

## Computer Science

### CS 1000 - Explorations in Computing

An introduction to the study of computing: fundamental concepts and skills; opportunities at Michigan Tech; career opportunities; social and ethical issues.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall

**Restrictions:** Must be enrolled in one of the following Major(s): Software Engineering, Computer Science, Computer Systems Science, Computer Engineering, Electrical Engineering; Must be enrolled in one of the following Class(es): Freshman

### CS 1090 - Special Topics in Computer Science

Special topics in computer science offered on occasion based on student and faculty demand and interest.

**Credits:** variable to 3.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

### CS 1121 - Introduction to Computer Science I

Starting point of the computer science programs. A high-level, object-oriented programming language is introduced as a problem-solving tool. Topics include design, coding, documentation, debugging, and testing of programs. Programming assignments are given in both a closed lab setting and as homework.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-2-2)

**Semesters Offered:** Fall, Spring, Summer

**Pre-Requisite(s):** MA 1031(C) or MA 1032(C)

### CS 1122 - Introduction to Computer Science II

Continuation of CS 1121. Topics include data abstraction, class hierarchies and polymorphism, list, stack and queue data structures, informal complexity-based algorithm and data structure choices, and recursion. Homework programming assignments are given. Not open to students with credit in CS1129.

**Credits:** 2.0

**Lec-Rec-Lab:** (0-2-0)

**Semesters Offered:** Fall, Spring, Summer

**Pre-Requisite(s):** CS 1121

### CS 1129 - Introduction to Computer Science II in C++

Continuation of CS1121. Topics include data abstraction, class hierarchies and polymorphism, list, stack and queue data structures, informal complexity-based algorithm and data structure choices, and recursion. The C and C++ programming languages are presented and uses. Not open to students with credit in CS1122.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** May not be enrolled in one of the following Major(s): Software Engineering, Computer Systems Science, Computer Engineering, Computer Science

**Pre-Requisite(s):** CS 1121

### CS 1131 - Computer Science I

An alternative starting point of the computer science programs for students with some programming experience, combining material from CS1121 and CS1122, offered at an accelerated pace. Homework programming assignments are given.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-4-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** Permission of department required

**Pre-Requisite(s):** MA 1031 or MA 1032

### CS 1721 - Object Oriented Design

Principles of object oriented design. Includes the software life cycle and unit testing. Students are required to design, unit test, implement, and final test a relatively large project.

**Credits:** 1.0

**Lec-Rec-Lab:** (0-1-0)

**Semesters Offered:** Fall, Spring

**Pre-Requisite(s):** CS 1121 or CS 1131

### CS 2090 - Special Topics in Computer Science

Special topics in computer science offered on occasion based on student and faculty demand and interest.

**Credits:** variable to 3.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

### CS 2141 - Software Development Methods Using C/C++

This course provides an accelerated coverage of C/C++ for Java programmers. Topics include object oriented design with UML, object oriented programming with C++, C/C++ memory model, differences between C and C++ use of libraries, and debugging with modern tools.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring, Summer

**Pre-Requisite(s):** CS 1721 and CS 2321

### CS 2311 - Discrete Structures

Presents fundamental concepts in discrete structures that are used in computer science. Topics include sets, trees, graphs, functions, relations, recurrences, proof techniques, logic, combinatorics, and probability.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring, Summer

**Pre-Requisite(s):** (CS 1122 or CS 1131) and (MA 1135 or MA 1160 or MA 1161)

### CS 2321 - Data Structures

Presents fundamental concepts in data structures. Topics include ADTs (trees, priority queues, dictionaries and graphs) and their implementations, algorithm analysis, sorting and text processing. Programming projects are designed to apply these topics.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring

**Pre-Requisite(s):** CS 1122 or CS 1131

### CS 3090 - Special Topics in Computer Science

Special topics in computer science offered on occasion based on student and faculty demand and interest.

**Credits:** variable to 3.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

### CS 3141 - Team Software Project

Introduction to the development of large software projects. Presents examples of software design, quality assurance techniques, and test-case design in conjunction with a significant team project involving design, test, and code documentation as well as user documentation. Other topics include teamwork, user interfaces, social and professional responsibility.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring

**Pre-Requisite(s):** CS 2141 and CS 2311

### CS 3311 - Formal Models of Computation

Introduction to the theory of formal languages and computation. Topics include regular languages and finite automata, context-free languages and push-down automata, Turing-acceptable languages, Turing machines and the halting problem. Proof techniques and applications, such as parsing, are also treated.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring

**Pre-Requisite(s):** CS 2311

### CS 3411 - Systems Programming

Development of programs on modern operating systems. Topics include: scripting; compilation, linking, loading; libraries; process creation; file system access and protection; network programming; heterogeneity.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CS 2141 and CS 3421

**CS 3421 - Computer Organization**

Introduction to the logical structure of computers, including the fundamentals of logic design, information storage and manipulation, control, input/output, and assembly language programming. Topics include a review of current hardware technology, combinational and sequential logic, arithmetic, datapaths, hard-wired control, interrupts, caches, virtual memory, and an introduction to pipelining.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-4-0)

**Semesters Offered:** Fall, Spring

**Pre-Requisite(s):** CS 2311

**CS 3451 - Computer Administration**

Administration of non-networked computers. Topics include: operating system installation; boot-up and shutdown; process management; account management; file systems; storage technology; backups; serial devices.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-3)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CS 3411(C) or CS 4411(C)

**CS 3911 - Introduction to Numerical Methods with FORTRAN**

Topics include floating point arithmetic, sources of numerical error, Taylor polynomials, solution of linear systems and nonlinear equations, interpolation, numerical integration, and numerical solution of differential equations. FORTRAN 90 topics include data types, control flow, arrays, procedures, pointers and dynamic data structures, I/O, and modules. Numerical algorithms will be coded.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** (MA 1160 or MA 1161) and (MA 2320(C) or MA 2321(C) or MA 2330(C)) and CS 2321

**CS 4000 - Senior Seminar**

Topics include ethical models, legal issues, privacy and security, social responsibility, professional responsibility and service, and the future of computing.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring

**Restrictions:** May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** CS 3141

**CS 4090 - Special Topics in Computer Science**

Special topics in computer science offered on occasion based on student and faculty demand and interest.

**Credits:** variable to 4.0; May be repeated

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

**CS 4099 - Directed Study in Computer Science**

Students study one or more special topics in computer science under the direction of one or more faculty members.

**Credits:** variable to 4.0; Repeatable to a Max of 6

**Semesters Offered:** Fall, Spring, Summer

**Restrictions:** Permission of instructor required

**CS 4121 - Programming Languages**

A discussion of the concepts underlying programming languages. Topics include programming paradigms; language properties (including syntax, semantics, run-time behavior, and implementation issues); data, procedure, functional, and control abstraction; functional programming; and logic programming.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring

**Pre-Requisite(s):** CS 2141 and CS 3311 and CS 3421

**CS 4131 - Compiler Construction**

Introduction to compilation techniques, including parsing, syntax-directed translation, run-time storage management, error recovery, code generation and optimization. Requires a significant project.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-1)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 4121

**CS 4311 - Introduction to Computation Theory**

Provides deeper insight into the power of computing using various models of computation. Topics reviewed include proof techniques, finite automata, regular languages, pushdown automata, and context-free languages. Topics covered include Turing machines and their variants, the Halting Problem and decidability, Rice's theorem, computability, time complexity, reducibility, NP-completeness, space complexity, machine self reference, recursion and fixed point theorems, s-m-n theorem.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CS 3311

**CS 4321 - Introduction to Algorithms**

Fundamental topics in algorithm design, analysis, and implementation. Analysis fundamentals include asymptotic notation, analysis of control structures, solving recurrences, and amortized analysis. Design and implementation topics include greedy sorting, searching, and graph algorithms. Design paradigms include greedy algorithms, divide-and-conquer algorithms, and dynamic programming.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall, Spring

**Pre-Requisite(s):** CS 1721 and CS 2311 and CS 2321

**CS 4331 - Introduction to Parallel Programming**

Introduction to developing parallel programs and solving problems using multiple concurrent processes. Shared memory and message passing paradigms are studied. Topics include conceptual models of parallel programming, basic analysis of parallel languages, parallel computer architecture, domain decomposition, and load balancing. Traditional computer science applications and numerical applications are also studied.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CS 3421 and CS 4321

**CS 4411 - Introduction to Operating Systems**

Presents topics on program representation and execution, operating systems, process and threads, process scheduling, memory management, and file systems. Programming homework is required.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-1)

**Semesters Offered:** Fall, Spring

**Pre-Requisite(s):** CS 2141 and CS 3421

**CS 4421 - Database Systems**

Topics include goals of database management; data definition; data models; data normalization; data retrieval and manipulation; security, integrity, and privacy measures; file, data, and storage organization; object-database systems; and parallel and distributed databases. Surveys a number of general database systems and examines in detail at least one database system.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 4411 or CS 4321

**CS 4431 - Computer Architecture**

Architecture of high-performance parallel computer systems. Introduces various forms of parallelism, such as multiple functional units, pipelining, multiprocessors, and processor arrays. Also covers interleaved memory, caching, and interconnection networks. Includes analytic and simulation models of architectural features that implement or support parallel processing.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-3)

**Semesters Offered:** Fall, Spring

**Pre-Requisite(s):** CS 3421

**CS 4451 - Network Administration**

Administration of computer networks. Topics include: TCP/IP networking, mail, printing, configuring and building kernels, remote file systems, license management, managing web systems, common network administration services.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-3)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 3451 and CS 4461(C)

**CS 4461 - Computer Networks**

Computer network architectures and protocols; design and implementation of datalink, network, and transport layer functions. Introduction to the Internet protocol suite and to network tools and programming.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 4321 and CS 4411

**CS 4471 - Computer and Network Security**

Development of administration of secure software systems. Topics include principles of software development, practical cryptography, program security, operating system security, network security, database security, administration, legal and ethical issues.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CS 3411 or CS 4411

**CS 4481 - Computer and Network Performance Analysis**

Analysis of the performance of computer systems. Topics include measurement techniques and tools, probability theory and statistics, experiment design and analysis, simulation, queuing models. Course includes a significant experimental component.

**Credits:** 4.0

**Lec-Rec-Lab:** (0-3-3)

**Semesters Offered:** Spring

**Pre-Requisite(s):** MA 2720 and CS 4411

**CS 4611 - Computer Graphics: Foundations of Computer Graphics**

Introduction to interactive computer graphics. Topics include graphics terminology, 3D viewing, 3D transformation, interactive techniques, use of graphics input devices, projections, modeling, lighting, texturing, evaluators, and graphics algorithms. Requires substantial programming homework.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Fall

**Pre-Requisite(s):** CS 2141

**CS 4710 - Model-Driven Software Development**

Focuses on the use of formal models throughout the software development life cycle. Topics include formal specification of requirements, behavioral modeling, automated analysis, architectural styles and design specification.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CS 3311 and CS 3141(C)

**CS 4711 - Software Processes and Management**

Focuses on the software development process and related management issues. Topics include software process models, the Capability Maturity Model, process tools, use of standards, software maintenance, configuration management, project planning and tracking, team management, and measurement and estimation.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CS 3141

**CS 4712 - Software Quality Assurance**

Covers the notion of software quality and how to ensure quality through the software process. Topics include requirements elicitation, analysis and documentation; usability and accessibility; testing; and quality assurance management.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Pre-Requisite(s):** CS 3141

**CS 4750 - Teaching Methods in Computer Science**

Provides teaching methods, models, and experiences for teaching computer science in secondary schools. Topics discussed include teaching methods, learning, security and maintenance of equipment, professional journals, ethics, legal issues, diversity, and problem solving. Requires admission to the Teacher Education Program.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** On Demand

**Restrictions:** Permission of department required; May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

**Pre-Requisite(s):** ED 4700

**CS 4760 - Human-Computer Interactions**

Principles of design and implementation of user interfaces (UI). Topics include: design principles, evaluation, tools and theory. Students experience designing, implementing, and evaluating UIs. Requires completion of a group project implementing a UI.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Pre-Requisite(s):** CS 3141

**CS 4791 - Senior Software Engineering Project I**

A capstone project course. Using software engineering principles and techniques, students work as part of a team responsible for developing a quality software project.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-1-4)

**Semesters Offered:** On Demand

**Restrictions:** Permission of instructor required

**Pre-Requisite(s):** CS 4710 or CS 4711 or CS 4712

**CS 4792 - Senior Software Engineering Project II**

A continuation of the capstone project experience, intended for Software Engineering majors.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-1-4)

**Semesters Offered:** Fall, Spring

**Restrictions:** Permission of instructor required

**Pre-Requisite(s):** CS 4791

**CS 4811 - Artificial Intelligence**

Fundamental ideas and techniques that are used in the construction of problem solvers that use AI technology. Topics include knowledge representation and reasoning, problem solving, heuristics, search heuristics, inference mechanisms, and machine learning.

**Credits:** 3.0

**Lec-Rec-Lab:** (0-3-0)

**Semesters Offered:** Spring

**Restrictions:** Must be enrolled in one of the following Class(es): Junior, Senior

**Pre-Requisite(s):** CS 1721 and CS 2321 and CS 3311