**Computer Science**

**CS 1136 (COSC 1136)** Computer Science Laboratory (1 semester hour) Laboratory course to accompany **CS 1336**. This course assists students in experiencing elementary programming in a high-level language. This class cannot be used to fulfill degree requirements for majors in the School of Engineering and Computer Science. Corequisite: **CS 1136**. (0-2) S

**CS 1325** Introduction to Programming (3 semester hours) Computer programming in a high-level, block structured language. Basic data types and variables, memory usage, control structures, functions/procedures and parameter passing, recursion, input/output. Programming projects related to engineering applications, numerical methods. This class is designed for Electrical and Mechanical Engineering majors and cannot be used to fulfill Major Requirements for Computer Engineering, Computer Science, Software Engineering, Telecommunications Engineering majors. Prerequisite: Basic computer literacy/programming skills. (3-0) S

**CS 1335** Computer Science I for Non-majors (3 semester hours) Introduction to object-oriented software analysis, design, and development. Classes and objects. Object composition and polymorphism. Sorting and searching. Strings using core classes. Inheritance and interfaces. Graphical User Interfaces. This class cannot be used to fulfill degree requirements for majors in the School of Engineering and Computer Science. Computer Science and Engineering majors may NOT take this course. Students who have taken **CE 1337** or **CS 1337** or **TE 1337** cannot receive credit for this course. Prerequisite: **CS 1336** with a grade of C or better or equivalent. (3-0) S

**CS 1336 (COSC 1336)** Programming Fundamentals (3 semester hours) Introduction to computers. Primitive data types, variable declarations, variable scope, and primitive operations. Control statements. Methods/functions. Arrays, and strings using primitive data arrays. Output formatting. Debugging techniques. Designed for students with no prior computer programming experience. This class cannot be used to fulfill degree requirements for majors in the School of Engineering and Computer Science. Corequisite: **CS 1136**. Note that a grade of C or better is required in order to register for **CS 1335** or **CE 1337** or **CS 1337** or **TE 1337**. (3-0) S

**CS 1337 (COSC 1337)** Computer Science I (3 semester hours) Introduction to object-oriented software analysis, design, and development. Classes and objects. Object composition and polymorphism. Sorting, searching, recursion. Strings using core classes. Inheritance and interfaces. Graphical User Interfaces. Includes a comprehensive programming project. Prerequisite: **CS 1336** with a grade of C or better or equivalent. (Same as **CE 1337** and **TE 1337**) (3-0) S

**CS 2305 (MATH 2305)** Discrete Mathematics for Computing I (3 semester hours) Principles of counting. Logic and proof methods, including induction. Basic recurrence relations. Basics of algorithm complexity. Sets, relations, functions. Elementary graph theory. Elementary number theory. Students cannot get credit for both **CS 2305** and (**CE 3307** or **TE 3307**). Prerequisite: **MATH 1326** or **MATH 2413** or **MATH 2417**. (Same as **CE 2305** and **TE 2305**) (3-0) S

**CS 2335** Computer Science II for Non-majors (3 semester hours) Exceptions and number formatting. File input/output using Stream classes. Implementation of primitive data structures, including linked lists, stacks, queues, and binary trees. Advanced data manipulation using core classes. This class cannot be
used to fulfill degree requirements for majors in the School of Engineering and Computer Science. Students who have taken CE 2336 or CS 2336 or TE 2336 cannot receive credit for this course. Prerequisite: CS 1335 or CE 1337 or CS 1337 or TE 1337. (3-0) S

**CS 2336 (COSC 2336)** Computer Science II (3 semester hours) Exceptions and number formatting. File input/output using Stream classes. Implementation of primitive data structures, including linked lists (all types), stacks, queues, and binary trees. Advanced data manipulation using core classes. Introduction to multi-threading, multimedia, and networking. Includes a comprehensive programming project. Prerequisite: CE 1337 or CS 1337 or TE 1337. Prerequisite or corequisite: CE 2305 or CS 2305 or TE 2305. (Same as CE 2336 and TE 2336) (3-0) S

**CS 2v95** Individual Instruction in Computer Science (1-6 semester hours) Individual study under a faculty member’s direction. May be repeated for credit as topics vary (6 hours maximum). Instructor consent required. ([1-6]-0) R

**CS 3149** Competitive Learning in Computer Science (1 semester hour) In this course, students will work together in small teams to solve graduated problems, similar to those used in programming contests around the world. Approaches to categorizing problems and selecting appropriate data structures and algorithms will be covered, along with types of algorithms for solving problems (brute force, greedy, divide and conquer, dynamic programming). Students will do problem solving in a competitive environment against the clock. May be repeated for credit (3 hours maximum). Prerequisites: (CE 2336 or CS 2336 or TE 2336) and CS 3305. (1-0) Y

**CS 3162** Professional Responsibility in Computer Science and Software Engineering (1 semester hour) Professional and ethical responsibilities of computer scientists and software engineers as influenced by growth in computer use and networks. Costs and benefits of computer technology. Risks and liabilities of safety-critical systems. Social implications of the Internet. Interaction between human values and technical decisions involving computing. Intellectual Property. Global impact of computing. Pre- or corequisites: CS 3345, CS 3354, and ECS 3361. (Same as SE 3162) (1-0) S

**CS 3305** Discrete Mathematics for Computing II (3 semester hours) Advanced counting methods; recurrence relations, divide and conquer algorithms, principle of inclusion and exclusion. Partial orders and lattices, Algorithmic complexity. Graph theory. Strings and languages. Number theory. Elements of modern algebra. Students cannot receive credit for both CS 3305 and CE 3307 or TE 3307. Prerequisite: (CE 2305 or CS 2305 or TE 2305), and (MATH 2414 or MATH 2419). (3-0) S

**CS 3333** Data Structures (3 semester hours) Programming with basic data structures (arrays, stacks, queues, lists, and trees) and their associated algorithms. Various sorting and searching techniques. Fundamental graph algorithms. This course covers much of the same material as CS 3345 without requiring the analysis of algorithms. Computer Science majors may NOT take this course. This course may not be taken for degree credit by students who have completed CE 2336 or CS 2336 or TE 2336. Prerequisite: CS 1335 or CE 1337 or CS 1337 or TE 1337 or CS 3335 or equivalent programming experience. (3-0) Y

**CS 3335** C and C++ (3 semester hours) Numerous programming projects in both C and C++. All fundamentals of C, with special emphasis on use of pointers. Use of C++ extensions to create and extend (by inheritance) abstract data types. The use/advantages of virtual functions (dynamic polymorphism). Prerequisite: CS 2335 or CE 2336 or CS 2336 or TE 2336 or equivalent. (3-0) T
CS 3340 Computer Architecture (3 semester hours) This course introduces the concepts of computer architecture by going through multiple levels of abstraction, and the numbering systems and their basic computations. It focuses on the instruction-set architecture of the MIPS machine, including MIPS assembly programming, translation between MIPS and C, and between MIPS and machine code. General topics include performance calculation, processor datapath, pipelining, and memory hierarchy. Students who have already completed CS 2310 or equivalent cannot receive credit for this course. Students cannot receive credit for both (CS 3340 or SE 3340 or TE 3340) and (CE 4304 or EE 4304). Prerequisites: (CE 1337 or CS 1337 or TE 1337 or equivalent) and (CE 2305 or CS 2305 or TE 2305). (Same as SE 3340 and TE 3340) (3-0) S

CS 3341 Probability and Statistics in Computer Science and Software Engineering (3 semester hours) Axiomatic probability theory, independence, conditional probability. Discrete and continuous random variables, special distributions of importance to CS/SE, and expectation. Simulation of random variables and Monte Carlo methods. Central limit theorem. Basic statistical inference, parameter estimation, hypothesis testing, and linear regression. Introduction to stochastic processes. Illustrative examples and simulation exercises from queuing, reliability, and other CS/SE applications. Students cannot get credit for both (CS 3341 or SE 3341 or STAT 3341) and ENGR 3341. Prerequisites: (MATH 1326 or MATH 2414 or MATH 2419), and (CE 2305 or CS 2305 or TE 2305). (Same as SE 3341 and STAT 3341) (3-0) S

CS 3345 Data Structures and Introduction to Algorithmic Analysis (3 semester hours) Analysis of algorithms including time complexity and Big-O notation. Analysis of stacks, queues, and trees, including B-trees. Heaps, hashing, and advanced sorting techniques. Disjoint sets and graphs. Course emphasizes design and implementation. Students that completed CE 3346 or TE 3346 cannot receive credit for this course. Prerequisites: (CE 2305 or CS 2305 or TE 2305) and (CE 2336 or CS 2336 or TE 2336). Prerequisite or corequisite: CS 3341 or SE 3341 or ENGR 3341. (Same as CE 3345 and SE 3345 and TE 3345) (3-0) S

CS 3346 Software Engineering (3 semester hours) Introduction to software life cycle models. Software requirements engineering, formal specification and validation. Techniques for software design and testing. Cost estimation models. Issues in software quality assurance and software maintenance. Prerequisites: (CE 2336 or CS 2336 or TE 2336 or CS 3333), and (CE 2305 or CS 2305 or TE 2305 or equivalent). Prerequisite or corequisite: ECS 3390. (Same as CE 3354 and SE 3354) (3-0) S

CS 3354 Computer Graphics for Artists and Designers (3 semester hours) Device and logical coordinate systems, and the nature of raster display. Algorithms for basic 2-D drawing primitives, such as line-drawing, clipping and Bezier curves. Perspectives in 3-D, and hidden-face elimination, such as Painter's and Z-Buffer algorithms. Color and texture. Fractals and the Mandelbrot set. ECS majors cannot receive credit for this course. Prerequisite: CS 2335. (3-0) Y

CS 3376 C/C++ Programming in a UNIX Environment (3 semester hours) Advanced programming techniques utilizing procedural and object oriented programming in a UNIX environment. Topics include file input and output, implementation of strings, stacks, queues, lists, and trees, and dynamic memory allocation/management. Design and implementation of a comprehensive programming project is required. Prerequisite: CE 2336 or CS 2336 or TE 2336 or equivalent. (Same as SE 3376) (3-0) S

CS 3385 Ethics, Law, Society, and Computing (3 semester hours) Issues of professional ethics; computer crime; wiretapping and encryption; protecting software and other intellectual property; privacy and information; careers and computers; reliability and safety; constitutional issues. Broader issues on the impact and control of computers. (3-0) S
CS 3v95  Undergraduate Topics in Computer Science (1-9 semester hours) Subject matter will vary from semester to semester. May be repeated for credit as topics vary (9 hours maximum). ([1-9]-0) S

CS 4141  Digital Systems Laboratory (1 semester hour) Laboratory to accompany CS 4341. The purpose of this laboratory is to give students an intuitive understanding of digital circuits and systems. Laboratory exercises include construction of simple digital logic circuits using prototyping kits and board-level assembly of a personal computer. Students who have already completed CS 2110 cannot receive credit for this course. Corequisite: CS 4341 or TE 4341. (Same as TE 4141) (0-2) S

CS 4314  Intelligent Systems Analysis (3 semester hours) Mathematical tools for investigating the asymptotic behavior of both deterministic and stochastic nonlinear dynamical systems for the purposes of building computational models in the fields of neuroscience, psychology, and artificial intelligence. Topics include: artificial neural network architectures, Lyapunov stability theory, nonlinear optimization theory, stochastic approximation theory, and the Gibbs Sampler. Prerequisite: CGS 4313 or instructor consent required. (Same as CGS 4314) (3-0) T

CS 4315  Intelligent Systems Design (3 semester hours) Mathematical tools for the design and evaluation of artificially intelligent deterministic and stochastic nonlinear dynamical systems for the purposes of building computational models in the fields of neuroscience, psychology, and artificial intelligence. Topics include: (1) Markov Random Field probability representations, and (2) asymptotic mathematical statistical theory for: parameter estimation, model selection, and hypothesis testing. Prerequisite: (CS 4314 or CGS 4314) or instructor consent required. (Same as CGS 4315) (3-0) T

CS 4332  Introduction to Programming Video Games (3 semester hours) Video game programming concepts. Programming with game engine. 2D and 3D computer graphics techniques and data structures. Computer animation, physics-based methods and collision detection. GPU and shader programming. Artificial intelligence for video games. Networking and multiplayer. Prerequisite: CE 3345 or CS 3345 or SE 3 345 or TE 3345. (3-0) Y

CS 4334  Numerical Analysis (3 semester hours) Solution of linear equations, roots of polynomial equations, interpolation and approximation, numerical differentiation and integration, solution of ordinary differential equations, computer arithmetic, and error analysis. Students cannot receive credit for both CS 4334 and ENGR 4334. Prerequisites: (CE 1337 or CS 1337 or TE 1337) and (MATH 2418 and MATH 2451). (Same as MATH 4334) (3-0) Y

CS 4336  Advanced Java (3 semester hours) Advanced Java programming techniques integrating the technologies of advanced swing GUI components, JavaBeans, Java Servlets and Server Pages, XML, Security, Java Database Connectivity, Remote Method Invocation, and Software applications for Wireless Devices. Students will have the opportunity to work on their own E-Business Solutions. Prerequisite: CE 2336 or CS 2336 or TE 2336 or equivalent. (3-0) T

CS 4337  Organization of Programming Languages (3 semester hours) Principles of design and implementation of contemporary programming languages. Formal description including specification of syntax and semantics of programming languages. Language definition structures including binding, scoping, data types, control structures, parameter passing, abstraction mechanism, and run-time considerations. Design issues of imperative languages, object-oriented languages, functional languages and logic languages. Design, implement, and debug programs in various programming language paradigms. Prerequisites: (CE 2336 or CS 2336 or TE 2336 or CS 3333) and (CE 2305 or CS 2305 or TE 2305) and (CS 3340 or SE 3340 or TE 3340 or CE 4304 or EE 4304). (Same as CE 4337) (3-0) S
CS 4341 Digital Logic and Computer Design (3 semester hours) Boolean algebra and logic circuits; synchronous sequential circuits; gate level design of ALSU, registers, and memory unit; register transfer operations; design of data path and control unit for a small computer; Input-Output interface. Students cannot receive credit for both CS 4341 or TE 4341 and (CE 3320 or EE 3320). Prerequisites: (CE 2310 or EE 2310) or (CS 3340 or SE 3340 or TE 3340) and PHYS 2326. Corequisite: (CS 4141 or TE 4141). (Same as TE 43 41) (3-0) S

CS 4347 Database Systems (3 semester hours) This course emphasizes the concepts and structures necessary for the design and implementation of database management systems. Topics include data models, data normalization, data description languages, query facilities, file organization, index organization, file security, data integrity, and reliability. Prerequisite: CE 3345 or CS 3345 or SE 3345 or TE 3 345. (Same as SE 4347) (3-0) Y

CS 4348 Operating Systems Concepts (3 semester hours) An introduction to fundamental concepts in operating systems: their design, implementation, and usage. Topics include process management, main memory management, virtual memory, I/O and device drivers, file systems, secondary storage management, and an introduction to critical sections and deadlocks. Prerequisites: (CS 3340 or SE 3340 or TE 3340 or equivalent), and (CE 3345 or CS 3345 or SE 3345 or TE 3345), and a working knowledge of C and UNIX. (Same as CS 4348 and SE 4348 and TE 4348) (3-0) S

CS 4349 Advanced Algorithm Design and Analysis (3 semester hours) Asymptomatic analysis, recurrences, and graph algorithms. Algorithm design techniques such as greedy method, dynamic programming, and divide-and-conquer. Issues from computational complexity. Course emphasizes a theoretical approach. Prerequisites: CS 3305, and (CE 3345 or CS 3345 or SE 3345 or TE 3345). (3-0) S

CS 4352 Human Computer Interactions I (3 semester hours) Methods and principles of human-computer interaction (HCI), user-centered design (UCD), and usability evaluation. Provides broad overview of HCI and how HCI informs UCD processes throughout product development lifecycle. (Same as CGS 4352) (3-0) T

CS 4353 Human Computer Interactions II (3 semester hours) Detailed exploration of human-computer interaction (HCI) through readings in journal articles and research reports. Practical experience in methodology typically used in the design of usable systems. Prerequisite: (CS 4352 or CGS 4352) or instructor consent required. (Same as CGS 4353) (3-0) T

CS 4361 Computer Graphics (3 semester hours) Review of graphic display architecture and graphic input devices. Two- and three-dimensional transformations, matrix formulations, and concatenation. Clipping and windowing. Data structures for graphics systems, segmented display files, rings, etc. Hidden line and surface elimination. Shading. Graphics packages and applications. Prerequisites: MATH 2418, and (CE 2336 or CS 2336 or TE 2336), and (CE 3345 or CS 3345 or SE 3345 or TE 3345 or equivalent). (3-0) Y

CS 4365 Artificial Intelligence (3 semester hours) Basic concepts and techniques that enable computers to perform intelligent tasks. Examples are taken from areas such as natural language understanding, computer vision, machine learning, search strategies and control, logic, and theorem proving. Prerequisite: CE 3345 or CS 3345 or SE 3345 or TE 3345 or equivalent. (3-0) Y

CS 4375 Introduction to Machine Learning (3 semester hours) Algorithms for creating computer programs that can improve their performance through learning. Topics include: cross-validation, decision trees, neural nets, statistical tests, Bayesian learning, computational learning theory, instance-based learning, reinforcement learning, bagging, boosting, support vector machines, Hidden Markov Models, clustering,
and semi-supervised and unsupervised learning techniques. Prerequisites: (CS 3341 or SE 3341) and (CE 3345 or CS 3345 or SE 3345 or TE 3345 or equivalent). (3-0) Y

**CS 4376** Object-Oriented Programming Systems (3 semester hours) In-depth study of the features/advantages of object-oriented approach to problem solving. Special emphasis on issues of object-oriented analysis, design, implementation, and testing. Review of basic concepts of object-oriented technology (abstraction, inheritance, and polymorphism). Object-oriented programming languages, databases, and productivity tools. Prerequisite: **CE 2336** or **CS 2336** or **TE 2336** or equivalent. (Same as **SE 4376**) (3-0) S

**CS 4384** Automata Theory (3 semester hours) A review of the abstract notions encountered in machine computation. Topics include finite automata, regular expressions, PDAs, and context-free languages. Prerequisite: **CS 3305**. (3-0) S

**CS 4386** Compiler Design (3 semester hours) Basic phases of a compiler and their design principles. Topics include lexical analysis, basic parsing techniques such as LR(K) and LL(K) grammars. Prerequisite: **CE 3345** or **CS 3345** or **SE 3345** or **TE 3345** (or equivalent). (3-0) R

**CS 4389** Data and Applications Security (3 semester hours) Data as a critical resource. Threats to data and applications security including access control violations, integrity violations, unauthorized intrusions and sabotage; techniques to enforce security. Prerequisite: **CS 4347** or **SE 4347**. (3-0) Y

**CS 4390** Computer Networks (3 semester hours) The design and analysis of computer networks. Topics include the ISO reference model, transmission media, medium-access protocols, LANs, data link protocols, routing, congestion control, internetworking, and connection management. Students cannot get credit for both (**CE 4390** or **CS 4390** or **TE 4390**) and **EE 4390**. Prerequisite: **CE 3345** or **CS 3345** or **SE 3345** or **TE 3345** or equivalent. (Same as **CE 4390** and **TE 4390**) (3-0) S

**CS 4391** Introduction to Computer Vision (3 semester hours) Techniques for manipulating and extracting information from digital images and video. Topics include color representations, analysis and processing based on image histograms, geometric transformations, convolutions, image blurring and sharpening, extraction of edges, matching, image and video motion. Prerequisites: **CE 3345** or **CS 3345** or **SE 3345** or **TE 3345** or equivalent. (3-0) Y

**CS 4392** Computer Animation (3 semester hours) Introduction to traditional animation. Kinematics of motion. Key framing. Coordinate systems and transformations (review), Euler angles and Quaternions, Catmull Rom and B-Splines, Advanced Key framing, articulated figures (forward kinematics), human and animal modeling (soft tissue, skin, etc.). Facial animation (parametric). Physically based modeling (rigid, collision detection). Physically based modeling (deformable). Behavioral and heuristic models. Algorithmic animation. Optimization techniques. Animation languages and systems. Motion capture and real time control. Virtual reality and animation. Rendering and temporal aliasing. 2D and 3D morphing. 3D modeling. Prerequisites: **MATH 2418** and (**CE 3345** or **CS 3345** or **SE 3345** or **TE 3345** or equivalent). (3-0) Y

**CS 4393** Computer and Network Security (3 semester hours) The study of security and vulnerabilities in computer and network systems. Common attacking techniques such as buffer overflow, viruses, worms, etc. Security in existing systems such as UNIX, Windows, and JVM. Fundamental access control and information flow concepts. Symmetric Ciphers such as DES and AES. Public-key encryption techniques and related number theory. Message authentication, hash functions, and digital signatures. Authentication applications, IP security and Web security. Prerequisite: **CE 4348** or **CS 4348** or **SE 4348** or **TE 4348** or equivalent. (3-0) Y
CS 4394 Implementation of Modern Operating Systems (3 semester hours) This course focuses on developing systems implementation skills through a set of projects. Each project will explore one fundamental component of operating systems such as process scheduling, memory management, device drivers, file systems, and network communication management. The projects are expected to involve kernel-level programming. Prerequisites: (CE 4348 or CS 4348 or SE 4348 or TE 4348) and CS 3335, or equivalent programming experience. (3-0) R

CS 4395 Human Language Technologies (3 semester hours) Introduction to human language technologies (HLT), the study of natural languages from a computational perspective. Topics include computational models of syntax and semantics, natural language applications (such as machine translation, speech processing, information retrieval, and information extraction), and general machine-learning techniques commonly used in state-of-the-art HLT research. Prerequisite: (CS 3341 or SE 3341, and (CE 3345 or CS 3345 or SE 3345 or equivalent). (3-0) Y

CS 4396 Networking Laboratory (3 semester hours) This course takes a lab-oriented approach to demonstrate how basic networking concepts are applied in a real network. The hands-on projects include setting up simple network topologies, configuring devices to run basic network protocols, and using various debugging tools to identify, locate, and fix common problems in networking. Pre- or corequisite: CS 4390 or equivalent. (3-0) Y

CS 4397 Embedded Computer Systems (3 semester hours) Introduction to embedded computer applications and concepts. Real-time operating systems and resource management. Real-time scheduling and communication. Senior data acquisition, processing and fusion. Error handling, fault tolerance, and graceful degradation. System performance analysis and optimization techniques. Includes a project to develop and analyze a small embedded computer application. Prerequisite: CE 4348 or CS 4348 or SE 4348 or TE 4348 or equivalent. (3-0) Y

CS 4398 Digital Forensics (3 semester hours) Creating and preserving digital evidence, data recovery and evidence collection algorithms, evidence construction and reconstruction, methods for certifying evidence, storing evidence, data acquisition, forensic analysis algorithms, image files, network forensics, logging methods to trace back attacks and digital trails, e-mail investigations. Prerequisites: (CE 4348 or CS 4348 or SE 4348 or TE 4348) and (CE 4390 or CS 4390 or TE 4390) or equivalent. (3-0) Y

CS 4399 Senior Honors in Computer Science (3 semester hours) For students conducting independent research for honors theses or projects. Topics may vary. (3-0) R

CS 4485 Computer Science Project (4 semester hours) This course is intended to complement theory and to provide an in-depth, hands-on experience in all aspects of a software development project. Students will work in teams on projects of interest to industry and will be involved in specifying the problem and its solution, designing and analyzing the solution, developing the software architecture, along with implementation and testing plans. The deliverables will include reports that document these steps as well as a final project report, including the challenges they faced, and a user manual of the developed system. Students will explore security issues of their project and its potential impact on society. Teams will also make presentations as well as demonstrate their software. Additionally, this course will cover topics related to computer science profession including ethics and professional responsibility, entrepreneurship, leadership, and project management. Prerequisites: (CE 3345 or CS 3345 or SE 3345 or TE 3345), and (CE 3354 or CS 3354 or SE 3354 or equivalent), and at least three CS 43XX classes. (4-0) S

CS 4v95 Undergraduate Topics in Computer Science (1-9 semester hours) Subject matter will vary from
semester to semester. May be used as CS Guided Elective on CS degree plans. May be repeated for credit as topics vary (9 hours maximum). ([1-9]-0) R

**CS 4v98** Undergraduate Research in Computer Science (1-9 semester hours) Topics will vary from semester to semester. May be repeated for credit as topics vary (9 hours maximum). Instructor consent required. ([1-9]-0) R