

CSE 1110; U 2.0; Introduction to Computing Technology; A course of general interest giving experience with personal computer software, e.g., word processors and spreadsheets; provides fundamental computer literacy; neither teaches nor requires programming.; **Distance Education; Exclusions:** Not open to students with credit for 1111 (101), 1113, or 100.

CSE 1111; U 3.0; Introduction to Computer-Assisted Problem Solving; Problem solving techniques using productivity software; spreadsheets, formulas, conditional logic; relational databases, relational algebra; word processing; data presentation; graphics.; **Distance Education; Exclusions:** Not open to students with credit for CSE 1112 or CSE 1113 or CSE 101 or CSE 105 or CSE 200; **GEC**

CSE 1112; U 3.0; Introduction to Computer-Assisted Problem Solving for Construction Systems Management; Using productivity software, especially spreadsheets and databases, to solve problems for construction management; relative/absolute cell referencing, logic, functions; relational databases, querying, project integration.; **Exclusions:** Not open to students with credit for CSE 1111 or CSE 1113 or CSE 101 or 105 or CSE 200

CSE 1113; U 1.0; Spreadsheet Programming for Business; Spreadsheet modeling/programming concepts and techniques to solve business related problems; efficient/effective data handling, computational analysis and decision support.; **Credit by Exam; Requisites:** (Math 1130 or higher) or (Math 130 or higher under quarters); **Exclusions:** Not open to students with credit for CSE 1111 or CSE 1112 or CSE 2111 or CSE 101 or CSE 105 or CSE 200

CSE 1114; U 1.5; Introduction to databases using MS Access; Database concepts and techniques for efficient/effective data handling, computational analysis and decision support.; **Exclusions:** Not open to students with credit for CSE 1111 or 1112 or 2111 or CSE 101 or CSE 105 or CSE 200.

CSE 1211; U 3.0; Computational Thinking in Context: Images, Animation, and Games; Introduction to computational thinking, focusing on problem solving and programming concepts and skills needed to manipulate digital images and to create interactive graphics, animations, and games; creativity and imagination encouraged.; **Exclusions:** Not open to students with credit for CSE 203 or CSE 204

CSE 1212; U 3.0; Computational Thinking in Context: Mobile Applications; Introduction to computational thinking, focusing on problem solving and programming concepts and skills needed to develop applications for mobile platforms; creativity and imagination encouraged.

CSE 1221; U 2.0; Introduction to Computer Programming in MATLAB for Engineers and Scientists; Introduction to computer programming and problem solving techniques with applications in engineering and the physical sciences; algorithm development; programming lab experience.; **Credit by Exam; Requisites:** Engr 1181 or Engr 1281 or Engr 181 or Engr 191 or ((Math 1151 or Math 1161 or Math 151 or Math 161) and (Phys 1250 or Phys 131)); **Exclusions:** Not open to students with credit for Engr 1221 or CSE 205; **Cross-Listings:** Engr 1221

CSE 1222; U 3.0; Introduction to Computer Programming in C++ for Engineers and Scientists; Introduction to computer programming and to problem solving techniques using computer programs with applications in engineering and the physical sciences; algorithm development; programming lab experience.; **Credit by Exam; Requisites:** co-req: Math 1151 or Math 1161; **Exclusions:** Not open to students with credit for Engr 1281.01 or Engr 1281.02 or CSE 202; **Cross-Listings:** Engr 1222

CSE 1223; U 3.0; Introduction to Computer Programming in Java; Introduction to computer programming and to problem solving techniques using computer programs; programming lab experience.; **Credit by Exam;**

Exclusions: Not open to students with credit for CSE 201

CSE 2021; U 3.0; Introduction to Modeling and Simulation; Concepts of modeling and simulation; develop MATLAB skills to explore modeling concepts; project: design, implementation, verification/validation of model; oral and written project report.; **Requisites:** Math 1151 (152) or equivalent, Phys 1250 (131); **Exclusions:** Not open to students with credit for ENGR 1221 or CSE 1221

CSE 2111; U 3.0; Modeling and Problem Solving with Spreadsheets and Databases; Spreadsheet and database modeling/programming concepts and techniques to solve business related problems; efficient/effective data handling, computational analysis and decision support. Addl topics:computer concepts, networking, project integration.; **Credit by Exam; Requisites:** (Math 1130 or higher) or (Math 130 or higher under quarters); **Exclusions:** Not open to students with credit for CSE 1111 or CSE 1112 or CSE 101 or CSE 105 or CSE 200; **GEC**

CSE 2112; U 3.0; Modeling and Problem Solving with Spreadsheets and Databases for Engineers; Spreadsheet and database modeling/programming concepts and techniques to solve business and engineering related problems; efficient/effective data handling, computational analysis and decision support.; **Requisites:** 1211 (203) or 1212 or 1221 (205) or 1222 (202) or 1223 (201) or 204 or EnGraph 167 or Engr 1221, or 1281.01H, or 1281.02H, or CSE Placement Level A. Pre-req or Concur: Math 1151 or 1161.01 or 1161.02; **Exclusions:** Not open to students with credit for CSE 2111, 1111 or 1112 or 1113 or CSE 101 or CSE 105 or CSE 200.

CSE 2122; U 3.0; Data Structures Using C++; Introduction to programming in C++ and object-oriented programming; encapsulation using classes, inheritance, etc.; **Requisites:** CSE 1222 or CSE 202; **Exclusions:** Not open to students with credit for CSE 230

CSE 2123; U 3.0; Data Structures Using Java; Subroutines and modular programming; searching; basic data structures; recursion; introduction to sequential files.; **Requisites:** CSE 1223 or CSE 201; **Exclusions:** Not open to students with credit for CSE 214

CSE 2133; U 3.0; Business Programming with File Processing; Business data processing principles and programming: sequential file processing algorithms, sorting, data validation; COBOL is taught.; **Requisites:** Prereq: 2123 (214).; **Exclusions:** Not open to students with credit for 314.

CSE 2193; U 1.0 - 10.0; Individual Studies in Computer Science and Engineering; Planning, conducting, and reporting a special study appropriate to the needs of the students.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 2193H; U 1.0 - 10.0; Individual Studies in Computer Science and Engineering; Planning, conducting, and reporting a special study appropriate to the needs of the students.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 2194; U 1.0 - 10.0; Group Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 2194H; U 1.0 - 10.0; Group Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 2221; U 4.0; Software I: Software Components; Intellectual foundations of software engineering; design-by-contract principles; mathematical modeling of software functionality; component-based software from client perspective; layered data representation.; **Credit by Exam; Requisites:** CSE 1211 or CSE 1212 or CSE 1221 or CSE 1222 or CSE 1223 or CSE 201 or CSE 202 or CSE 203 or CSE 204 or CSE 205 or EG 167 or CSE Placement Level A; co-req: Math 1151 or Math 1161; **Exclusions:** Not open to students with credit for CSE 321

CSE 2222; U 3.0; Software I.5-Transition: Development of Software Components; Templates for generalization and decoupling; container components; component-based software from implementer's perspective; data representation using layering and using pointers. Transition course: requires CSE 221, serves as prereq for CSE 2231.01.; **Requisites:** CSE 221; **Exclusions:** Not open to students with credit for CSE 222

CSE 2231; U 4.0; Software II: Software Development and Design; Data representation using hashing, search trees, and linked data structures; algorithms for sorting; using trees for language processing; component interface design; best practices in Java.; **Requisites:** CSE 2221; co-req: CSE 2321; **Exclusions:** Not open to students with credit for CSE 2231.01 or CSE 321 or CSE 421

CSE 2231.01; U 4.0; Software II-Transition: Software Development and Design; Transition from quarters to semesters, Resolve/C++ to Java; data representation using hashing, search trees, and linked data structures; sorting; using trees for language processing; component interface design; best practices in Java.; **Requisites:** CSE 2222 or CSE 222 or CSE 222H; co-req: CSE 2321; **Exclusions:** Not open to students with credit for CSE 321

CSE 2232; U 2.0; Software II.5-Transition: Software Development in Java; Transition from quarters to semesters, Resolve/C++ to Java; introduction to Java; tools for coding, testing, version control, documentation; language-specific best practices stemming from principles of component-based design.; **Requisites:** CSE 321; **Exclusions:** Not open to students with credit for CSE 421 or CSE 2221 or CSE 2222 or CSE 2231 or CSE 2231.01

CSE 2233; U 3.0; Business Programming with File Processing; Business data processing principles and programming: sequential file processing algorithms, sorting, data validation; COBOL is taught.; **Requisites:** CSE 1233 or CSE 214; **Exclusions:** Not open to students with credit for CSE 314

CSE 2321; U 3.0; Foundations I: Discrete Structures; Propositional and first-order logic; basic proof techniques; graphs, trees; analysis of algorithms; asymptotic analysis; recurrence relations.; **Requisites:** Prereq: 2122 (230), 2123 (214), or 2221 (222); and Math 1151 (152), or 1161. Concur (for students with credit for 2221): 2231.; **Exclusions:** Not open to students with credit for 625 or 680.

CSE 2331; U 3.0; Foundations II: Data Structures and Algorithms; Design/analysis of algorithms and data structures; divide-and-conquer; sorting and selection, search trees, hashing, graph algorithms, string matching; probabilistic analysis; randomized algorithms; NP-completeness.; **Requisites:** (CSE 2231 or CSE 321) and (CSE 2321 or Math 366) and (Math 2566 or Math 566) and (Stat 3470 or Stat 427).; **Exclusions:** Not open to students with credit for CSE 5331 or CSE 680

CSE 2421; U 4.0; Systems I: Introduction to Low-Level Programming and Computer Organization; Introduction to computer architecture at machine and assembly language level; pointers and addressing; C programming at machine level; computer organization.; **Requisites:** (CSE 1232 or CSE 1233 or CSE 2231 or CSE 321) and (CSE 2321 or Math 2566 or Math 366); **Exclusions:** Not open to students with credit for CSE 360

CSE 2431; U 3.0; Systems II: Introduction to Operating Systems; Introduction to operating system concepts: process, CPU scheduling, memory management, file system and storage, and multi-threaded programming.; **Requisites:** CSE 2421 or ((CSE 360 or ECE 2560 or ECE 265) and (CSE 2451 or CSE 459.21 or CSE 459.22)); **Exclusions:** Not open to students with credit for CSE 660

CSE 2451; U 2.0; Advanced C Programming; Advanced C features for students with significant programming experience in another language.; **Requisites:** CSE 2221 or CSE 222; co-req: CSE 2231; **Exclusions:** Not open to students with credit for CSE 2421

CSE 2501; U 1.0; Social, Ethical, and Professional Issues in Computing; Social, ethical, and professional issues facing computing professionals; ethical principles; discussion of case studies.; **Grading Basis:** Satisfactory/Unsatisfactory; **Requisites:** (CSE 1222 or CSE 1223 or CSE 2231 or CSE 214 or CSE 230 or CSE 222) and (CSE 2321 or Math 366) and (CSE 2421 or CSE 360); **Exclusions:** Not open to students with credit for CSE 601

CSE 2502S; U 0.0; Digital Bridge; Organization and information relationships in building community computing; technical inter-workings of components, wireless networking, and software; refurbishing computers and teaching customer service best practices.; **Grading Basis:** Satisfactory/Unsatisfactory

CSE 3231; U 3.0; Software Engineering Techniques; Software engineering issues, techniques, methodologies and technologies; software lifecycle activities: requirements analysis, architecture, design, testing, deployment, maintenance; project management; enterprise software systems; frameworks.; **Requisites:** Prereq: 3901 or 3902 or 3903.; **Exclusions:** Not open to students with credit for 5231 (757).

CSE 3232; U 3.0; Software Requirements Analysis; Information systems analysis; object-oriented analysis models and tools; use cases, system modeling using UML; requirements specification development; term project.; **Requisites:** CSE 3901 or CSE 3902 or CSE 560; **Exclusions:** Not open to students with credit for CSE 5232 or CSE 616

CSE 3241; U 3.0; Introduction to Database Systems; Database systems use; logical design; entity-relationship model; normalization; query languages and SQL; relational algebra and calculus; object relational databases; XML; active databases; database design project.; **Requisites:** (CSE 2231 or CSE 321) and (CSE 2321 or Math 366); **Exclusions:** Not open to students with credit for CSE 5241 or CSE 670

CSE 3244; U 3.0; Data Management in the Cloud; Systematic organization of data on cloud computing architectures; basic indexing techniques, including B-tree and hash-based indexing; fundamentals of query optimization, including access path selection and cardinality estimation; full and partial replication; data partitioning and distributed task scheduling.; **Requisites:** Prereq: 3241 or 5241; 2421 or 3430.

CSE 3321; U 3.0; Automata and Formal Languages; Machine-based and grammatical models of computation; finite automata and regular languages; pushdown automata and context-free languages; Turing machines; non-determinism; Church's Thesis; halting problem.; **Requisites:** (CSE 2231 or CSE 321) and (CSE 2331 or Math 566) and (CSE 2421 or CSE 360); **Exclusions:** Not open to students with credit for CSE 5321 or CSE 625

CSE 3341; U 3.0; Principles of Programming Languages; Formal languages and grammars; recursive descent parsing; data types, expressions, control structures, parameter passing; compilers and interpreters; memory management; functional programming principles.; **Requisites:** CSE 2231 and (CSE 2331 or CSE 680) and CSE 2421 and (CSE 3901 or CSE 3902 or CSE 560); **Exclusions:** Not open to students with credit for CSE 5341 or CSE 655

CSE 3421; U 3.0; Introduction to Computer Architecture; Organization of hardware and software in modern computer systems, including instruction set design, processor control, ALU design, pipelining, multicores and accelerators, and memory subsystem design.; **Requisites:** (CSE 2231 or CSE 321) and (CSE 2421 or CSE 360 or ECE 2560 or ECE 265) and (ECE 2000 or ECE 261); **Exclusions:** Not open to students with credit for CSE 5421 or CSE 675.01 or CSE 675.02

CSE 3430; U 4.0; Overview of Computer Systems For Non-Majors; Introduction to computer architecture and organization at machine and assembly level; pointers and addressing using C programming; introduction to operating system concepts: process, memory management, file system and storage, and multi-threaded programming.; **Requisites:** Prereq: 2122 or 2123, and 2321; **Exclusions:** Not for CSE/CIS majors. Not open to students with credit for CSE 2421, 2431, 360, 660

CSE 3461; U 3.0; Computer Networking and Internet Technologies; Computer networks, communication protocols, Internet TCP/IP and applications, wireless communications and network security.; **Requisites:** Prereq: 2421; or 2451 and ECE 2560 (265). Concur: 2431.; **Exclusions:** Not open to students with credit for 5461 (677).

CSE 3521; U 3.0; Survey of Artificial Intelligence I: Basic Techniques; Survey of basic concepts and techniques in artificial intelligence, including problem solving, knowledge representation, and machine learning.; **Requisites:** CSE 2331 or (CSE 222 and Math 366) or senior standing; **Exclusions:** Not open to students with credit for CSE 5521 or CSE 630

CSE 3541; U 3.0; Computer Game and Animation Techniques; Fundamental algorithms and mathematics in production of computer animation and video games, emphasizing control and rendering of animated characters.; **Requisites:** CSE 3901 or CSE 3902 or CSE 560; **Exclusions:** Not open to students with credit for CSE 5541 or CSE 683

CSE 3901; U 4.0; Project: Design, Development, and Documentation of Web Applications; Intensive group project involving design, development, and documentation of a web application; client-side and server-side scripting; communication skills emphasized; builds programming maturity.; **Requisites:** Prereq: 2231; and 2321; and 2421 or 3430, or 2451 and ECE2560

CSE 3902; U 4.0; Project: Design, Development, and Documentation of Interactive Systems; Intensive group project involving design, development, and documentation of an interactive software system, a 2D interactive game; communication skills emphasized; builds programming maturity.; **Requisites:** Pre-req: 2231; and 2321; and 2421 or 3430, or 2451 and ECE2560.

CSE 3903; U 4.0; Project: Design, Development, and Documentation of System Software; Intensive group project involving design, development, and documentation of system software including an assembler and a linking loader; communication skills emphasized; builds programming maturity.; **Requisites:** Pre-req: 2231; and 2321; and 2421 or 3430, or 2451 and ECE2560; **Exclusions:** Not open to students with credit for 560.

CSE 4193; U 1.0 - 10.0; Individual Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 4193H; U 1.0 - 10.0; Individual Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Grading Basis:**

Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus;** **Requisites:** Honors status; Permission of Instructor

CSE 4194; U 1.0 - 10.0; Group Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled;** **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus;** **Requisites:** Permission of Instructor

CSE 4194H; U 1.0 - 10.0; Group Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled;** **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus;** **Requisites:** Honors status; Permission of Instructor

CSE 4221; G 3.0; Introduction to Object-Oriented Programming; Introduction to object-oriented programming for experienced procedural programmers; interfaces, classes, packages; implements and extends relationships; design patterns; best practices.; **Requisites:** Previous programming experience in a procedural language; **Exclusions:** Not open to CSE or CIS majors; not open to students with credit for CSE 502

CSE 4231; U 3.0; Software II: Software Development and Design; Data representation using hashing, search trees, and linked data structures; algorithms for sorting; using trees for language processing; component interface design; best practices in Java.; **Requisites:** CSE 2221 or CSE 4221; **Exclusions:** Not open to students with credit for CSE 2231.01 or CSE 321 or CSE 421 or CSE 2231

CSE 4251; U 1.0; The UNIX Programming Environment; Introduction to the UNIX programming environment including: shell programming (csh); regular expressions; makefiles; grep, sed, and awk programming languages.; **Grading Basis:** Satisfactory/Unsatisfactory; **Requisites:** CSE 2231 or CSE 321; **Exclusions:** Not open to students with credit for CSE 459.11

CSE 4252; U 1.0; Programming in C++; Syntax and pragmatics of C++ programming; C++ types, arrays, classes, pointers; objects and classes; compile-time vs. run-time picture; inheritance; template classes.; **Grading Basis:** Satisfactory/Unsatisfactory; **Requisites:** CSE 2231; **Exclusions:** Not open to students with credit for CSE 459.22

CSE 4253; U 1.0; Programming in C#; C# programming for students well-versed in programming with another object-oriented language.; **Grading Basis:** Satisfactory/Unsatisfactory; **Requisites:** CSE 2231; **Exclusions:** Not open to students with credit for CSE 459.24

CSE 4254; U 1.0; Programming in Lisp; Lisp programming for students well-versed in programming with another language.; **Grading Basis:** Satisfactory/Unsatisfactory; **Requisites:** CSE 2231; **Exclusions:** Not open to students with credit for CSE 459.31

CSE 4255; U 1.0; Programming in Perl; Syntax and pragmatics of Perl programming; Perl mechanisms for text and file processing, scripting, client-server programming, etc.; powerful ways to combine these mechanisms.; **Grading Basis:** Satisfactory/Unsatisfactory; **Requisites:** CSE 2231 and CSE 2331 and CSE 2421; **Exclusions:** Not open to students with credit for CSE 459.51

CSE 4471; U 3.0; Information Security; Introduction to security of digital information; threats and attacks; regulations; risk management; attack detection and response; cryptography; forensics; technical training and certifications.; **Requisites:** Prereq: 2231 and 2321, or 321.; **Exclusions:** Not open to students with credit for 551.

CSE 4521; G 3.0; Survey of Artificial Intelligence for Non-Majors; Survey of the basic concepts and techniques in artificial intelligence, including problem solving, knowledge representation, and machine learning.; **Requisites:** CSE 1211 or CSE 1221 or CSE 1222 or CSE 1223 or CSE 2221 or graduate standing; **Exclusions:** Not open to CSE or CIS majors; not open to students with credit for CSE 3521 or CSE 5521 or CSE 630

CSE 4689; U 0.0; Professional Practice in Industry; Preparation and submission of a comprehensive report based on actual employment experience in a co-op job in industry.; **Flexibly Scheduled; Grading Basis:** Progress - S/U; **Repeatable:** 0.0 credits, 8 completions allowed; **Requisites:** Permission of the CSE Advising Office

CSE 4901; G 4.0; Project: Design, Development, and Documentation of Web Applications; Intensive group project involving design, development, and documentation of a web application; client-side and server-side scripting; communication skills emphasized; builds programming maturity.; **Requisites:** Programming maturity and graduate standing; **Exclusions:** Not open to CSE and CIS majors; not open to students with credit for CSE 3901

CSE 4902; G 4.0; Project: Design, Development, and Documentation of Interactive Systems; Intensive group project involving design, development, and documentation of an interactive software system, a 2D interactive game; communication skills emphasized; builds programming maturity.; **Requisites:** Programming maturity and graduate standing; **Exclusions:** Not open to CSE and CIS majors; not open to students with credit for CSE 3902

CSE 4998; U 1.0 - 10.0; Undergraduate Research in Computer Science and Engineering; Opportunity for undergraduate student to conduct research in Computer Science and Engineering.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 4998H; U 1.0 - 10.0; Undergraduate Research in Computer Science and Engineering; Opportunity for undergraduate student to conduct research in Computer Science and Engineering.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Honors status; Permission of Instructor

CSE 4999; U 1.0 - 10.0; Computer Science and Engineering Research for Thesis; Supervised research and project work arranged individually.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 4999H; U 1.0 - 10.0; Computer Science and Engineering Research for Thesis; Supervised research and project work arranged individually for honors students; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Honors status; Permission of Instructor

CSE 5032; UG 2.0; Foundations I: Discrete Structures; Propositional and first-order logic; basic proof techniques; graphs, trees; analysis of algorithms; asymptotic analysis; recurrence relations.; **Requisites:** 5022 or equivalent; **Exclusions:** Not open to students with credit for 625 or 680 or 2321.

CSE 5042; UG 3.0; Systems I: Introduction to Low-Level Programming and Computer Organization; Introduction to computer architecture at machine and assembly language level; pointers and addressing; C programming at machine level; computer organization.; **Requisites:** 2122 (230) or 2123 (314) or 2231 or 321, and 2321 or Math 2366 or Math 366; **Exclusions:** Not open to students with credit for 360 or 2421.

CSE 5043; UG 3.0; Overview of Computer Systems For Non-Majors; Introduction to computer architecture and organization at machine and assembly level; pointers and addressing using C programming; introduction to operating system concepts: process, memory management, file system and storage, and multi-threaded programming.; **Requisites:** Prereq: 5022 or equivalent, and 5032 or equivalent; **Exclusions:** Not for CSE/CIS majors.

Not open to students with credit for CSE 2421 or 5042 or 2431 or 3430 or 360 or 660

CSE 5194; UG 3.0; Legal Topics for Computer Engineers; This course introduces students to areas of law that govern computer engineering and design. The goals of the course include mastery of a set of legal doctrines, as well as immersion in the legal method used by lawyers to analyze problems and by judges to decide cases. Students can expect to learn how to evaluate computer engineering methods and projects through the lens of legal analysis.; **Requisites:** CSE 2501 or Philos 1338, and CSE 39xy; or grad standing; or with permission of instructor

CSE 5194.01; UG 3.0; Group Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Repeatable:** 10.0 credits, 10 completions allowed; **Requisites:** Graduate standing or permission of instructor

CSE 5194.02; UG 1.0 - 10.0; Group Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Requisites:** Permission of Instructor

CSE 5194.99; UG 3.0; Data Intensive Query Interfaces; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Repeatable:** 10.0 credits, 10 completions allowed; **Requisites:** CSE 5242 or CSE 5244, or permission of instructor

CSE 5231; UG 2.0; Software Engineering Techniques; Software engineering issues, techniques, methodologies and technologies; software lifecycle activities: requirements analysis, architecture, design, testing, deployment, maintenance; project management; enterprise software systems; frameworks.; **Requisites:** CSE 3901 or CSE 3902 or CSE 560; **Exclusions:** Not open to students with credit for CSE 3231 or CSE 757

CSE 5232; UG 2.0; Software Requirements Analysis; Information systems analysis; object-oriented analysis models and tools; use cases, system modeling using UML; requirements specification development; term project.; **Requisites:** CSE 3901 or CSE 3902 or CSE 560; **Exclusions:** Not open to students with credit for CSE 3232 or CSE 616

CSE 5234; UG 3.0; Distributed Enterprise Computing; Current application and middleware frameworks for distributed enterprise computing; XML; Enterprise Java; SOAP and REST web services; AJAX and JSON; enterprise service bus; Hadoop; mobile computing.; **Requisites:** CSE 3431 or CSE 5431 or CSE 660; **Exclusions:** Not open to students with credit for CSE 769

CSE 5235; UG 3.0; Applied Enterprise Architectures and Services; Modeling/analysis of complex enterprise architectures; enterprise patterns (workflow, broker, warehousing); methods for service performance (lean, ontologies, data mining, etc.); emerging topics in semantic cyber-infrastructures, social computation.; **Requisites:** CSE 5911 or CSE 5912 or CSE 5913 or CSE 5914 or CSE 5915 or CSE 682 or CSE 731 or CSE 758 or CSE 762 or CSE 772 or CSE 778

CSE 5236; UG 3.0; Mobile Application Development; Mobile application development frameworks;

Architecture, design and engineering issues, techniques, methodologies for mobile application development.; **Requisites:** CSE 3901 or CSE 3902 or CSE 5901 or CSE 5902 or CSE 560

CSE 5239; UG 2.0; Intermediate Studies in Software Engineering; Intermediate-level topics in software engineering.; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5241; UG 2.0; Introduction to Database Systems; Database systems use; logical design; entity-relationship model; normalization; query languages and SQL; relational algebra and calculus; object relational databases; XML; active databases; database design project.; **Requisites:** (CSE 2231 or CSE 321) and (CSE 2321 or Math 366); **Exclusions:** Not open to students with credit for CSE 3241 or CSE 670

CSE 5242; UG 3.0; Advanced Database Management Systems; Transaction management; query processing and optimization; organization of database systems, advanced indexing, multi-dimensional data, similarity-based analysis, performance evaluation, new database applications.; **Requisites:** CSE 3241; **Exclusions:** Not open to students with credit for CSE 770

CSE 5243; UG 3.0; Introduction to Data Mining; Knowledge discovery, data mining, data preprocessing, data transformations; clustering, classification, frequent pattern mining, anomaly detection, graph and network analysis; applications.; **Requisites:** CSE 2331 and CSE 3241; **Exclusions:** Not open to students with credit for CSE 674

CSE 5244; UG 2.0; Data Management in the Cloud; Systematic organization of data on cloud computing architectures; basic indexing techniques, including B-tree and hash-based indexing; fundamentals of query optimization, including access path selection and cardinality estimation; full and partial replication; data partitioning and distributed task scheduling.; **Requisites:** 3241 or 5241, and 2421 or 3430; or grad standing; **Cross-Listings:** 3244

CSE 5245; UG 3.0; Introduction to Network Science; Introduction to Network Science; Global and Local Network Measures; PageRank; Community Discovery Algorithms; Network Models; Understanding the role of network analysis in Web and Social network applications; **Flexibly Scheduled;** **Requisites:** CSE 2331

CSE 5249; UG 2.0; Intermediate Studies in Databases; Intermediate-level topics in databases.; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5321; UG 2.0; Automata and Formal Languages; Machine-based and grammatical models of computation; finite automata and regular languages, pushdown automata and context-free languages, Turing machines; non-determinism; Church's Thesis; halting problem.; **Requisites:** (CSE 2231 or CSE 321) and (CSE 2331 or Math 566) and (CSE 2421 or CSE 360); **Exclusions:** Not open to students with credit for CSE 3321 or CSE 625

CSE 5329; UG 2.0; Intermediate Studies in Computation Theory; Intermediate-level topics in computation theory.; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5331; UG 2.0; Foundations II: Data Structures and Algorithms; Design/analysis of algorithms and data structures; divide-and-conquer; sorting and selection, search trees, hashing, graph algorithms, string matching; probabilistic analysis; randomized algorithms; NP-completeness.; **Requisites:** (CSE 2231 or CSE 321) and (CSE 2321 or Math 366) and (Math 2566 or Math 566) and (Stat 3470 or Stat 427); **Exclusions:** Not open to students with credit for CSE 2331 or CSE 680

CSE 5339; UG 2.0; Intermediate Studies in Algorithms; Intermediate-level topics in algorithms.; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5341; UG 2.0; Principles of Programming Languages; Formal languages and grammars; recursive descent parsing; data types, expressions, control structures, parameter passing; compilers and interpreters; memory management; functional programming principles.; **Requisites:** CSE 2231 and (CSE 2331 or CSE 680) and CSE 2421 and (CSE 3901 or CSE 3902 or CSE 560); **Exclusions:** Not open to students with credit for CSE 3341 or CSE 655

CSE 5343; UG 3.0; Compiler Design and Implementation; Lexical and syntax analyses using compiler generation tools; type checking; intermediate code; control-flow analysis; dataflow analysis; code optimizations; code generation; compiler project.; **Requisites:** (CSE 3901 or CSE 3902 or CSE 560) and (CSE 3341 or CSE 655); **Exclusions:** Not open to students with credit for CSE 756

CSE 5349; UG 2.0; Intermediate Studies in Programming Languages; Intermediate-level topics in programming languages.; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5351; UG 3.0; Introduction to Cryptography; Foundations of cryptography; mathematical formulations/proofs of security goals; theory and practical constructions of encryption schemes, MACs, digital signatures; zero-knowledge proof systems; cryptographic protocols.; **Requisites:** (Stat 3460 or Stat 3470 or Stat 427) and (CSE 2331 or CSE 5331 or CSE 680 or Math 4573 or Math 573 or Math 4580 or Math 580); **Exclusions:** Not open to students with credit for CSE 723 or CSE 794Q

CSE 5359; UG 2.0; Intermediate Studies in Cryptography; Intermediate-level topics in cryptography.; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5361; UG 3.0; Numerical Methods; Numerical methods for scientific computation: computer arithmetic, rounding errors, machine precision, machine representation, root-finding, interpolation, integration, linear systems, splines, smoothing, curve-fitting, linear programming.; **Requisites:** CSE 2231 and (Math 2568 or 568 or 571) and (Math 1151 or Math 151); **Exclusions:** Not open to students with credit for CSE 541

CSE 5421; UG 2.0; Introduction to Computer Architecture; Organization of hardware and software in modern computer systems, including instruction set design, processor control, ALU design, pipelining, multicores and accelerators, and memory subsystem design.; **Requisites:** (CSE 2231 or CSE 321) and (CSE 2421 or CSE 360 or ECE 2560 or ECE 265) and (ECE 2000 or ECE 261); **Exclusions:** Not open to students with credit for CSE 3421 or CSE 675.01 or CSE 675.02

CSE 5429; UG 2.0; Intermediate Studies in Computer Architecture; Intermediate-level topics in computer architecture.; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5431; UG 2.0; Systems II: Introduction to Operating Systems; Introduction to operating system concepts: process, CPU scheduling, memory management, file system and storage, and multi-threaded programming.; **Requisites:** CSE 2421 or ((ECE 2560 or ECE 265 or CSE 360) and CSE 2451); **Exclusions:** Not open to students with credit for CSE 2431 or CSE 660

CSE 5432; UG 3.0; Mobile Handset Systems and Networking; Mobile handset architecture: processors, memory, I/O devices, sensors, virtual machine and power management; different ranges of wireless communication technologies; TCP/IP over wireless; mobile social networking.; **Requisites:** CSE 2421 or ((ECE 2560 or ECE 265) and (CSE 2451 or CSE 459.21))

CSE 5433; UG 3.0; Operating Systems Laboratory; Introduction to the internals of operating systems; designing and implementing components within commercial operating systems: system calls, CPU scheduling, context switching, process management, memory management, file systems.; **Requisites: CSE 2431 or CSE 5431 or (CSE 660 and (CSE 2451 or CSE 459.21)); **Exclusions:** Not open to students with credit for CSE 662**

CSE 5434; UG 2.0; Comparative Operating Systems; A careful examination of a number of representative computer operating systems.; **Requisites: CSE2431 (660) or CSE5431; **Exclusions:** Not open to students with credit for CSE 741**

CSE 5439; UG 2.0; Intermediate Studies in Operating Systems; Intermediate-level topics in operating systems.; **Repeatable: 8.0 credits, 4 completions allowed**

CSE 5441; UG 3.0; Introduction to Parallel Computing; Parallel programming models; sequential and parallel performance issues; high-performance computer architecture; design, analysis, implementation and performance evaluation of parallel algorithms.; **Requisites: Pre-req: (CSE 2231 and CSE 2321 and (CSE 2421 or ((ECE 2560 or ECE 265) and CSE 2451)) and (Math 2568 or Math 568 or Math 571)) or graduate standing.; **Exclusions:** Not open to students with credit for CSE 621**

CSE 5449; UG 2.0; Intermediate Studies in Parallel Computing; Intermediate-level topics in parallel computing.; **Repeatable: 8.0 credits, 4 completions allowed**

CSE 5461; UG 2.0; Computer Networking and Internet Technologies; Computer networks, communication protocols, Internet TCP/IP and applications, wireless communications and network security.; **Requisites: CSE 2421 or ((ECE 2560 or 265) and CSE 2451); co-req: CSE 2431; **Exclusions:** Not open to students with credit for CSE 3461 or CSE 677**

CSE 5462; UG 3.0; Network Programming; IP-based socket programming in C/C++, TinyOS programming in NesC.; **Requisites: CSE 3461 or CSE 5461 or CSE 677**

CSE 5463; UG 3.0; Introduction to Wireless Networking; Fundamental concepts in cellular design, Wireless-LANs, MANETs, and sensor networks will be explored. Specific topics will include propagation, fading, cellular-design, power-management, routing, scheduling, and control.; **Requisites: CSE 3461 or 677 or ECE 3367 or 561 or graduate standing in engineering or math & physical sciences.; **Cross-Listings:** Cross-listed with ECE 5101.**

CSE 5469; UG 2.0; Intermediate Studies in Computer Networking; Intermediate-level topics in computer networking.; **Repeatable: 8.0 credits, 4 completions allowed**

CSE 5471; UG 3.0; Information Security; Introduction to security of digital information; threats and attacks; regulations; risk management; attack detection and response; cryptography; forensics; technical training and certifications.; **Requisites: (CSE 2231 and CSE 2321) or CSE 321; **Exclusions:** Not open to students with credit for CSE 551**

CSE 5472; UG 3.0; Information Security Projects; Team-based projects: solve information security problems (mobile/static host/network hardening, intrusion detection and vulnerability scanning, forensics); results communicated through report writing and presentation.; **Requisites: (CSE 3901 or CSE 3902 or CSE 560) and (CSE 3461 or CSE 5461 or CSE 5471); **Exclusions:** Not open to students with credit for CSE 652**

CSE 5473; UG 3.0; Network Security; Security threats and services, elements of cryptography, protocols for security services, network and internet security, advanced security issues and technologies.; **Requisites:** CSE 3461 or CSE 5461 or CSE 677; **Exclusions:** Not open to students with credit for CSE 651

CSE 5479; UG 2.0; Intermediate Studies in Computer Security; Intermediate-level topics in computer security.; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5501; UG 1.0; Social, Ethical, and Professional Issues in Computing; Social, ethical, and professional issues facing computing professionals; ethical principles; discussion of case studies.; **Grading Basis:** Satisfactory/Unsatisfactory; **Requisites:** (CSE 1222 or CSE 1223 or CSE 2231 or CSE 214 or CSE 230 or CSE 222) and (CSE 2321 or Math 366) and (CSE 2421 or CSE 360); **Exclusions:** Not open to students with credit for CSE 2501 or CSE 601

CSE 5521; UG 2.0; Survey of Artificial Intelligence I: Basic Techniques; Survey of the basic concepts and techniques in artificial Intelligence, including problem solving, knowledge representation, and machine learning.; **Requisites:** CSE 2331 or (CSE 222 and Math 366); **Exclusions:** Not open to students with credit for CSE 3521 or CSE 630

CSE 5522; UG 3.0; Survey of Artificial Intelligence II: Advanced Techniques; Survey of advanced concepts, techniques, and applications of artificial intelligence, including knowledge representation, learning, natural language understanding, and vision.; **Requisites:** CSE 3521 or CSE 5521 or CSE 630 or grad standing; **Exclusions:** Not open to students with credit for CSE 730

CSE 5523; UG 3.0; Machine Learning and Statistical Pattern Recognition; Introduction to basic concepts of machine learning and statistical pattern recognition; techniques for classification, clustering and data representation and their theoretical analysis.; **Requisites:** (CSE 3521 or CSE 5521 or CSE 5243) and (CSE 5522 or Stat 3460 or Stat 3470); **Exclusions:** Not open to students with credit for CSE 735

CSE 5524; UG 3.0; Computer Vision for Human-Computer Interaction; Computer vision algorithms for use in human-computer interactive systems; image formation, image features, segmentation, shape analysis, object tracking, motion calculation, and applications.; **Requisites:** CSE 2331 or senior or grad standing; **Exclusions:** Not open to students with credit for CSE 634

CSE 5525; UG 3.0; Foundations of Speech and Language Processing; Fundamentals of natural language processing, automatic speech recognition and speech synthesis; lab projects concentrating on building systems to process written and/or spoken language.; **Requisites:** (CSE 3521 or CSE 5521) and (CSE 5522 or Stat 3460 or Stat 3470); **Exclusions:** Not open to students with credit for CSE 733

CSE 5526; UG 3.0; Introduction to Neural Networks; Survey of fundamental methods and techniques of neural networks; single- and multi-layer perceptrons; radial-basis function networks; support vector machines; recurrent networks; supervised and unsupervised learning.; **Requisites:** CSE 3521; **Exclusions:** Not open to students with credit for CSE 779

CSE 5531; UG 3.0; Introduction to Cognitive Science; Interdisciplinary survey of the fields of artificial intelligence, linguistics, neuroscience, philosophy of mind, and psychology; various aspects of cognitive perception, representation, and computation.; **Requisites:** At least 12 sem-cr-hrs equivalent from at least two of the following four areas: computer science, linguistics, philosophy, and psychology; at most 6 sem-cr-hrs can come from any one area; **Exclusions:** Not open to students with credit for CSE 612, Ling 612, Phil 612, or Psych 612; **Cross-Listings:** Cross listed with Psychology, Linguistics, Philosophy

CSE 5539; UG 2.0; Intermediate Studies in Artificial Intelligence; Intermediate-level topics in artificial intelligence.; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5541; UG 2.0; Computer Game and Animation Techniques; Fundamental algorithms and mathematics in the production of computer animation and video games, emphasizing the control and rendering of animated characters.; **Requisites:** CSE 3901 or CSE 3902; **Exclusions:** Not open to students with credit for CSE 3541 or CSE 683

CSE 5542; UG 3.0; Real-Time Rendering; Comprehensive list of topics in real-time rendering using OpenGL and GLSL, including coordinate systems, transformations, viewing, illumination, texture mapping, and shader-based algorithms.; **Requisites:** (CSE 3901 or CSE 3902 or CSE 4901 or CSE 4902 or CSE 560) and (Math 2568 or Math 568 or Math 571); **Exclusions:** Not open to students with credit for CSE 781

CSE 5543; UG 3.0; Geometric Modeling; Common algorithmic and mathematical techniques for modeling geometric objects in computer graphics and CAD applications; sample based modeling, mesh generation, and hierarchical representations.; **Requisites:** Math 2568 or Math 568 or Math 571; **Exclusions:** Not open to students with credit for CSE 784

CSE 5544; UG 3.0; Introduction to Data Visualization; Principles and methods for visualizing data from measurements and calculations in physical and life sciences, and transactional and social disciplines; information visualization; scientific visualization.; **Requisites:** Prereq: 5361, Stat 3301, 3541, or 5541.; **Exclusions:** Not open to students with credit for 694L.

CSE 5545; UG 3.0; Advanced Computer Graphics; Advanced topics in computer graphics; image synthesis, lighting and rendering, sampling and material properties, volume rendering.; **Requisites:** CSE 5541 or CSE 581; **Exclusions:** Not open to students with credit for CSE 782

CSE 5559; UG 2.0; Intermediate Studies in Computer Graphics; Intermediate-level topics in computer graphics.; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5889; UG 2.0; Intermediate Studies in Multidisciplinary Computing; Intermediate-level topics in multidisciplinary computing techniques; **Repeatable:** 8.0 credits, 4 completions allowed

CSE 5891; UG 2.0; Proseminar in Cognitive Science; In-depth examination of the interdisciplinary field of Cognitive Science; fundamental issues of each discipline; illustrations of representative research being conducted at OSU.; **Repeatable:** 4.0 credits, 2 completions allowed; **Requisites:** CSE 5531; **Cross-Listings:** Cross-listed with Linguistics, Philosophy, Psychology

CSE 5911; UG 4.0; Capstone Design: Software Applications; Capstone design project: application of software engineering techniques, methodologies and technologies in software lifecycle activities using enterprise software frameworks; teamwork, written and oral communication.; **Requisites:** (CSE 2501 or CSE 5501 or CSE 601) and (CSE 3901 or CSE 3902 or CSE 4901 or CE 4902 or CSE 560) and (CSE 3231 or CSE 5231 or CSE 757); **Exclusions:** Not open to students with credit for CSE 758 or CSE 762

CSE 5912; UG 4.0; Capstone Design: Game Design and Development; Capstone design project; conceptual and technical design and implementation of interactive game, integrating custom code and toolkits; teamwork, written and oral communication skills.; **Requisites:** (CSE 2501 or CSE 5501 or CSE 601) and (CSE 3901 or CSE 3902 or CSE 4901 or CSE 4902 or CSE 560) and (CSE 3541 or CSE 5541 or CSE 581); **Exclusions:** Not open to students with credit for CSE 786

CSE 5913; UG 4.0; Capstone Design: Computer Animation; Capstone design project: conceptual and technical design and implementation of computer animation incorporating animation elements; teamwork, written and oral communication skills.; **Requisites:** (CSE 2501 or CSE 5501 or CSE 601) and (CSE 3901 or CSE 3902 or CSE 4901 or CSE 4902 or CSE 560) and (CSE 3541 or CSE 5541 or CSE 683); **Exclusions:** Not open to students with credit for CSE 682

CSE 5914; UG 4.0; Capstone Design: Knowledge-Based Systems; Capstone design project; conceptual and technical design; theory and practice of knowledge-based systems; teamwork, written and oral communication skills.; **Requisites:** (CSE 2501 or CSE 5501 or CSE 601) and (CSE 3901 or CSE 3902 or CSE 4901 or CSE 4902 or CSE 560) and (CSE 3521 or CSE 5521 or CSE 630); **Exclusions:** Not open to students with credit for CSE 731

CSE 5915; UG 4.0; Capstone Design: Information Systems; Capstone design project; information system principles: database design methods and tools, indexing, searching, application development, testing, evaluation; teamwork, written and oral communication skills.; **Requisites:** (CSE 2501 or CSE 5501 or CSE 601) and (CSE 3901 or CSE 3902 or CSE 4901 or CSE 4902 or CSE 560) and (CSE 3241 or CSE 5241 or CSE 670); **Exclusions:** Not open to students with credit for CSE 772

CSE 6193; G 1.0 - 10.0; Individual Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 6194; G 1.0 - 10.0; Group Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 6231; G 3.0; Formal Foundations of Software Engineering; Formal approaches to program semantics and software properties; software specification and verification; model checking; static analysis; systematic testing.; **Requisites:** (CSE 3321 or CSE 5321 or CSE 625) and (CSE 3341 or CSE 5341 or CSE 655)

CSE 6239; G 1.0 - 3.0; Advanced Studies in Software Engineering; Advanced-level topics in software engineering.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6249; G 1.0 - 3.0; Advanced Studies in Databases; Advanced-level topics in databases.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6321; G 3.0; Computability and Complexity; Turing machines, decidability, recursive enumerability; many-to-one and polynomial-time reductions; NP-completeness, Cook-Levin Theorem; Recursion Theorem.; **Requisites:** CSE 5321 or CSE 3321 or CSE 625; **Exclusions:** Not open to students with credit for CSE 725

CSE 6329; G 1.0 - 3.0; Advanced Studies in Computation Theory; Advanced-level topics in computation theory.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6331; G 3.0; Algorithms; Algorithm design paradigms; mathematical analysis of algorithms.; **Requisites:** CSE 2331 or CSE 5331 or CSE 680; **Exclusions:** Not open to students with credit for CSE 780

CSE 6332; G 3.0; Advanced Algorithms; Advanced graph algorithms, string algorithms, linear programming,

matrix operations, Fourier transforms, randomized algorithms, approximation algorithms, geometric algorithms.; **Requisites:** CSE 6331 or CSE 780; **Exclusions:** Not open to students with credit for CSE 790 or CSE 794A

CSE 6333; G 3.0; Distributed Algorithms; Fundamental concepts in distributed computing; algorithms for distributed control and data; impossibility and limits; algorithms for fault-tolerance; specification, design and verification of distributed programs.; **Requisites:** CSE 6431 or CSE 760; **Exclusions:** Not open to students with credit for CSE 763

CSE 6339; G 1.0 - 3.0; Advanced Studies in Algorithms; Advanced-level topics in algorithms.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6341; G 3.0; Foundations of Programming Languages; Conceptual foundations of programming languages: attribute grammars; types; functional languages; language semantics; abstract interpretation.; **Requisites:** CSE 3341 or CSE 5341 or CSE 655; **Exclusions:** Not open to students with credit for CSE 755

CSE 6349; G 1.0 - 3.0; Advanced Studies in Programming Languages; Advanced-level topics in programming languages.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6359; G 1.0 - 3.0; Advanced Studies in Cryptography; Advanced-level topics in cryptography.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6421; G 3.0; Computer Architecture; Principles and tradeoffs behind the design of modern computer architectures, including instruction-level parallelism, memory system design, advanced cache architectures, cache coherence, multiprocessors, energy-efficient and embedded architectures.; **Requisites:** (CSE 3421 or CSE 5421 or CSE 675 or ECE 5362 or ECE 662) and (CSE 3431 or CSE 5431 or CSE 660); **Exclusions:** Not open to students with credit for CSE 775

CSE 6422; G 3.0; Advanced Computer Architecture; Fundamental design issues in parallel architectures, design of scalable shared memory and distributed memory systems, interconnection networks (on-chip and off-chip), multi-core architectures, accelerators, embedded systems, and exascale systems.; **Requisites:** (CSE 6421 or CSE 775) and (CSE 6441 or CSE 721); **Exclusions:** Not open to students with credit for CSE 875

CSE 6429; G 1.0 - 3.0; Advanced Studies in Computer Architecture; Advanced-level topics in computer architecture.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6431; G 3.0; Advanced Operating Systems; Advanced topics in operating systems and concurrency; introduction to distributed systems.; **Requisites:** CSE 2431 or CSE 5431 or CSE 660; **Exclusions:** Not open to students with credit for CSE 760

CSE 6439; G 1.0 - 3.0; Advanced Studies in Operating Systems; Advanced-level topics in operating systems.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6441; G 3.0; Parallel Computing; Principles and practice of parallel computing; design, implementation, and performance evaluation of parallel programs for shared-memory, distributed-memory and heterogeneous parallel systems.; **Requisites:** CSE 5441 or CSE 621; **Exclusions:** Not open to students with credit for CSE 721

CSE 6449; G 1.0 - 3.0; Advanced Studies in Parallel Computing; Advanced-level topics in parallel computing.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6461; G 3.0; Computer Communication Networks; Foundational understanding of network analysis, error-control, routing, congestion-control, multi-access, and their examples in the context of the existing communication networks.; **Requisites:** Undergraduate course in probability or Stat 3470 or Math 530 or Stat 428 or Stat 520 or ECE 6001 or ECE 804; **Exclusions:** Not open to students with credit for CSE 861, CSE 862, ECE 6101, ECE 861, or ECE 862; **Cross-Listings:** Cross-listed with ECE 6101

CSE 6469; G 1.0 - 3.0; Advanced Studies in Computer Networking; Advanced-level topics in computer networking.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6479; G 1.0 - 3.0; Advanced Studies in Computer Security; Advanced-level topics in computer security.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6539; G 1.0 - 3.0; Advanced Studies in Artificial Intelligence; Advanced-level topics in artificial intelligence.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6559; G 1.0 - 3.0; Advanced Studies in Computer Graphics; Advanced-level topics in computer graphics.; **Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 15.0 credits, 8 completions allowed

CSE 6998; G 1.0 - 10.0; MS Research in Computer Science and Engineering; MS research in Computer Science and Engineering.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 100.0 credits, 10 completions allowed; **Off Campus**

CSE 6999; G 1.0 - 10.0; MS Thesis Research in Computer Science and Engineering; MS research in Computer Science and Engineering, leading to a thesis.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 100.0 credits, 10 completions allowed; **Off Campus**

CSE 8193; G 1.0 - 10.0; Individual Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 8194; G 1.0 - 10.0; Group Studies in Computer Science and Engineering; Designed to give the student an opportunity to pursue special studies not otherwise offered.; **Flexibly Scheduled; Repeatable:** 10.0 credits, 10 completions allowed; **Off Campus; Requisites:** Permission of Instructor

CSE 8998; G 1.0 - 10.0; PhD Research in Computer Science and Engineering; PhD research in Computer Science and Engineering.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 100.0 credits, 10 completions allowed; **Off Campus**

CSE 8999; G 1.0 - 10.0; PhD Dissertation Research in Computer Science and Engineering; PhD research in Computer Science and Engineering, leading to a dissertation.; **Flexibly Scheduled; Grading Basis:** Satisfactory/Unsatisfactory; **Repeatable:** 100.0 credits, 10 completions allowed; **Off Campus**