**COMPUTER SCIENCE**

**CMP SCI 4010 Advanced Web Development with Java: 3 semester hours**
Prerequisites: CMP SCI 2261 and CMP SCI 3010, or consent of instructor. Covers more advanced Java topics, along with related concepts and technologies for Web development. Topics may include database connectivity, multi threading, security, networking, MVC pattern, testing and source control for Java applications, and server-side topics such as servlets and web servers.

**CMP SCI 4012 Introduction to Enterprise Web Development: 3 semester hours**
Prerequisites: CMP SCI 4010. This course covers design and implementation issues for enterprise web development, and some popular advanced technologies. Topics include MVC and persistence frameworks, such as Spring and Hibernate. Other topics may include Java Web services, EJB, messaging standards such as JMS, and Java EE design patterns. Students will develop enterprise-level web application projects. Credit cannot be earned for both CMP SCI 4012 and CMP SCI 5012.

**CMP SCI 4020 Introduction to Android Apps: Android Fundamentals: 3 semester hours**
Prerequisites: CMP SCI 4010, or consent of the instructor. This course covers the fundamental programming principles, software architecture and user experience considerations underlying handheld software applications and their development environments. Involves in-depth, hands-on examples, implemented on the Android Platform, and discussion of security. Credit not granted for both CMP SCI 4020 and CMP SCI 5020.

**CMP SCI 4030 Introduction to Intelligent Web: 3 semester hours**
Prerequisites: CMP SCI 2261, CMP SCI 2750, CMP SCI 3010, and CMP SCI 3130. Covers the application of artificial intelligence and other modern techniques to help construct, navigate, and experience the Web. Topics may include retrieval models, classification, mining, association, topology, and indexing algorithms such as PageRank and HITS. Credit cannot be earned for both CMP SCI 4030 and CMP SCI 5030.

**CMP SCI 4140 Theory Of Computation: 3 semester hours**
Prerequisite: CMP SCI 3130. Provides an introduction to the theory of computation. Describes basic computational models, such as finite state machines, pushdown automata, Turing machines and grammars. Covers the concept of nondeterministic computation and the relationships between different computational models. Discusses decidability, reducibility, and classification of problems into complexity classes based on their time and space complexity, such as P, NP, and PSPACE.

**CMP SCI 4220 Introduction to iOS Programming and Apps: 3 semester hours**
Prerequisites: CMP SCI 2261, CMP SCI 2750, and CMP SCI 3010. This course covers Objective-C and uses it for building iOS apps. It also introduces Xcode, Interface Builder, basic architectural patterns for MVC such as action, delegation, and outlets. Additional topics may include online services, mapping, persistence with core data, and single and multiple views.

**CMP SCI 4222 iOS Apps: 3 semester hours**
Prerequisites: CMP SCI 4220 or consent of the instructor. This course focuses on building more sophisticated apps using Objective-C and the scripting language Swift. May include networking such as web services, Bluetooth and wifi connectivity, graphics and animation in 2-d and 3-d, autolayouts, OpenGL, advanced data sources such as plist and core data, source control and unit testing. May also discuss security topics. Credit not granted for both CMP SCI 4222 and CMP SCI 5222.
**CMP SCI 4250 Programming Languages: 3 semester hours**
Prerequisite: CMP SCI 2261 and CMP SCI 3010 or Graduate Standing. Studies the principles, approaches, and trade-offs in modern programming languages, including a comparative study of syntax, semantics, and pragmatics. Examines major programming paradigms: object-oriented, imperative, functional and logic.

**CMP SCI 4280 Program Translation: 3 semester hours**
Prerequisites: CMP SCI 2700, CMP SCI 2750, CMP SCI 3130, and CMP SCI 4250. Focuses on methods, techniques, and mechanisms used to create the abstraction from high level programming to machine level execution. This course also requires an individual, semester long project.

**CMP SCI 4300 Introduction to Artificial Intelligence: 3 semester hours**
Prerequisites: CMP SCI 2261, CMP SCI 2750 and CMP SCI 3130. Provides an introduction to artificial intelligence. The list of topics may include search, planning, knowledge-based reasoning, probabilistic inference, machine learning, natural language processing, and practical applications.

**CMP SCI 4340 Introduction to Machine Learning: 3 semester hours**
Prerequisites: CMP SCI 2261, CMP SCI 2750 and CMP SCI 3130. Provides an introduction to machine learning in the context of applications such as data mining, natural language processing, and adaptive computer systems. The course reviews several supervised, unsupervised, and reinforcement machine learning techniques such as naive Bayes networks, clustering, and decision trees. Selected concepts in computational learning theory may also be covered. Credit cannot be granted for both CMP SCI 4340 and CMP SCI 5340.

**CMP SCI 4410 Computer Graphics: 3 semester hours**
Prerequisites: CMP SCI 2750 and CMP SCI 3130. Covers the theoretical foundation and algorithms for computer graphics. Students learn the basics of graphics programming for modeling, rendering, and animation of 2D and 3D objects. Vector and raster graphics, and different display devices are also discussed. A brief discussion of special graphics hardware, such as GPU, may be presented.

**CMP SCI 4420 Introduction to Digital Image Processing: 3 semester hours**
Prerequisites: CMP SCI 2750 and CMP SCI 3130. Focuses on image analysis and visual perception. Students learn data structures and algorithms for image processing, region and texture analysis, image filtering, edge detection, contour following, and image enhancement in both spatial and frequency domain. Other topics may include color processing, coding for storage, retrieval, transmission, and image restoration. Credit cannot be granted for both CMP SCI 4420 and CMP SCI 5420.

**CMP SCI 4500 Introduction to the Software Profession: 3 semester hours**
Prerequisite: CMP SCI 2261, CMP SCI 2700, CMP SCI 2750, CMP SCI 3010, and CMP SCI 3130. Focuses on software development and on the skills required for success in the software profession. Topics related to software development may include software process, models and views, software architectures, documentation, and testing strategies. Topics related to the profession may include ethics, licensing, copyright, trademarks, and professional conduct. Individual and group projects, research, and presentations may be required in this capstone course.

**CMP SCI 4520 Introduction to Object-Oriented Analysis And Design: 3 semester hours**
Prerequisite: CMP SCI 2261, CMP SCI 3010, CMP SCI 3130. Covers object-oriented development, illustrated with a visual modeling language and following an agile process. Discusses elements of analysis, requirements, design, implementation, and deployment such as use cases, static and dynamic diagrams, patterns, and frameworks. This course includes a semester long project starting with requirements and culminating with deployment. Credit not granted for both CMP SCI 4520 and CMP SCI 5520.
**CMP SCI 4610 Database Management Systems: 3 semester hours**
Prerequisites: CMP SCI 2750 and MATH 3000. Focuses on database theory and applications, with emphasis on the relational model. Topics include database design, modeling, file systems, indexing, integrity constraints, relational algebra, normalization, transaction processing, and concurrency control. Students are exposed to emerging DBMS technologies and applications. Several programming projects will be required, using a popular SQL server.

**CMP SCI 4700 Computer Forensics: 3 semester hours**
Prerequisites: CMP SCI 2700, CMP SCI 2750, and CMP SCI 3010. This course explores topics and methodologies for examining digital evidence, along with some principles of the investigative process. Includes memory, file system, operating system, network, and mobile device forensics. Addresses both theory and hands-on aspects for conducting digital forensic examinations.

**CMP SCI 4710 Mobile and Ubiquitous Computing: 3 semester hours**
Prerequisites: CMP SCI 2261. This course provides an introduction to the rapidly developing field of ubiquitous computing while at the same time exploring more focused topics in the three main categories of this field, namely systems, experience, and sensors. Explores setting up the infrastructure, privacy issues, evaluation of field applications, internationalization, user interfaces, and geolocation analysis.

**CMP SCI 4730 Computer Networks and Communications: 3 semester hours**
Prerequisites: CMP SCI 2750 and MATH 1320. This course provides a broad overview of computer networks and communications. Covers the fundamental principles and protocols across the whole layering structure of the Internet protocol stack. A top-down approach covers multiple topics including network application layer, transport layer, network layer, link layer, and physical layer protocols. May also include a range of related technologies such as WWW, HTTP, FTP, DNS, SMTP, TCP, UDP, ICMP, IPv4, IPv6, OSPF, RIP, BGP, IEEE 802.11 (WiFi), cellular networks, LANs, Ethernet, CSMA/CD, CDMA, multimedia networking, network management, and security in Internet.

**CMP SCI 4750 Introduction to Cloud Computing: 3 semester hours**
Prerequisite: CMP SCI 2750. This course provides an introduction to development and deployment of applications in the cloud space. Touches on different aspects of cloud computing such as IaaS, PaaS, and SaaS. Includes significant discussion on legal and security aspects of clouds in the marketplace. May also include public, private, and hybrid clouds, and Internet of Things. Credit not granted for both CMP SCI 4750 and CMP SCI 5750.

**CMP SCI 4760 Operating Systems: 3 semester hours**
Prerequisites: CMP SCI 2700, CMP SCI 2750, and CMP SCI 3130. Covers the structure of a generic operating system, considering in detail the algorithms for interprocess communication, process scheduling, resource management, memory management, file systems, and device management. Presents examples from contemporary operating systems. This course also requires practical projects implemented within a modern operating system or simulator environment.

**CMP SCI 4780 Computer and Network Security: 3 semester hours**
Prerequisite: CMP SCI 2750. This course provides a broad overview of computer and network security technologies and concerns from multiple perspectives, such as cryptography, Public Key Infrastructures (PKI), hashes and message digests, computer viruses and malware, email security, TCP/IP security, IPSec, Secure Socket Layer (SSL), Transport Layer Security (TLS), Virtual Private Networks (VPN), Firewall, AAA (Authentication, Authorization, Accounting), wireless and mobile systems security, secure identifications (IDs), cloud security, privacy and integrity, network attacks, system monitoring, and Intrusion Detection System (IDS). Management and human factors related to security will also be discussed.
**CMP SCI 4782 Information Security: 3 semester hours**
Prerequisites: CMP SCI 4730 or CMP SCI 4780 or consent of instructor. This course covers topics related to maintaining security in an organizational infrastructure, including risk analysis of the environment, access level and control including multi-factor authentication, and detection capabilities to ensure adequate security monitoring. Additional topics may include network level protections, firewalls, intrusion detection/prevention systems, securing web and mobile applications, securing cloud implementations, and overall architectural considerations for system security. Credit not granted for both CMP SCI 4782 and CMP SCI 5782.

**CMP SCI 4880 Individual Studies: 1-3 semester hours**
Prerequisites: Consent of the instructor. This course allows a student to pursue individual studies under the supervision of a faculty member. It may include development of a software project. The course may be repeated for credit.

**CMP SCI 4890 Topics in Computer Science: 3 semester hours**
Prerequisites: Consent of the instructor. Covers a special topic in computer science to be determined by recent developments in the field and the interests of the instructor. Course may be repeated for credit.

**CMP SCI 5012 Enterprise Web Development: 3 semester hours**
Prerequisite: CMP SCI 4010 or consent of instructor. Covers design and implementation issues for enterprise web development, and some popular advanced technologies. Topics include MVC and persistence frameworks, such as Spring and Hibernate. Other topics may include Java Web services, EJB, messaging standards such as JMS, and Java EE design patterns. Students will develop enterprise-level web application projects. Credit cannot be earned for both CMP SCI 4012 and CMP SCI 5012.

**CMP SCI 5020 Android Apps: Android Fundamentals: 3 semester hours**
Prerequisites: CMP SCI 4010 or consent of the instructor. Covers the fundamental programming principles, software architecture and user experience considerations underlying handheld software applications and their development environments. Involves in-depth, hands-on examples, implemented on the Android Platform, and discussion of security. Credit not granted for both CMP SCI 4020 and CMP SCI 5020.

**CMP SCI 5030 Intelligent Web: 3 semester hours**
Prerequisite: Consent of the instructor. Covers the application of artificial intelligence and other modern techniques to help construct, navigate, and experience the Web. Topics may include retrieval models, classification, mining, association, topology, and indexing algorithms such as PageRank and HITS. Topics are the same as CMP SCI 4030 but material is covered at a greater depth and additional projects are required. Credit cannot be earned for both CMP SCI 4030 and CMP SCI 5030.

**CMP SCI 5130 Advanced Data Structures and Algorithms: 3 semester hours**
Prerequisite: An elementary course in analysis of algorithms or consent of the instructor. This course covers analysis of time and space complexity of iterative and recursive algorithms along with performance bounds, design of data structures for efficient performance, sorting algorithms, probabilistic algorithms, divide and conquer strategies, various algorithms on graphs, and np completeness.

**CMP SCI 5222 Advanced iOS Apps: 3 semester hours**
Prerequisites: CMP SCI 4220 or consent of the instructor. Focuses on building sophisticated apps using Objective-C and the scripting language Swift. Will cover recent developments in networking such as web services, Bluetooth and wifi connectivity, graphics and animation in 2-d and 3-d, autolayouts, OpenGL, advanced data sources such as plist and core data, source control and unit testing. May also discuss security topics. Credit not granted for both CMP SCI 4222 and CMP SCI 5222.
**CMP SCI 5320 Introduction to Evolutionary Computation: 3 semester hours**
Prerequisites: CMP SCI 4300 or consent of instructor. This course introduces the concepts of nature-inspired problem solving population dynamics, Darwinian selection, and inheritance. It discusses problems applicable to evolutionary algorithms, overviews the existing models and instances, and analyzes specific instances such as genetic algorithms and genetic programming.

**CMP SCI 5340 Machine Learning: 3 semester hours**
Prerequisites: Consent of instructor. Provides an introduction to machine learning in the context of applications such as data mining, natural language processing and adaptive computer systems. Reviews several supervised, unsupervised, and reinforcement machine learning techniques such as naive Bayes networks, clustering and decision trees. Selected concepts in computational learning theory may also be covered. Topics are the same as CMP SCI 4340 but material is covered at a greater depth and additional projects are required. Credit cannot be granted for both CMP SCI 4340 and CMP SCI 5340.

**CMP SCI 5420 Digital Image Processing: 3 semester hours**
Prerequisites: Consent of instructor. Covers topics in image analysis and visual perception. Students learn data structures and algorithms for image processing, region and texture analysis, image filtering, edge detection, contour following, and image enhancement in both spatial and frequency domain. Other topics may include color processing, coding for storage, retrieval, transmission, and image restoration. Topics are the same as CMP SCI 4420 but material is covered at a greater depth and additional projects are required. Credit cannot be granted for both CMP SCI 4420 and CMP SCI 5420.

**CMP SCI 5500 Software Engineering: 3 semester hours**
Prerequisite: Consent of instructor. Introduces software engineering as a discipline, discusses stages of the software life cycle, compares development models such as waterfall, prototyping and incremental/iterative, covers requirements analysis, effort and cost estimation, compares structured and object-oriented analysis and design methods. Discusses verification/validation, quality assurance, software reliability, testing methods, maintenance, documentation, project management and team structure, metrics, and available tools.

**CMP SCI 5520 Object Oriented Analysis and Design: 3 semester hours**
Prerequisite: Consent of the instructor. Covers object-oriented development, illustrated with visual modeling language and following an agile process. Discusses elements of analysis, requirements, design, implementation, and deployment such as use cases, static and dynamic diagrams, patterns and frameworks. A semester long project, starting with requirements and culminating with deployment, is required. Topics are the same as CMP SCI 4520 but material is covered at a greater depth and additional projects are required. Credit not granted for both CMP SCI 4520 and CMP SCI 5520.

**CMP SCI 5700 Computer Systems: 3 semester hours**
Prerequisite: Background in computer organization or architecture or consent of the instructor. This course focuses on parallel computing architectures, including RISC, pipelining, vector processing, SIMD, MIMD, and array processing. It introduces different memory and I/O subsystems, hardware description languages, and it demonstrates performance enhancement using different architectures studied.

**CMP SCI 5740 High Performance Computing: 3 semester hours**
Prerequisite: Consent of the instructor. Introduces algorithms for multiprocessor and multi-core architectures. Students learn the models of modern parallel computation and techniques to take advantage of parallel architectures for distributed and shared memory multi-processor architectures.
**CMP SCI 5750 Cloud Computing: 3 semester hours**
Prerequisites: Graduate Standing. Provides an introduction to development and deployment of applications in the cloud space. Touches on different aspects of cloud computing such as IaaS, PaaS, and SaaS. Includes significant discussion on legal and security aspects of clouds in the marketplace. May also include public, private, and hybrid clouds, and Internet of Things. Credit not granted for both CMP SCI 4750 and CMP SCI 5750.

**CMP SCI 5782 Advanced Information Security: 3 semester hours**
Prerequisites: Consent of the instructor. The topics covered in this course are risk analysis to understand the security requirements of an environment; access controls to understand the level of controls needed for different practical situations, including multi-factor authentication; detection capabilities, to ensure adequate security monitoring for information systems; network level protections, with firewalls, intrusion detection/prevention systems; securing the web and mobile applications and cloud implementations; and overall security architecture to understand how various controls can provide the security-in-depth that is required in the current environment. Credit not granted for both CMP SCI 4782 and CMP SCI 5782.

**CMP SCI 5880 Computer Science Independent Project: 1-3 semester hours**
Prerequisites: Graduate standing and consent of instructor This course offers the student an opportunity to work on an advisor-supervised project, individually or in a group. A student may repeat the course for up to 6 credit hours total, but at most 6 hours can be accumulated for CMP SCI 5880 and CMP SCI 6900.

**CMP SCI 5890 Topics in Computer Science: 1-3 semester hours**
Prerequisites: Graduate standing and consent of the instructor This course offers various topics not offered on a regular basis. It may be taken more than once for credit with the consent of the department.

**CMP SCI 5900 Graduate Internship in Computer Science: 3 semester hours**
Prerequisites: Consent of Advisor. The internship provides for a student to attain field experience in an organization related to Computer Science. A student is employed off-campus for an assignment of at least 320 hours working on a project as directed by his/her supervisor in the host organization. The project should be approved by the student's academic advisor, or a designated faculty member, who will monitor the student’s progress. The student is responsible for having the project supervisor at the company establish contact with the academic advisor to establish schedule and goals, and a procedure to evaluate the goals. The student will submit a written report to the advisor at the end of internship. The course cannot be repeated for credit. Students completing this course will be allowed only up to three hours of Independent Study (CMP SCI 5880).

**CMP SCI 6320 Advances in Evolutionary Computation: 3 semester hours**
Prerequisite: CMP SCI 5320 or consent of instructor. This course focuses on some advanced topics in Genetic and Evolutionary Computation, both theoretical and practical. Topics may include competent genetic algorithms, learning classifier systems, and Markov models. A substantial part of the course will be based on recent literature. Projects may involve literature research, developing specific applications or implementing a specific model.

**CMP SCI 6340 Genetic Programming: 3 semester hours**
Prerequisite: CMP SCI 5320 or consent of instructor. This course provides an in-depth exploration of Genetic programming, including advanced concepts such as scalability, evolution of modularity and regularity, and constrained evolution with CGP, STGP, or CFG-based GP. It may be reading, research, or application oriented.
**CMP SCI 6410 Topics in Computer Graphics: 3 semester hours**
Prerequisites: CMP SCI 4410 or consent of instructor. This course covers various aspects of advanced graphics techniques, such as geometric modeling, rendering, shading, texturing, and computer animation. The course provides an in-depth study of recent advanced topics in computer graphics.

**CMP SCI 6420 Topics in Image Processing and Multimedia: 3 semester hours**
Prerequisites: CMP SCI 5400, CMP SCI 5420 or consent of instructor. This course covers new developments in digital image processing, computer vision, and multimedia. Topics to be covered may include image databases, object tracking, and large-scale data visualization.

**CMP SCI 6740 High Performance Computing: 3 semester hours**
Prerequisites: CMP SCI 5740, or Graduate standing and consent of instructor. Looks at the current state of the art in parallel and distributed computing, with emphasis on programming in such environments. Introduction to the state of the art in code optimization and grid computing environments.

**CMP SCI 6900 Thesis: 1-6 semester hours**
Prerequisites: Completion of at least 12 graduate credits and approval of research topic by thesis advisor. This course is designed for those students intending to present a thesis as part of their M.S. program. At most 6 hours can be accumulated for CMP SCI 5880 and CMP SCI 6900.

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