Computer Science and Engineering

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Degrees Offered: B.S., M.S., and Ph.D. in Computer Science, and M.S. with Information Technology Option

The Department of Computer Science and Engineering is focused on an exciting and rapidly growing body of knowledge with constantly changing emphasis.

The curriculum of the department includes courses in both theory and application. It prepares students to apply the principles of logic and mathematics to the design and construction of hardware and software systems using current engineering paradigms and also exposes them to major applications of computing.

The *Bachelor of Science in Computer Science* is accredited by the Computing Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore MD 21202-4012, telephone (410) 347-7700. The program emphasizes fundamental principles while striking a careful balance between the applications of computer technology and the theory of computing. In addition to the required fundamental computer science courses, students must also take technical electives to broaden their knowledge in major computer science application areas. Graduates of this program will be well prepared for both industry employment and graduate study.

The *Master of Science in Computer Science* program is designed for students who wish to further broaden or deepen their knowledge of computer science and applications. Both thesis and non-thesis options are offered; an independent study report is required for the non-thesis option. Master's students usually participate in faculty research projects to complete their thesis or independent study.

New Mexico Tech's Department of Computer Science and Engineering also offers a *Ph.D. in Computer Science* program. This program gives students the opportunity to take courses, to select committee members, to use the resources of the department, and to pursue research in a fairly large number of areas of computer science and its applications.

The department has been certified, since 2002, by the National Security Agency and the Department of Homeland Security as a National Center of Academic Excellence in Information Assurance Education. Since 2009, the department has also been certified as a National Center of Academic Excellence in Information Assurance Research.

The department has its own network of computers and servers plus a variety of other equipment in several laboratories. The Tech Computer Center supports a larger network that is also available to the department. Computing equipment at the research labs associated with Tech includes both symmetric multiprocessors and special purpose massively parallel computers. The department also has access to massively parallel machines at national laboratories and supercomputing centers.

Mission

The mission of the Computer Science and Engineering Program is to produce computer science graduates who, trained in the design, implementation, and analysis of computational systems and skilled in technical communication, will contribute towards the advancement of computing science and technology.

Program Educational Objectives

Within a few years of graduating with a B.S. degree in Computer Science, our students will demonstrate that they have:

1. the ability to design, implement, and analyze computational systems;
2. the capability to tackle complex computer science and engineering related problems in the real world;
3. contributed towards the advancement of computing science and technology;
4. the capacity to work effectively with peers in computational tasks; and
5. cognizance of ethical, social, and legal issues pertaining to computer science and engineering.

Program Outcomes

The undergraduate academic program in Computer Science will enable our graduates to acquire by the time of their graduation:

1. the ability to design, implement, and test small software programs, as well as large programming projects;
2. knowledge of the theoretical concepts of computing;
3. knowledge of the fundamental principles of programming languages, systems, and machine architectures;
4. exposure to one or more application areas within computer science;
5. technical communication skills in written and oral form;
6. the capacity to work as part of a team; and
7. awareness of the legal, ethical, and societal impact of developments in the field of computer science.

Undergraduate Program
Bachelor of Science in Computer Science

Minimum credit hours required—130

In addition to the General Education Core Curriculum (page 89), the following courses are required:

- CSE 101 (2), 113 (4), 122 (3), 213 (3), 221 (3), 222 (3), 241 (3), 324 (3), 325 (4), 326 (3), 331 (3), 342 (3), 344 (3), 353 (3), 382 (3), 423 (4)
- MATH 352 (3), 382 (3), 382L (1),
- Technical Electives: A sequence of 12 hours of CSE courses numbered 300 or higher, pre-approved by the student's advisor and the CSE Department. Students are encouraged to select a coherent set of courses as technical electives that will prepare them for a specific focus in their career.
- Each of the above courses must be completed with a grade of *C* or better.
- Electives to complete 130 credit hours.

Sample Curriculum 1 for the **Bachelor of Science in Computer Science** *program*

Semester 1 (Fall)
  4   MATH 131 (calculus)
  2   CSE 101 (introduction to comp science & info tech)

4 CSE 113 (introduction to programming)
3 ENGL 111 (college English)
13 Total credit hours

Semester 2 (Spring)
4 MATH 132 (calculus)
3 CSE 122 (algorithms and data structures)
4 CHEM 121 & 121L (general chemistry I)
3 ENGL 112 (college English)
14 Total credit hours

Semester 2.5 (Summer)
4 CHEM 122 & 122L (general chemistry II)
4 Total credit hours

Semester 3 (Fall)
3 CSE 221 (computer systems)
3 CSE 241 (foundations of computer science)
3 Humanities
5 PHYS 121 & 121L (general physics I)
3 ENGL 341 (technical writing)
17 Total credit hours

Semester 4 (Spring)
3 CSE 213 (intro to object oriented programming)
3 CSE 222 (systems programming)
3 Social Science
5 PHYS 122 & 122L (general physics II)
3 MATH 352 (basic concepts of mathematics)
17 Total credit hours

Semester 5 (Fall)
3 CSE 331 (computer architecture)
3 CSE 344 (design and analysis of algorithms)
3 Humanities
3 MATH 382 (probability and statistics)
1 MATH 382L (probability and statistics)
3 Technical Electives
1 Electives
17 Total credit hours

Semester 6 (Spring)
3 CSE 326 (software engineering)
3 CSE 342 (formal languages and automata)
3 CSE 324 (principles of programming languages)
3 Technical Electives
3 Electives
15 Total credit hours

Semester 7 (Fall)

   3 CSE 353 (data and computer communications)
   4 CSE 423 (compiler writing)
   3 Humanities/Social Science
   3 Technical Electives
   3 Social Science
  16 Total credit hours

Semester 8 (Spring)

   4 CSE 325 (operating systems)
   3 CSE 382 (legal, ethical, social issues)
   3 Humanities/Social Science
   3 Technical Electives
   3 Electives
  16 Total credit hours

Sample Curriculum 2 for the **Bachelor of Science in Computer Science** *program*

Semester 1(Spring)

   4 MATH 131 (calculus)
   4 CSE 113 (introduction to programming)
   3 ENGL 111 (college English)
   4 CHEM 121 & 121L (general chemistry I)
  15 Total credit hours

Semester 1.5 (Summer)

   4 CHEM 122 & 122L (general chemistry II)
   4 Total credit hours

Semester 2 (Fall)

   4 MATH 132 (calculus)
   2 CSE 101 (introduction to comp science & info tech)
   3 CSE 122 (algorithms and data structures)
   5 PHYS 121 & 121L (general physics I)
   3 ENGL 112 (college English)
  17 Total credit hours

Semester 3 (Spring)

   3 CSE 213 (intro to object oriented programming)
   3 CSE 222 (systems programming)
   5 PHYS 122 & 122L (general physics II)
   3 MATH 352 (basic concepts of mathematics)
   3 Social Science
  17 Total credit hours

Semester 4 (Fall)

   3 CSE 221 (computer systems)

3 CSE 241 (foundations of computer science)
2 Electives
3 ENG 341 (technical writing)
3 Humanities
14 Total credit hours

Semester 5 (Spring)
3 CSE 324 (principles of programming languages)
3 CSE 326 (software engineering)
3 CSE 342 (formal languages and automata)
3 MATH 382 (probability and statistics)
1 MATH 382L (probability and statistics)
3 Social Science
16 Total credit hours

Semester 6 (Fall)
3 CSE 331 (computer architecture)
3 CSE 344 (design and analysis of algorithms)
3 CSE 353 (data and computer communications)
3 Humanities
3 Technical Electives
15 Total credit hours

Semester 7 (Spring)
4 CSE 325 (operating systems)
3 CSE 382 (legal, ethical, social issues)
3 Humanities/Social Science
3 Technical Electives
3 Electives
16 Total credit hours

Semester 8 (Fall)
4 CSE 423 (compiler writing)
3 Technical Electives
3 Technical Electives
3 Humanities/Social Science
3 Electives
16 Total credit hours

Minor in Computer Science

Minimum credit hours required: 19
The following courses are required:
- CSE 113 (4) and CSE 122(3)
- Any four out of CSE 324 (3), CSE 325(4), CSE 326(3), CSE 331(3), CSE 342(3), CSE 344(3), and CSE 353(3).
- Each of the above courses must be completed with a grade of *C* or better.

Graduate Program
Master of Science

Students may earn a Master of Science degree in Computer Science or a Master of Science degree in Computer Science with the Information Technology Option through cooperation with the Information Technology faculty.

Master of Science Degree in Computer Science
Without Thesis:
1.) Students must have demonstrated proficiency in the core undergraduate curriculum including the topics normally covered by CSE 324, 325, 331, 342, 344, and 423. Proof of proficiency usually requires grades of B or better in these courses or in equivalent courses approved by the department.
2.) Course work approved by the student's advisory committee fulfilling the general requirements of 27 credit hours for the master's degree. At least 15 credit hours must be in computer science courses numbered 500 or above, not including CSE 590 (Independent Study) or 591 (Thesis). Three of these hours must be CSE 585 (Graduate Seminar).
3.) CSE 590: 3 credit hours.

With Thesis:
1.) Students must have demonstrated proficiency in the core undergraduate curriculum including the topics normally covered by CSE 324, 325, 331, 342, 344, and 423. Proof of proficiency usually requires grades of B or better in these courses or in equivalent courses approved by the department.
2.) Course work approved by the student's advisory committee fulfilling the general requirements of 24 credit hours for the master's degree. At least 15 credit hours must be in computer science courses numbered 500 or above, not including 590 (Independent Study) or 591 (Thesis). Three of these hours must be CSE 585 (Graduate Seminar).
3.) CSE 591 (Thesis): 6 credit hours.

Master of Science Degree in Computer Science with Information Technology Option

Students earning a Master of Science degree in Computer Science can choose the Information Technology Option. The requirements for the Information Technology Option are the same as those for a Master of Science in Computer Science, except that:

Students must demonstrate proficiency in the topics normally covered by CSE 324, CSE 331, CSE 344, IT 321, IT 326, and IT 373. Proof of proficiency usually requires grades of B or better in these courses or in equivalent courses approved by the department.

Course work approved by the student's advisory committee fulfilling the general requirements of 24 credit hours (with thesis) or 27 credit hours (without thesis) for the master's degree. At least 15 credit hours must be in computer science courses numbered 500 or above, not including 590 (Independent Study) or 591 (Thesis). Three of these hours must be CSE 585 (Graduate Seminar). A minimum of 9 credit hours must be in a sequence of upper-division information technology courses approved by the student's advisory committee.

CSE 590 (Independent Study): 3 credit hours; or CSE 591 (Thesis): 6 credit hours.

There is no foreign language requirement for the Master of Science degree in Computer Science or the Master of Science degree in Computer Science with the Information Technology Option. The independent study or thesis topic may be selected, subject to approval from the student's advisory committee and the computer science chair (or information technology program coordinators), from any area of computer science or information technology.

Doctor of Philosophy in Computer Science

Students of exceptional ability as demonstrated in previous course work are encouraged to pursue a doctor of philosophy degree; individuals with substantial experience in industrial research and development may also apply to the doctoral program. The current research programs of the department include parallel computation, information assurance, high speed networks, neural networks, software engineering, verification, genetic algorithms, databases and knowledge-base systems, and computational intelligence. The department also encourages interdisciplinary work with other departments and divisions at Tech and in cooperation with researchers at Los Alamos and Sandia national laboratories.

As computer science and engineering is a diverse and rapidly changing discipline, the program of study of a Ph.D. student will depend on the area of specialization and on prior experience and education. All Ph.D. students will be required to demonstrate master's-level knowledge of the core areas of computer science, as well as a thorough understanding of the intended area of specialization. The core areas include systems (operating systems and computer architectures), programming (programming languages, compilers, data structures, and formal semantics), and theory (automata theory, algorithms, and computational complexity). In addition, all Ph.D. students are required to take three credit hours of CSE 585 (Graduate Seminar). The specific course requirements are determined with the consultation and approval of the student's advisory committee and the chair of the department.

The student must pass a preliminary examination in each of the core areas. A detailed list of topics to be covered is available from the department. The student must also pass a candidacy examination in his or her specific area of specialization. See the description of the Graduate Program, page 47, for further details.

Computer Science Courses:

In the following, each prerequisite requires a grade of *C* or better.

CSE 101, Introduction to Computer Science and Information Technology, 2 cr, 2 cl hrs

Usually offered in the Fall semester.
Brief overview of the discipline of computer science and information technology topics including computer architecture, operating systems and networks, automata and models of computation, programming languages and compilers, algorithms, databases, security and information assurance, artificial intelligence, graphics, and social/ethical issues of computing. (Same as IT 101)

CSE 107, Introduction to Computer Programming using Python, 4 cr, 3 cl hrs, 2 lab hrs

Co-requisite: Math 103
Usually offered in the Fall semester.
The course is designed to introduce programming and its applications to scientists and engineers. The first part of the class focuses on problem solving, algorithm development, top-

down design, modular programming, debugging, testing, data types, flow-control, looping, iteration and recursion, fundamental data structures, and an introduction to object oriented programming. The second part of the class explores data analysis with Python. (Same as IT 107)

CSE 113, Introduction to Programming, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: MATH 103 or equivalent

Usually offered in both Fall and Spring semesters.

The course is designed to introduce problem solving and programming in C to Computer Science majors. Topics include algorithm development; top-down design; modular programming; debugging; testing; control structures including selection, iteration and recursion; number systems; data representation; data types including arrays, strings, pointers and dynamic structures involving memory management. Concepts implemented through extensive programming using good programming style. (Same as IT 113).

CSE 122, Algorithms and Data Structures, 3 cr, 3 cl hrs

Prerequisite: CSE 113

Corequisite: MATH 132

Usually offered in both Fall and Spring semesters.

Fundamental data structures including linked lists, trees, hash tables, and graphs. Algorithms for sorting, searching, and other fundamental operations. Introduction to mathematical foundations for analysis of iterative and recursive algorithms and for bask correctness proofs. Analysis of algorithms. Implementation of selected algorithms using sound programming methodologies. (Same as IT 122)

CSE 209, Programming Language Practicum, 1 cr, 3 lab hrs

Prerequisite: Knowledge of elementary programming

A practical course teaching the use of a programming language of current interest. May be repeated for credit with different languages.

CSE 213, Introduction to Object Oriented Programming, 3 cr, 3 cl hrs

Prerequisite: CSE 113, 122

Usually offered in the Spring semester.

Introduction to programming in an object oriented language (e.g., Java): review of problem solving, algorithm development, top-down design, modular programming, debugging, testing, control structures including selection, iteration and recursion, data types including arrays, strings, pointers, and dynamic structures. Object oriented concepts will include: objects, classes, inheritance, instances, methods, interfaces, packages, encapsulation, and polymorphism. Concepts implemented through extensive programming using good programming style. (Same as IT 213)

CSE 221, Computer System Organization, 3 cr, 3 cl hrs

Prerequisite: CSE 122

Usually offered in the Fall semester.

The hardware/software interface. Basic organization of hardware and operating systems. Memories, buses, interrupts, input and output, and instruction set architecture. Programming in assembly language. (Same as IT 221)

CSE 222, Systems Programming, 3 cr, 3 cl hrs

Prerequisite: CSE 122

Usually offered in the Spring semester

This course provides an introductory overview of operating systems and system programming, mainly focusing on system-level programming based on OS services and other APIs. Topics include system calls, file I/O, files and directories, memory management, process control, inter-process communication (IPC), socket-based network programming, remote procedure call (RPC) programming, and basic security mechanisms. Course work includes substantial programming homework and team-based projects.

CSE 241, Foundations of Computer Science, 3 cr, 3 cl hrs

Prerequisite: Math 132
Usually offered in the Fall semester

Propositional and predicate logic. Analytic reasoning and mathematical proofs. Abstraction, iteration, recursion, and induction. Fundamental discrete structures. Basic concepts of algorithms, formal languages, and computation.

CSE 321, Internet and Web Programming, 3 cr, 3 cl hrs

Prerequisite: CSE 213, 221

This course has a practical emphasis on the design and techniques for developing internet-based applications, mainly focusing on web programming. Topics include HTML, client-side scripting language (JavaScript), server-side programming (Servlets, JSP, and J2EE), and XML/web services (Java and .NET). This course will also cover some important topics needed for internet-based application developments, such as Internet architectures, basic object-oriented programming (OOP) concepts, and web security. Course work includes substantial programming homework and team-based projects. (Same as IT 321)

CSE 324, Principles of Programming Languages, 3 cr, 3 cl hrs

Prerequisite: CSE 122
Co-requisite: CSE 213
Usually offered in the Spring semester.

Introduction to low (micro/macro) and high level languages (L/HLLs) -- features and positions within the computer system. definition of HLLs of syntax and semantics. Data types, control structures, concurrency, declarations, procedures. Recursion and recursive definitions. Procedural and data abstraction. Critique of major programming languages features and design issues (e.g., power, efficiency, security, modularity, readability, etc).Examples from major realms of current programming languages -- imperative (block structured, object oriented), declarative (function, logic) paradigms.

CSE 325, Principles of Operating Systems, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: CSE 221 and 222
Usually offered in the Spring semester.

Software I/O buffering. Discussion of concurrent processes, including mutual exclusion, synchronization, and deadlock. Processor scheduling, memory management, and resource control. Hoare's monitors. File systems. Each student is expected to design and implement a small operating system as a substantial portion of the course grade.

CSE 326, Software Engineering, 3 cr, 3 cl hrs

Prerequisites: CSE 122, 213
Usually offered in the Spring semester.

This course provides the introductory overview of software engineering, concentrating on

large-scale software system design and implementation. Topics include software life cycle, UML-based design language, design tools and techniques, design documentation, software testing, and software project management. Course work includes a team-based project. (Same as IT 326)

CSE 328, Secure Software Construction, 3 cr, 2 cl hrs, 1 lab hr
Prerequisite: CSE 222, CSE 213
Formal methods and practical techniques for the specification, design, implementation, and validation of computer software. Current software engineering and management practices, with emphasis on ensuring software reliability, safety, and security. Course work includes a team project to develop a sizeable, real-world application software. (Same as IT 328)

CSE 331, Computer Architecture, 3 cr, 3 cl hrs
Prerequisite: CSE 221
Usually offered in the Fall semester.
Computer design fundamentals and hardware components: instruction set design, memory hierarchies, ALU's, control units, bus architectures, input and output, system design. Performance modeling and measurement.

CSE 342, Formal Languages and Automata, 3 cr, 3 cl hrs
Prerequisite: CSE 241; MATH 352.
Usually offered in the Spring semester.
Regular expressions. Regular, context-free, context-sensitive and unrestricted grammars and languages. Finite and pushdown automata. Turing machines, recursive and recursively enumerable languages. Decidability and the halting problem.

CSE 344, Design and Analysis of Algorithms, 3 cr, 3 cl hrs, 1 lab hr
Prerequisites: CSE 122, CSE 241; MATH 352
Usually offered in the Fall semester.
Asymptotic complexity of algorithms. Analysis of iterative and recursive algorithms; amortized analysis. Design paradigms: greedy and dynamic programming approaches. Interplay of data structures and algorithms. Introduction to the theory of NP–completeness.

CSE 351, Modeling and Simulation Technologies for Information Systems, 3 cr, 3cl hrs
Prerequisites: CSE 122; CSE 241
Fundamentals and techniques for designing and using simulation, modeling, and optimization algorithms with applications in system performance modeling, business infrastructure modeling, and distributed and parallel computing. An introduction to advanced complex systems models. (Same as IT 351)

CSE 353, Data and Computer Communication, 3 cr, 3 cl hrs
Prerequisites: CSE 222
Usually offered in the Fall semester.
Basic concepts of data communication. Transmission media (wireline and wireless) characteristics and utilization. Digital and analog data signaling, modulation, and coding. Signal and channel analysis. Concepts from information theory. Data channel multiplexing and subnet switching. Fiber optics networking technology-- design and deployment, all-optical-fiber-networks, Synchronous and asynchronous carriers (DS, SONET/ SDH). MAC protocols for channel access and allocation. Data link control, design issues, link management, error and flow control. Wireless technology and protocols standards-- IEEE 802.11 Terra b/s physical layer & 802.11 MAC sublayer protocols. Overview of the OSI vs. TCP/IP protocol

stacks. The Internet protocol structure- "subnet" and interfaces. Examples of LAN, MAN, and WAN. Principles of internetworking: relays and protocols (bridges/routers/gateways) and , Introduction to Internet Security and protocols-- IPSec; VPN. (Same as IT 353)

CSE 373, Introduction to Database Systems, 3 cr, 3 cl hrs

Prerequisite: CSE 122, CSE 241

Conceptual modeling and database design using the entity-relationship model. The relational model; relational algebra and relational query languages; design theory for relational databases. Database integrity. Physical data organization. Introduction to problems of concurrency control, recovery, security, and distributed databases. Course work includes a project using SQL and the Oracle Database Management System. (Same as IT 373)

CSE 382, Legal, Ethical, and Social Issues of Information Technology, 3 cr, 3 cl hrs

Prerequisite: CSE 326
Usually offered in both Fall and Spring semesters

A survey of current legal IT (and general business and management) issues. Social and ethical issues associated with IT and management of secure information systems. (Same as IT 382)

CSE 391, Directed Study, cr and topics arranged

CSE 423, Compiler Writing, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: CSE 324, 326, 342, 344
Corequisite: CSE 331
Usually offered in the Fall semester.

Implementation of compilers for higher level computer languages including: parsing, symbol table management, code emission, and code optimization. Each student implements a small compiler and designs an optimizing compiler as a substantial portion of the course grade. Individual and group projects. Practice in developing software requirement, specification, design, and test plan documents.

CSE 441, Cryptography and Applications, 3 cr, 3 cl hrs (Same as IT 441)

Prerequisites: CSE 122, CSE 241

This course provides an introductory overview of modern cryptographic theory and techniques, mainly focusing on their application into real systems. Topics include number theory, probability and information theory, computational complexity, symmetric and asymmetric cryptosystems, one-way functions, block and stream ciphers, Kerberos authentication systems, public key infrastructure (PKI), secure socket layer/transport layer security (SSL/TLS), and cryptographic protocols/applications in many real systems. (Same as IT 441)

CSE 451, Introduction to Parallel Processing, 3 cr, 3 cl hrs

Prerequisites: CSE 122

Introduction to supercomputers and massively-parallel machine architecture, models of parallel computation, parallel algorithms, synchronization, parallel languages, data and functional parallelism, parallel performance analysis, popular interfaces, and parallel debugging. Students will gain experience in parallelization of sequential algorithms and implementation of parallel algorithms. (Same as IT 451)

CSE 452, Introduction to Sensor Networks, 4 cr, 3 cl hrs, 2 lab hrs

Prerequisites: CSE 325 and CSE 353, or consent of instructor

Introduction to sensory technology with special focus on wireless sensor networks (WSNs) applications, topologies, deployment, sensed data manipulation, mobile ad-hoc wireless communication, security. Low power consumption and data rates WSNs protocols (e.g., ZigBee/IEEE808.15.4). Students will get familiar with sensor nodes' hardware (motes and sensor boards) and programming (TintOS and ZigBee application objects) via a set of practical lab/field experiments that covers the design, implementation, deployment, and data collection/analysis of some actual WSNs data/vent acquisition systems (e.g., environment monitoring, remote asynchronous event detection--forest fire, border intrusion, tsunami, earthquake, volcanic activities, etc).

CSE 453, Computer Networks and the Internet, 3 cr, 3 cl hrs
Prerequisite: CSE 353
Layering of protocols (ISO, ITU and TCP/IP stacks) and network architectures. Fiber optics technology and high speed networks. Internetworking: global addresses/names and translation, virtual networks and tunnels, routing, subnetting, IPv6, multicasting. Mobile IP. End-to-end protocols, TCP and UDP. Congestion control and resource allocation. Socket interfacing, client-server and API. The QoS mechanism integrated/differentiated), ATM QoS. Network security: information and link security, encryption, internetworking security, IPsec, firewalls, VPN, wireless security. (Same as IT 453)

CSE 454, Computer Graphics, 3 cr, 3 cl hrs
Prerequisites: CSE 213, 222; MATH 254
Design and implementation of visual interfaces. Graphics input and output hardware, display programming, 2-D transformations, approximation techniques for curve and surface representation. Introduction to the creation of 3-D computer-generated images, color theory, lighting and shading.

CSE 463, Information Assurance, 3 cr, 3 cl hrs
Prerequisite: Senior standing
Defense and offensive information warfare. Information system security. Computer break-ins, hacking, and other attack methods. Vulnerability and risk analysis. Theory and applications of cryptography. Intrusion detection and incident response. Security planning and management. (Same as IT 463)

CSE 464, Introduction to Soft Computing, 3 cr, 3 cl hrs
Prerequisites: CSE 344; MATH 382
Major types of artificial neural networks. Fuzzy logic theory and fuzzy systems construction. Genetic algorithms and evolutionary computing. Intelligent systems and engineering applications. Comparative study of the soft computing paradigm as a problem solving methodology.

CSE 476, Visualization, 3 cr, 3 cl hrs
Prerequisite: CSE 122 or consent of instructor
This course presents application of graphical visualization to current problems, with a focus on extracting and representing information in multidimensional data sets using 2D and 3D graphics. Topics include visualization tools and techniques, human vision and perception, color mapping, sound, data representation for insight extraction, time visualization, visual analytics, volume rendering, surface extraction and rendering. Students will develop visualizations of real world problems. (Same as IT 476)

CSE 489, Special Topics in Computer Science, 3 cr, 3 cl hrs
Prerequisites: CSE 213, 222 and consent of instructor
Undergraduate special topics in computer science.

CSE 491, Directed Study, cr and topics arranged
Can not be used toward graduation.

CSE 500, Directed Research, cr and topics arranged
This course may not be used to fulfill graduate degree requirements. Research under the guidance of a faculty member.

CSE 523, Advanced Compiler Writing, 3 cr, 3 cl hrs
Prerequisite: CSE 423
Advanced topics in compilation, such as theory of parsing, error recovery, optimization, semantics- directed translation, and hardware-independent and hardware-specific code generation.

CSE 525, Advanced Operating Systems, 3 cr, 3 cl hrs
Prerequisites: CSE 325 and 331; or consent of instructor
Advanced topics in operating systems such as real-time, distributed systems, fault-tolerance, parallel I/O, performance, safety-critical systems, and verification.

CSE 528, Formal Methods in Software Development, 3 cr, 3 cl hrs
Prerequisites: CSE 342; CSE 325 or 328 or 423 or equivalent experience
Use of mathematics, logic, and computer science theory in software development. Formal specifications; systematic development of programs from specifications. Correctness proofs and other analysis techniques.

CSE 531, Advanced Computer Architecture, 3 cr, 3 cl hrs
Prerequisite: CSE 331
Advanced topics in computer architecture.

CSE 532,Fault-Tolerant Computing, 3 cr, 3 cl hrs
Prerequisite: CSE 331; or consent of instructor
Techniques for design of fault-tolerant digital devices with on-line self-error-detection and self-error-correction. Fault-tolerant PLAs, gate arrays, and computer memories. Fault-tolerant computer architectures. Application of error-detecting and error-correcting codes for design of reliable devices with self-error detection/correction. Design of self-checking checkers. Combining on-line and off-line error-detecting techniques. Reliability analysis of fault-tolerant devices. Self-error detection/correction for multiprocessors.

CSE 542, Advanced Formal Language Theory, 3 cr, 3 cl hrs
Prerequisite: CSE 342
Extensive study of context-sensitive and recursively enumerable languages; closure properties, decidability, and ambiguity of various language classes. Special topics as time permits.

CSE 544, Analysis of Algorithms, 3 cr, 3 cl hrs
Prerequisite: CSE 344
Analysis of correctness and complexity of asymptotically efficient algorithms. Set partitioning, dominators of dags (with applications in code optimization), Strassen's matrix multiplication algorithm, FFT, Schonnage-Strassen integer multiplication algorithm, pattern matching, NP complete problems (both time and space), lower bounds. Discussion of

problems for which no efficient algorithms exist.

CSE 546, Theory of Computation, 3 cr, 3 cl hrs

Prerequisite: CSE 342

Effective computability of functions and sets in terms of Turing machines and other computational models. Universal machines and examples of unsolvable problems. The Church-Turing thesis and formal proofs of the equivalence of Turing machines, systems of recursion equations, and other models of computation. Mathematical properties of the classes of recursive functions. Recursive and recursively enumerable sets.

CSE 551, Advanced Parallel Processing, 3 cr, 3 cl hrs

Prerequisite: CSE 451; or consent of instructor

This course focuses on the application of models of parallel computation, parallel algorithms, synchronization, parallel languages, parallel performance analysis, and parallel debugging to large problems and complex systems. Topics include: integrating data and shared memory parallelism, multilevel domain decompositions, portability, and scalability. Student will parallelize and analyze the performance of a complex system or application.

CSE 553, Advanced Computer Networks, 3 cr, 3 cl hrs

Prerequisite: CSE 453

Models of computer networks. Design and analysis issues. Abstract syntax notation, data compression, security and authentication. Recent developments in the field.

CSE 565, Neural Nets, 3 cr, 3 cl hrs

Prerequisites: CSE 344; MATH 254 and 382; or consent of instructor

Neuron modeling. The perceptron and multilayer perceptrons. Learning algorithms. The Kohonen model, the Grossberg model, the Hopfield model. Associative memory. Applications. Recent developments in the field.

CSE 567, Soft Computing, 3 cr, 3 cl hrs

Prerequisites: MATH 254, 382; CSE 344 or equivalent, or consent of instructor

Artificial neural networks, with emphasis on multiplayer feedback networks, self-organizing networks, and Hopfield-style networks. Learning algorithms. Introduction to fuzzy systems and evolutionary computing. Engineering applications of soft computing. (Same as MENG 567: Smart Engineering Systems)

CSE 568, Intelligent Systems, 3 cr, 3 cl hrs

Prerequisites: MATH 254, 382; CSE 344 or equivalent, or consent of instructor

Overview of the major paradigms of soft computing: neural networks, fuzzy systems, and evolutionary computing. In-depth coverage of selected topics in each area as relevant to intelligent systems. Recent advances in the field, and case studies of intelligent systems. Coursework includes a large-scale project. (Same as MENG 568: Smart Engineering Systems II)

CSE 569, Embedded Systems Design, 3 cr, 3 cl hrs

Prerequisite: consent of instructor

Hardware/software systems and codesign. Embedded processor architecture and programming. Models of computation for embedded systems. Behavioral design. OS primitives for concurrency, timeouts, scheduling, communication and synchronization. Architecture selection. Simulation, synthesis, and verification. Hardware/software implementation. Performance analysis and optimization. Application-level embedded system

design concepts such as basic signal processing and feedback control. Design methodologies and tools. Design examples and case studies.

CSE 570, Real-Time Systems, 3 cr, 3 cl hrs
Prerequisite: consent of instructor
Classification of real-time systems. Fundamental theorems and corollaries of deadline and fixed priority real-time scheduling techniques. Schedulability analysis. Scheduling techniques to guarantee an array of timing requirements. Implementation of a set of tasks with periodic and aperiodic timing requirements. Execution time estimation of a piece of code. Modification of scheduling algorithms in a real-time kernel. Performance evaluation of an operating system for real-time applications.

CSE 573, Database and Knowledge-base Systems, 3 cr, 3 cl hrs
Prerequisites: CSE 373; CSE 241
Databases, object bases, and knowledge bases.Data models. Logical foundations of database and knowledge-base systems.Query optimization.Selected topics from current research.

CSE 576, Advanced Visualization, 3 cr, 3 cl hrs
Prerequisite: consent of instructor
This course presents application of graphical visualization to large problems and complex systems, with a focus on extracting and representing information in multidimensional data sets using 2D and 3D graphics. Topics include visualization tools and techniques, human vision and perception, color mapping, sound, data representation for insight extraction, time visualization, visual analytics, volume rendering, surface extraction and rendering. Students will perform visual analytics research for large problems and/or complex systems.

CSE 581, Directed Study, cr to be arranged

CSE 585, Graduate Seminar, 3 cr

CSE 589, Special Topics in Computer Science, 3 cr, 3 cl hrs
Prerequisites: Two semesters of upper division courses in computer science and consent of instructor.
Graduate special topics in computer science.

CSE 590, Independent Study, cr to be arranged

Under the direction of a faculty member appointed by the department, the student shall prepare a paper making use of standard reference sources on some topics not covered by other course work.

CSE 591, Thesis (master's program), cr to be arranged

CSE 595, Dissertation (doctoral degree program), cr to be arranged

Faculty Research Interests

Anselmo—Strategic Management, Decision Theory, Risk Analysis
Lassez—Constraint and Logic Programs, Dynamical Systems, Bioinformatics
Liebrock—Computer Forensics, Information Assurance, Parallel Processing, Well Posedness Analysis, Visualization
Mazumdar—Mobile and distributed databases: integrity, privacy, security; Information

Systems, Software Integrity

Mukkamala—Information Assurance, Digital Forensics, Knowledge Mining, Applied Soft Computing Techniques, Bioinformatics, Information and Network Security Practices

Rezgui —Cloud Computing, Service-based computing, Energy-aware cellular networks

Shin— System security, Usable Security, Applied Cryptography, Software Engineering

Soliman—Computer Networks — fiber/wireless modern technologies and protocols, Sensor Networks — modern technologies and protocols, Computer/Sensor Networks Security, Programming Languages, Neural Networks — applications in: image compression, cloud computing management, and sensor networks.

Stavely—Formal Methods in Software Engineering, Programming Languages, Computational Logic

Sung—Computational Intelligence, Information Security, Bioinformatics

Zheng—Computer Architecture, Wireless Networking, Image Processing