of assessing a technology for use in delivery of products. It examines how new tools, processes, and training fit into an overall technology-adoption decision.

SE-603   MOST Implementation   **Credits: 3**
Prerequisite(s): SE-565
Term Offered: Spring Term
Course Type(s): CISEL
A practical application of MOST concepts by following the process of adopting a new technology and putting the appropriate elements into an organization. Focuses on technology assessment, cost, scheduling, training, and project management.

SE-610   Software Systems Security   **Credits: 3**
Prerequisite(s): SE-505
Term Offered: All Terms
Course Type(s): None
Threats, vulnerabilities, and attacks to network- based systems, Heuristic procedures for breaking systems. UNIX and Internet case studies. Security modeling techniques including Bell-Lapadula, Biba, and Clark-Wilson. Composition of non-deducibility and noninterference security. Safeguard techniques including cryptographic protocols, online auditing and intrusion detection, access control, Internet firewalls, authentication, security kernel design, and trusted software development. Case studies in database security and secure network design.

SE-611   Secure Web Services Design   **Credits: 3**
Prerequisite(s): SE-565
Term Offered: Spring Term
Course Type(s): None
Web applications present a complex set of security issues for architects, designers, and developers. The most secure and hack-resilient Web applications are those that have been built from the ground up with security in mind. This course focuses on principles of secure Web applications design. Topics include threats and counter measures, security in Web service frameworks, session control, access control, and data protection. Also listed as CS-611.

SE-615   Usability Engineering/Human-Computer Interaction   Credits: 3
Prerequisite(s): SE-565
Term Offered: Spring Term
Course Type(s): None
Explores the requirements analysis, design and evaluation of the Computer User Interface in the context of Software Engineering Processes. Specific methods and design problems will be illustrated with real-world examples in information technology, the Internet, communications, mobility, multimedia, and speech technologies. Prepares students to perform usability tasks directly or to successfully manage and collaborate with usability experts.

SE-616   Extensible Markup Language (XML)   **Credits: 3**
Prerequisite(s): CS-501B
Course Type(s): None
Presents XML fundamental concepts, XML as a document format, XML as a data format, and special topics in using XML.

SE-620   Networked Software Systems I   **Credits: 3**
Prerequisite(s): SE-565
Course Type(s): CISEL
Network Computing Models, Concepts and Requirement specification; Techniques for Interprocess Communication; Message Passing; Remote Procedures Calls; Directory Service; Synchronization; Task Partition and Allocation; Threads; Security and Authentication; Time Management.
Prerequisites: SE-565

SE-621   Networked Software Systems II   **Credits: 3**
Prerequisite(s): SE-620
Term Offered: Spring Term
Course Type(s): None
Distributed File Systems, Replication, Shared Data, Transactions, Distributed Operating Systems, Micro Kernels, Network Operating Systems, Computing Environments and Toolkits: ONC, DCE, ISIS, Languages.

SE-623   Management Information Systems   **Credits: 3**
Term Offered: Fall Term
Course Type(s): None
A survey of the concepts of management information systems and the information needs of management. A user-oriented introduction of the fundamentals of information systems and their integration into business organizations. Also listed as MIS-623. Not open to students who have successfully completed BM-520.

SE-625   Information Systems Architecture   **Credits: 3**
Prerequisite(s): SE-565 or MIS-565
Term Offered: All Terms
Course Type(s): None
Theoretical and practical issues related to the modeling and design of information systems to support medium to large organizations. The Target Architecture and its roles in building enterprise-wide information systems. Operational, warehouse, departmental, and individual-level data. Data modeling levels and associated constructs: Entity-Relationship Diagrams, Data Item Sets, Physical Data Models. Process modeling levels and associated constructs: Functional decomposition, Context diagrams, Data Flow Diagrams, State transition Diagrams, HIPO charts, Pseudo-code and programming specs. Relationship with Object-based modeling. Also listed as MIS-525.

SE-626   Information Systems Engineering   **Credits: 3**
Prerequisite(s): SE-625
Term Offered: Spring Term
Course Type(s): None
Theoretical and practical issues related to the implementation of information systems to support medium to large organizations. Databases within the Target Architecture and their role in building enterprise-wide information systems. Logical vs. Physical database design. Transaction Processing (TPS) and Decision Support Systems (DSS): similarities and differences. Knowledge-based systems. Implementation issues; reliability, integrity, security, performance, scalability and maintainability. Review of existing commercial tools and environments for building, using and maintaining Information Systems for the enterprise.

SE-640   Real-time Systems   **Credits: 3**
Prerequisite(s): CS-501B and SE-505
Term Offered: Fall Term
Course Type(s): CISEL
Theoretical foundations and practical algorithms in the specification and validation of real-time systems and applications. Important topics include real-time system specification, scheduling, resource access control, real-time task assignment, and high-level system modeling and analysis.

SE-641   Real-time Robot Control   **Credits: 3**
Prerequisite(s): SE-640
Term Offered: Spring Term
Course Type(s): CISEL
Fundamentals of real-time and embedded software technology. Inter-process communication and synchronization. Robot operating system. Modern robot programming toolkits. Robot movement control. Robot speech and vision recognition.

SE-650   Software Project Management   **Credits: 3**
Prerequisite(s): SE-505
Term Offered: Fall Term
Course Type(s): None
Project management techniques and their application to the management of software projects. How to develop a software development plan and its associated tasks, milestones and deliverables. Software project scheduling and the establishment of relationships among the different tasks. Tasks, dependencies and conflict resolution. Resource management and allocation. Software project cost estimation. Algorithmic models for estimating costs: the COCOMO model and its derivatives. Risk assessment and its impact in the planning and scheduling of software projects. Software project measurement and tracking. Comparative review of software tools for software project management. Software configuration management and its importance in the management of large software projects. Also listed as MIS-550. For Software Engineering students only.

SE-651   Software Organization Management   **Credits: 3**
Prerequisite(s): SE-505
Term Offered: Spring Term
Course Type(s): None
Management issues regarding the software process. Authority and delegation. Leadership and leadership paradigms. Software Team management: organization, staffing and valuation, organizational alternatives. Centralized vs. Decentralized organizations. Managing design, development and testing teams. Managing software support organizations. Strategies for staffing: minimal vs. redundant staffing. Combining generalists and specialists to achieve an optimal staff configuration. Staff development and growth. Fostering professional growth within the organization. Evaluation strategies and techniques. Compensation and reward issues. Also listed as MIS-551.

SE-655   Cloud Computing - Concepts, Technology and Architecture
    Credits: 3
Prerequisite(s): CS-503
Term Offered: Summer Term
Course Type(s): CISEL
This course will introduce students to proven and mature cloud computing technologies and practices into a series of well-defined concepts, models, and technology mechanisms and architectures. Case studies will be presented to applying the concepts to practical applications. Also listed as CS-655.

SE-691   Software Engineering Thesis Research   **Credits: 3**
Prerequisite(s): SE-565 and SE-580.
Term Offered: All Terms
Course Type(s): None
Independent research in software engineering, spanning a period of two consecutive semesters in an area not substantially covered in a regular course offering, under the supervision of a software engineering faculty member. A formal thesis is required. An oral defense of the thesis before a committee of two faculty members, plus the advising professor is required. Depending on the topic, a reviewer from outside the software engineering department may be asked to serve as a committee member. Limited to Software Engineering majors.

SE-692   Software Engineering Thesis Research   **Credits: 3**
Prerequisite(s): SE-691 and prior permission of the advising professor
Term Offered: All Terms
Course Type(s): None
Independent research in software engineering, spanning a period of two consecutive semesters in an area not substantially covered in a regular course offering, under the supervision of a software engineering faculty member. A formal thesis is required. An oral defense of the thesis before a committee of two faculty members, plus the advising professor is required. Depending on the topic, a reviewer from outside the software engineering department may be asked to serve as a committee member. Limited to Software Engineering majors.

SE-695A   Software Engineering Practicum   **Credits: 3**
Prerequisite(s): SE-565 and SE-580
Term Offered: All Terms
Course Type(s): None
A two-semester course sequence with major emphasis on hands-on, team-oriented large software development projects. Students will be asked to form groups of three to five persons, who will work as a software team whose purpose will be to develop a software product. The particular product will be chosen through negotiation with the instructor. Teams will operate in accordance with a well-defined set of policies and procedures (documented in an SE Handbook) that governs the entire development process. This document process addresses work products, roles, activities, entry and exit criteria, reviews and audits, documented procedures, and training. The practicum will also include the use of a set of approved tools. Additional software project management topics such as planning, estimation, and tracking will be covered. Project management techniques and their application to the management of software projects. How to define a software development plan, its associated tasks, milestones, and deliverables. Software project scheduling and the establishment of relationships among the different tasks. Task dependencies and conflict resolution. Resource management and allocation. Software project cost estimation. Algorithmic models for estimating costs: the COCOMO model and its derivatives. Risk assessment and its impact in the planning and scheduling of software projects. Software project measurement and tracking. Comparative review of software tools for software project management. Software configuration management and its importance in the management of large software projects. The students will be asked to serve in team roles, hold oral reviews, and prepare documentation appropriate to their project. Students in the class will participate in the reviews of other teams in the class. At the end of the second semester, each team will give a formal presentation on the project. Limited to Software Engineering majors.

SE-695B   Software Engineering Practicum   **Credits: 3**
Prerequisite(s): SE-695A
Term Offered: All Terms
Course Type(s): None
A two-semester course sequence with major emphasis on hands-on, team-oriented large software development projects. Students will be asked to form groups of three to five persons, who will work as a software team whose purpose will be to develop a software product. The particular product will be chosen through negotiation with the instructor. Teams will operate in accordance with a well-defined set of policies and procedures (documented in an SE handbook) that governs the entire development process. This documented process addresses work products, roles, activities, entry and exit criteria, reviews and audits, documented procedures, and training. The practicum will also include the use of a set of approved tools. Additional software project management topics such as planning, estimation, and tracking will be covered. Project management techniques and their application to the management of software projects. How to define a software development plan, its associated tasks, milestones, and deliverables. Software project scheduling and the establishment of relationships among the different tasks. Task dependencies and conflict resolution. Resource management and allocation. Software project cost estimation. Algorithmic models for estimating costs: the COCOMO model and its derivatives. Risk assessment and its impact in the planning and scheduling of software projects. Software project measurement and tracking. Comparative review of software tools for software project management. Software configuration management and its importance in the management of a large software project. Students will be asked to serve in team roles, hold oral reviews, and prepare documentation appropriate to their project. Students will participate in the reviews of other teams in the class. At the end of the second semester, each team will give a formal presentation on the project. Limited to Software Engineering majors.

SE-698   Special Topics in Software Engineering   **Credits: 3**
Term Offered: All Terms
Course Type(s): None
The subject matter varies with the interest of the students and of the professor teaching the course. The exact nature of the topic covered in any given semester is indicated in the student's transcript. Approval of the department is required to take this course. If a prerequisite is required it will be announced in the course schedule.

SE-699 Individual Research Project in Software Engineering   Credits: 3
Term Offered: All Terms
Course Type(s): None
The development and execution of a significant research project designed by the student in consultation with a software engineering professor. An experience meant to focus learning on an area of special interest to the student. Prior permission of the directing professor and department chair is required to take this course.