

# Computer Science and Engineering

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

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.

Our graduate programs provide students the opportunity to take courses, select advisory committee members, and pursue research in an area of interest to a faculty supervisor. 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. Master's students usually participate in faculty research projects to complete their thesis or (non-thesis) independent study report.

New Mexico Tech's Department of Computer Science and Engineering also offers a *Ph.D. in Computer Science* program. The Ph.D. program is appropriate for students with motivation for research and either a superior track record in coursework or substantial experience in industrial research and development.

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**

Our mission 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 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.

## Program Outcomes

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

- the ability to design, implement, and test small software programs, as well as large programming projects;
- knowledge of the theoretical concepts of computing;
- knowledge of the fundamental principles of programming languages, systems, and machine architectures;
- exposure to one or more computer science application areas;
- technical communication skills in written and oral form;
- the capacity to work as part of a team; and
- 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—123*

In addition to the General Education Core Curriculum (page 88), 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 (4), 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, with no more than one course numbered CSE 485. 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.
- General 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 (intro to comp science & info tech)
- 4 CSE 113 & 113L (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 CSE 331 (computer architecture)
- 5 PHYS 122 & 122L (general physics II)
- 3 MATH 352 (basic concepts of mathematics)
- 17 Total credit hours

#### Semester 5 (Fall)

- 4 CSE 325 & 325L (operating systems)
- 4 CSE 344 & 344L (design & analysis of algorithms)
- 4 MATH 382 & 382L (probability and statistics)
- 3 Technical Electives
- 15 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 Humanities
- 15 Total credit hours

## Semester 7 (Fall)

3	CSE 353 (data and computer communications)
4	CSE 353 (data and computer communications)
3	CSE 382 (legal, ethical, social issues)
3	Humanities/Social Science
3	Technical Electives
<u>3</u>	Social Science
15	Total credit hours

## Semester 8 (Spring)

4	CSE 423 & 423L (compiler writing)
6	Humanities/Social Science
<u>3</u>	Technical Electives
13	Total credit hours *

\* In order to earn or retain the NM Lottery Scholarship, students must earn 15 credits each semester. Please see

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

## Semester 1(Spring)

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

## Semester 1.5 (Summer)

<u>4</u>	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)
<u>3</u>	ENGL 112 (college English)
17	Total credit hours

## Semester 3 (Spring)

3	CSE 213 (intro to object oriented programming)
3	CSE 222 (systems programming)
3	CSE 324 (principles of programming languages)
5	PHYS 122 & 122L (general physics II)
<u>3</u>	Social Science
17	Total credit hours

## Semester 4 (Fall)

3	CSE 221 (computer systems)
3	CSE 241 (foundations of computer science)
3	MATH 352 (basic concepts of mathematics)
3	ENG 341 (technical writing)
<u>3</u>	Humanities
15	Total credit hours

## Semester 5 (Spring)

3	CSE 326 (software engineering)
3	CSE 331 (computer architecture)
3	CSE 342 (formal languages and automata)
4	MATH 382 & 382L (probability and statistics)
<u>3</u>	Social Science
16	Total credit hours

## Semester 6 (Fall)

4	CSE 325 & 325L (operating systems)
4	CSE 344 & 344L (design and analysis of algorithms)
3	CSE 353 (data and computer communications)
<u>3</u>	Humanities
14	Total credit hours *

## Semester 7 (Spring)

4	CSE 423 & 423L (compiler writing)
3	Humanities/Social Science
<u>6</u>	Technical Electives
13	Total credit hours *

## Semester 8 (Fall)

3	CSE 382 (legal, ethical, social issues)
3	Technical Electives
3	Technical Electives
<u>3</u>	Humanities/Social Science
12	Total credit hours *

\* In order to earn or retain the NM Lottery Scholarship, students must earn 15 credits each semester. Please see your advisor for more information.

**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 Specialization in Information Technology through cooperation with the Information Technology faculty.

#### Master of Science Degree in Computer Science

The M.S. program in Computer Science is based on course work as well as research (either thesis or independent study option). The student must meet the general requirements of the Graduate Program. In addition, the student must fulfill the following requirements, depending on the research option:

##### Without Thesis:

- 1) Course work approved by the student's advisory committee fulfilling the general requirements of 27 credit hours for the master's degree must include CSE 524, 525, 544, and 546, unless already completed with a C or better. At least 18 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).
- 2) CSE 590: 3 credit hours.

##### With Thesis:

- 1) Course work approved by the student's advisory committee fulfilling the general requirements of 24 credit hours for the master's degree must include CSE 524, 525, 544, and 546, unless already completed with a C or better. At least 18 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).
- 2) CSE 591 (Thesis): 6 credit hours.

#### Master of Science Degree in Computer Science with Specialization in Information Technology

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

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 must include CSE 524, 528, 544, and 553, unless already completed with C or better. At least 18 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.

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 Specialization in Information Technology. 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.

#### Five Year Program: CS B.S./M.S. Program

Highly motivated students with strong academic records may earn a Bachelor of Science in Computer Science and a Master of Science in Computer Science within a five-year period. The BS in CS degree requires a total of 123 credit hours, while the MS in CS degree associated with this program requires a total of 30 credits hours. Three credits of 300-level or above may be shared between the graduate and undergraduate degree. Combined, a total of 150 credit hours are required to earn both degrees. Students may apply for the CS BS/MS program at the end of their 4th semester, and students admitted to the program may apply for graduate standing during their senior year. The BS in CS and MS in CS degrees will be awarded simultaneously upon completion of the MS in CS degree requirements.

## 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 page 58 for further details.

Before the degree is approved and granted, at least one paper on the subject matter from the dissertation must be accepted for publication to a reputable journal or conference proceedings acceptable to the doctoral committee of the student.

## Computer Science Courses:

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

**Some courses are marked 'cannot be used towards graduation' to emphasis that they cannot be used to fulfill the requirements for the major; they *can* be used as general electives to complete 130 credit hours.**

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

*Usually offered in both the Fall and Spring semesters.*

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**

*Co-requisite: MATH 131*

*Usually offered in both Fall and Spring semesters.*

The course is designed to introduce problem solving and programming in C to Computer Science majors and those interested in applications of the language that involve dynamic structures and memory management. 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 with a grade of C or higher*

*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 basic 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 and CSE 101 with a grade of C or higher.*

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 101, 113, 122 each with a grade of C or higher*

*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 101, 122 each with a grade of C or higher*

*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 101, 122 each with a grade of C or higher*

*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: CSE 101, Math 132 each with a grade of C or higher*

*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 with a grade of C or higher*

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 (e.g., Servlets, JSP, and J2EE), and XML/web services (e.g., 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 with a grade of C or higher*

*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, 222 each with a grade of C or higher*

*Usually offered in the Fall 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 each with a grade of C or higher*

*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 each with a grade of C or higher*

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 with a grade of C or higher*

*Usually offered in the Spring 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 each with a grade of C or higher*

*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, 4 cr, 3 cl hrs, 1 lab hr**

*Prerequisites: CSE 122, CSE 241; MATH 352 each with a grade of C or higher*

*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 each with a grade of C or higher*

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, Introduction to Computer Networks, 3 cr, 3 cl hrs**

*Prerequisites: CSE 222 with a grade of C or higher*

*Usually offered in the Fall semester*

Introduction to computer networking, the ISOOSI protocol stack, LAN, MAN, and WAN. Physical layer: transmission media (wireline and wireless); data signaling, modulation, and coding; multiplexing. Fiber optics networking technology: protocols & examples. Data link Layer: error/flow control— protocols design issues; MAC protocols for channel access and allocation. Wireless technology and protocols standards — IEEE 802.11 physical layer and MAC sublayer protocols. Network layer: subnet switching (CS/DG/VC) & routing protocols (Non/Adaptive); Congestion Control and QoS protocols. ISO vs. (TCP-UDP)/IP the Internet protocol stacks. Internet relays and protocols, e.g., routers, gateways, etc. Introduction to network security. Application layer protocols, E.G., DNS, E-mail, etc. (Same as IT 353.)

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

*Prerequisite: CSE 122, CSE 241 each with a grade of C or higher*

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, 382D, Ethical and Social Issues of Information Technology, 3 cr, 3 cl hrs**

*Prerequisite: CSE 326 with a grade of C or higher*

*Usually offered in the Fall semester*

Philosophy of ethics. Social and ethical issues associated with computing and information technologies. Ethics and the responsibilities of computing professionals. Legal ramifications will be explored whenever possible. (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 each with a grade of C or higher*

*Corequisite: CSE 331*

*Usually offered in the Spring 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 each with a grade of C or higher*

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, 451D, Introduction to Parallel Processing, 3 cr, 3 cl hrs**

*Prerequisites: CSE 122 with a grade of C or higher*

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

*Prerequisites: CSE 325 and CSE 353 each with a C or higher, 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 (TinyOS 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, Advances in Computer Networks and the Internet, 3 cr, 3 cl hrs**

*Prerequisite: CSE 353 with a grade of C or higher*

In depth coverage of layering of protocols' stacks (ISOOSI and TCP/IP) and computer networks architectures, modern examples of LANs, MANs, WANs protocols/architectures. Recent developments in Fiber optics technology — protocols and architectures. High speed "all-fiber-optics" networks. Internetworking: global addresses/names and translation, virtual networks and tunnels, routing, subnetworks switching protocols, IPv6, multicasting. Mobile IP. End-to-end protocols, TCP and UDP. Advances in congestion control and resource allocation. Client-server models & applications. The QoS mechanism integrated/differentiated), ATM QoS. Network security: information and link security, encryption, internetworking security, IPsec, firewalls, VPN, wireless security. Analysis of networks protocols. (Same as IT 453.)

**CSE 454, Computer Graphics, 3 cr, 3 cl hrs**

*Prerequisites: CSE 213, 222; MATH 254 each with a grade of C or higher*

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, 463D, 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 each with a grade of C or higher*

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, 476D, Visualization, 3 cr, 3 cl hrs**

*Prerequisite: CSE 122 with a grade of C or higher, 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 485, Undergraduate Seminar on Special Topics, 3 cr, 3 cl hrs**

*Prerequisite: Senior standing, one semester of upper division courses in computer science, and consent of the instructor*

A research seminar for undergraduate students with a focus either on special topics in computer science or on the methodology and skills required for research in computer science. *Use as technical electives is limited (see requirements above), but may be taken multiple times as a general elective.*

**CSE 489, 489D, Special Topics in Computer Science, 3 cr, 3 cl hrs**

*Prerequisites: CSE 213, 222 with a grade of C or higher and consent of instructor*

Undergraduate special topics in computer science. For a list of recent offerings, please visit the department's website.

**CSE 491, 491D, Directed Study, cr and topics arranged**

*Cannot 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 with a grade of C or higher*

Advanced topics in compilation, such as theory of parsing, error recovery, optimization, semantics- directed translation, and hardware-independent and hardware-specific code generation.

**CSE 524, Advanced Programming Languages, 3 cr, 3 cl hrs**

*Prerequisites: CSE 324, 344 each with a grade of C or higher, or consent of instructor*

In depth coverage of High Level languages pure/hybrid Paradigms, data manipulation and coding complexity. Modern trends in the design and philosophy of languages. Formal semantics of programming languages. Selected topics from current research.

**CSE 525, Advanced Operating Systems, 3 cr, 3 cl hrs**

*Prerequisites: CSE 325 and 331 with a grade of C or higher 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 326, 342, and 344 with a grade of C or higher 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 with a grade of C or higher or consent of instructor*

This course covers advanced topics in computer architecture which may include superscalar and superpipelined architectures, memory hierarchies, multicore systems, multiprocessor systems, vector processors, interconnection networks.

**CSE 532, Fault-Tolerant Computing, 3 cr, 3 cl hrs**

*Prerequisite: CSE 331 with a grade of C or higher, 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 with a grade of C or higher*

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, Advanced Algorithms, 3 cr, 3 cl hrs**

*Prerequisite: CSE 344 with a grade of C or higher, or consent of instructor*

Analysis of correctness and complexity of asymptotically efficient algorithms. Hybrid data structures; Competitive algorithms; Graph algorithms including flow networks and maximum bipartite matching; Algorithms for matrix inversion and solution of linear equations; Linear Programming; Computational geometry; NP-complete problems and Approximation algorithms. Algorithms in areas of current interest.

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

*Prerequisite: CSE 342 with a grade of C or higher*

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, 551D, Advanced Parallel Processing, 3 cr, 3 cl hrs**

*Prerequisite: CSE 451 with a grade of C or higher, 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 353 with a grade of C or higher*

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

**CSE 563, Access Control and System Security, 3 cr, 3 cl hrs**

*Prerequisites: Consent of instructor*

Topics include theoretical foundations for access control, formal access control models, access control mechanisms, tools and techniques, information flow policy, trust management, security architectures, and current issues of advanced research in access control. In addition, the protection mechanisms of general-purpose operating systems, software systems, and web applications are discussed.

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

*Prerequisites: CSE 344; MATH 254 and 382 with a grade of C or higher, 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 with a grade of C or higher, 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 with a grade of C or higher, 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 570, Privacy in Mobile Environments, 3 cr, 3 cl hrs**

*Prerequisite: consent of instructor*

The notion of privacy; privacy threat model; Anonymity through k-anonymity, l-diversity, t-closeness, etc. Approaches to protect the location, identity, and query history of mobile users. Recent developments.

**CSE 572, Advanced Data Management, 3 cr, 3 cl hrs**

*Prerequisite: consent of instructor*

Semi-structures, unstructured, and graph data; Large data versus BigData; Relational versus NoSQL and centralized versus distributed databases; Query processing and the MapReduce model; Storage, Recovery, Concurrency, Consistency, Availability, and Scalability.

**CSE 573, 573D, Database and Knowledge-base Systems, 3 cr, 3 cl hrs**

*Prerequisites: CSE 373, CSE 241 with a grade of C or higher*

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, 576D, 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, 585D, Graduate Seminar, 3cr, 3 cl hrs**

*Prerequisite: CSE Graduate Standing*

An introduction to the methodology and skills required for academic research with emphasis on computer science. Students will learn the skills involved in discussing technical ideas; articulating research problems; critiquing, writing, and defending research proposals; reading, reviewing, and presenting research articles with appropriate visual aids; and exploring ethical issues associated with research. Students are expected to attend all presentations by outside speakers in the *CS Speaker Series* during the semester. Typically offered each fall.

**CSE 589, 589D, 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. For a list of recent offerings, please visit the department's website.

**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**

*Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.*

## Faculty Research Interests

Anselmo—Strategic Management, Decision Theory, Risk Analysis

Clausen — Software Construction, Internet via Satellite, Multimedia/Internet Technologies, Embedded Systems

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

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

Sung—Computational Intelligence, Information Security, Bioinformatics

Zheng—Mobile Computing, Computer and Network security, Machine Learning and its Applications