Rose-Hulman Institute of Technology Course Catalog

Software Engineering

Software engineering is the creation of software using a process similar to other engineering disciplines. It allows for software to be reliable and developed within time and cost estimates. The software engineering curriculum prepares students for a career in reliable, economical software development.

Programming is only one phase (construction) of software engineering. There are many other aspects of the software engineering process, such as requirements definition, architectural design, and quality assurance, which need to be applied in order to develop reliable software on time and within budget constraints. The software engineering curriculum provides students a solid background in both the theory and practice of all phases in the software engineering process, beginning with their first course of study in the Department of Computer Science and Software Engineering, and continuing to the end of the senior year.

Since software is a non-physical product developed and executed on computers, the software engineering curriculum has computer science as its primary engineering science. The computer science courses taken by software engineering majors include the study of algorithms, data structures, database concepts, computer architecture, programming languages and operating systems. Software engineering majors also complete important courses in other closely related fields, such as discrete mathematics, digital logic design, and engineering statistics.

Coverage of software engineering topics begins in a three-term introduction to software development during the freshman and sophomore years. This study continues with coverage of core software engineering areas in the junior year, including software requirements, software architecture, software design, software project management, software construction, software maintenance, software evolution, software quality assurance, and formal methods in software specification and design. All of these courses include individual and team projects relevant to that particular area of software engineering. These projects generally include both written and oral presentations, building upon a technical communication course which introduces the student to the skills necessary for this important aspect of being a software professional. Throughout the senior year, a capstone team project develops and delivers software for a “real-world” client, which is put on display locally at a public exposition.

Throughout society, software exists for a wide variety of application domain areas. Each student is required to take at least three courses in a particular application domain, so that RHIT software engineering graduates can more effectively apply the software engineering principles they learn to that domain area. Students can choose from a variety of domain areas, including engineering, scientific and commercial applications.

Courses in various computer science topics such as computer graphics, artificial intelligence, computer networks, computer vision, web-based information systems, and cryptography are among those available as advanced electives. In addition, free elective courses allow students to tailor their undergraduate education to their specific goals.

The department has its own local area network. This network is connected to the campus-wide network and the Internet. Laboratory machines are mostly Sun Ultra workstations. Software engineering majors have unlimited access to the department's laboratories. Software engineering students are frequently employed by the computing center as user consultants and by the department as system managers and course assistants.

The student chapter of the Association for Computing Machinery provides seminars and other technical activities throughout the year. The national honor society in the computing and engineering disciplines, Upsilon Pi Epsilon and Tau Beta Pi, both have chapters at Rose-Hulman. Software engineering majors are also eligible to join the Order of the Engineer, which focuses on the ethical and professional responsibilities of an engineer, during the spring of their last year of study.

Software Engineering Program Educational Objectives

The software engineering program prepares its graduates for many types of careers in the computing industry as well as for graduate study in software engineering and in closely related disciplines. Within a few years after completing the software engineering degree program, our graduates will:

1. Advance beyond their entry-level position to more responsible roles, or progress towards completion of advanced degree(s).
2. Continue to keep pace with advancements in their disciplines, and develop professionally in response to changes in roles and responsibilities.
3. Demonstrate that they can collaborate professionally within or outside of their disciplines at local, regional, national, or international levels.
4. Contribute to the body of computing products, services, or knowledge.

Software Engineering Student Outcomes

By the time students graduate with a Software Engineering degree from Rose-Hulman, they will be able to:

1. Apply software engineering theory, principles, tools and processes, as well as the theory and principles of computer science and mathematics, to the full lifecycle of complex, scalable software systems
2. Elicit, analyze and specify software requirements through a productive working relationship with project stakeholders
3. Design and construct software using contemporary software design and architecture principles and patterns so relevant tradeoffs can be analyzed to produce effective solutions
4. Apply appropriate codes of ethics and professional conduct to the solution of software engineering problems
5. Evaluate and discuss the legal, social, and ethical aspects of significant events that arise in the field of computing both domestically and internationally
6. Interact effectively with colleagues and clients located abroad and overcome challenges that arise from geographic distance, cultural differences, and multiple languages
7. Communicate effectively through oral and written reports as well as software documentation
8. Participate productively on software project teams involving colleagues from a variety of disciplines

9. Recognize the need for, and engage in, lifelong learning

The Computer Science and Software Engineering faculty strives to maintain an open atmosphere that encourages mutual respect and support as well as learning and sharing of knowledge.

The software engineering program is accredited by the Engineering Accreditation Commission of ABET,www.abet.org

SOFTWARE ENGINEERING

Summary of graduation requirements for the software engineering major

To complete the major in software engineering a student must complete the following:

1. All required courses listed by number in the schedule of courses above: CSSE120, CSSE132, CSSE220, CSSE230, CSSE232, CSSE304, CSSE332, CSSE333, CSSE371, CSSE372, CSSE373, CSSE374, CSSE375, CSSE376, CSSE477, CSSE497, CSSE498, CSSE499; MA111, MA112, MA113, MA212, MA275, MA375, MA381; PH111, PH112, CHEM111; RH 131, RH330; CLSK100.
2. Four additional credits of CSSE courses except CSSE325, CSSE473, CSSE474, and CSSE479. In addition, use of CSSE49x to satisfy the CSSE elective requires approval of the Director of Software Engineering or the CSSE department head.
3. A Domain Track set of courses.
    a. SE Domain Track Process:

       As part of the Bachelor of Science in Software Engineering (BSSE) degree requirements, the domain track provides a means of applying software engineering in an application domain outside of computing (e.g., biology is a domain where software applications are commonly developed).

       SE Domain Tracks

       Domain Track Declaration Form

1. Four additional credits of courses offered by the Department of Mathematics excluding MA351 – MA356. The student's academic advisor must approve the course used to satisfy this requirement. Where appropriate, a course in the student's application domain track can be used to satisfy this requirement.
2. Four credits of science electives, which can be any CHEM, GEOL, PH, or BIO courses not already required for the software engineering major.
3. Twenty-eight credits of additional courses offered by the Department of Humanities and Social Sciences; the distribution of these courses must meet the requirements of that department. Where appropriate, one or more courses in the student's application domain track can be used to satisfy part of this requirement.
4. Sufficient free elective courses to meet the minimum credit hour requirement of 192 hours for a software engineering major. These courses must have the approval of the student's academic advisor. Free electives may be selected from any Rose-Hulman course.

Area Minor in Software Engineering

Advisor: Dr. Shawn Bohner

Required Courses

CSSE 120, Introduction to Software Development

CSSE 220, Object-Oriented Software Development
CSSE 230, Data Structures and Algorithm Analysis
CSSE 371, Software Requirements Engineering
CSSE 374, Software Design

Two additional courses in software engineering chosen from CSSE 372, 373, 375, 376, and 477.

Course Sequence

Freshman

Fall

Course	Credit
CSSE 120 Introduction to Software Development	4
MA 111 Calculus I	5
PH 111 Physics I	4
RH 131 Rhetoric & Composition	4
CLSK 100 College & Life Skills	1
	Total Credits: 18

Winter

Course	Credit
CSSE 220 Object-Oriented Software Development	4
MA 112 Calculus II	5
PH 112 Physics II	4
HSS Elective	4
	Total Credits: 17

Spring

Course	Credit
CSSE 132 Introduction to Computer Systems Design	4
MA 113 Calculus III	5
HSS Elective	4
Science Elective	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
CHEM 111 General Chemistry I	4
CSSE 232 Computer Architecture I	4
MA 212 Matrix Algebra & Systems of Differential Equations	4
MA 275 Discrete & Combinatorial Algebra I	4
	Total Credits: 16

Winter

Course	Credit
CSSE 230 Data Structures & Algorithm Analysis	4
CSSE 304 Programming Lang. Con	4
MA 375 Discrete & Combinatorial Algebra II	4
RH 330 Technical & Professional Communication	4
CSSE 332 Operating Systems	4
	Total Credits: 20

Spring

Course	Credit
CSSE 376 Software Quality Assurance	4
MA Elective	4
CSSE 333 Database Systems	4
Domain track course	4
	Total Credits: 16

Junior

Fall

Course	Credit
CSSE 371 Software Requirements Engineering	4
CSSE 372 Software Project Management	4
MA 381 Introduction to Probability with Statistical Applications	4
Domain track course	4
	Total Credits: 16

Winter

Course	Credit
CSSE 374 Software Design	4
Domain track course	4
HSS Elective	4
	Total Credits: 12

Spring

Course	Credit
CSSE 373 Formal Methods in Specification & Design	4
CSSE 375 Software Construction & Evolution	4
HSS Elective	4
Domain track course or free elective	4
	Total Credits: 16

Senior

Fall

Course	Credit
CSSE 477 Software Architecture	4
CSSE 497 Senior Capstone Project I	4
HSS Elective	4
Domain track course or free elective	4
	Total Credits: 16

Winter

Course	Credit
SSE 498 Senior Capstone Project II	4
CSSE Elective	4
HSS Elective	4
Free Elective	4
	Total Credits: 16

Spring

Course	Credit
CSSE 499 Senior Capstone Project III	4
HSS Elective	4
Free Elective	4
	Total Credits: 12

Software Engineering - Course Descriptions

CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
An introduction to procedural and object-oriented programming with an emphasis on problem solving. Problems may include visualizing scientific or commercial data, interfacing with external hardware such as robots, or solving numeric problems from a variety of engineering disciplines. Procedural programming concepts covered include data types, variables, control structures, arrays, and data I/O. Object-oriented programming concepts covered include object creation and use, object interaction, and the design of simple classes. Software engineering concepts covered include testing, incremental development, understanding requirements, and teamwork.

CSSE 132 Introduction to Computer Systems 3R-3L-4C F,S
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Provides students with an understanding of system level issues and their impact on the design and use of computer systems. Examination of both hardware and software layers. Basic computation structures and digital logic. Representation of instructions, integers, floating point numbers and other data types. System requirements, such as resource management, security, communication and synchronization, and their hardware and/or software implementation. Exploration of multiprocessor and distributed systems. Course topics will be explored using a variety of hands-on assignments and projects.

CSSE 212 Hardware-oriented Programming 3R-3L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Simple computer architecture. Special hardware-oriented programming. Introduction to the C programming language, especially the use of pointers. Interrupt programming. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Object-oriented programming concepts, including the use of inheritance, interfaces, polymorphism, abstract data types, and encapsulation to enable software reuse and assist in software maintenance. Recursion, GUIs and event handing. Use of common object-based data structures, including stacks, queues, lists, trees, sets, maps, and hash tables. Space/time efficiency analysis. Testing. Introduction to UML.

CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F
Prerequisites: A score of 4 or 5 on the APCS A exam or permission of instructor
Corequisites: There are no corequisites for this course.
This course is intended for students who have sufficient programming experience to warrant placement in an accelerated course covering the topics from CSSE 120 and CSSE 220. This course will satisfy the prerequisite requirements for courses that have CSSE 220 as a prerequisite.

CSSE 225 Programming 3 3R-3L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Differences between Java and C++. C++ concepts of object-oriented programming (classes, objects, inheritance, polymorphism). Storage management. Multiple inheritance, operator overloading, friend-concept, exception handling, I/O. Error analysis of programs. Generic programming and introduction to C++ - standard library. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S* or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F*, and MA 112 Calculus II 5R-0L-5C F,W,S *with a grade of C or better
Corequisites: There are no corequisites for this course.
This course reinforces and extends students' understanding of current practices of producing object-oriented software. Students extend their use of a disciplined design process to include formal analysis of space/time efficiency and formal proofs of correctness. Students gain a deeper understanding of concepts from CSSE 220, including implementations of abstract data types by linear and non-linear data structures. This course introduces the use of randomized algorithms. Students design and implement software individually, in small groups, and in a challenging multi-week team project.

CSSE 232 Computer Architecture I 3R-3L-4C F,W
Prerequisites: CSSE 132 Introduction to Computer Systems 3R-3L-4C F,S or CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S, and ECE 180 Introduction to Signal Processing 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Computer instruction set architecture and implementation. Specific topics include historical perspectives, performance evaluation, computer organization, instruction formats, addressing modes, computer arithmetic, ALU design, floating-point representation, single-cycle and multi-cycle data paths, and processor control. Assembly language programming is used as a means of exploring instruction set architectures. The final project involves the complete design and implementation of a miniscule instruction set processor.

CSSE 241 Computing in a Global Society 2R-6L-4C
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F Arranged prerequisite
Corequisites: There are no corequisites for this course.
The ability to work with colleagues from other cultures and to work on international projects are key assets in today's job market. The centerpiece of this course is a real-world computing project that students develop in cooperation with peers from an institution of higher education in a foreign country. Exposes students to the procedures and complexities of working on projects that span many time-zones and cultures. Additionally, students examine the use and impact of computing in a global community. International travel is required; students will be expected to incur additional expenses (will vary depending on the project, institution, and country). May be repeated once (for free elective credit only) if the country involved is different.

CSSE 280 Introduction to Web Programming 3R-3L-4C W
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F
Corequisites: There are no corequisites for this course.
Introduction to the client-side and server-side mechanisms for creating dynamic web pages with persistent data storage. Browser-webserver interaction via HTTP. Static web page creation using HTML5 and CSS3. Client-side programming using JavaScript, DOM, JSON. Server-side programming and data storage using PHP and mySQL. Asynchronous client-server communication using AJAX and extensions of JavaScript. Session maintenance using cookies. Security considerations. This course provides breadth of knowledge of many tools/technologies rather than deep knowledge of any particular tool/language. No previous experience with web page creation is required.

CSSE 290 Special Topics in Computer Science 1 - 4C
Prerequisites: Arranged prerequiste - permission of instructor
Corequisites: There are no corequisites for this course.
Selected topics of current interest. May be repeated for credit if topic is different.

CSSE 304 Programming Language Concepts 4R-0L-4C S
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
Syntax and semantics of programming languages. Grammars, parsing, data types, control flow, parameter passing, run-time storage management, binding times, functional programming and procedural abstraction, syntactic extensions, continuations, language design and evaluation. Students will explore several language features by writing an interpreter that implements them.

CSSE 325 Fractals & Chaotic Dynamical Systems 4R-0L-4C
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S* or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F*, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S* *Arranged prerequisite
Corequisites: There are no corequisites for this course.
Emphasis on the mathematical and computer graphics foundations behind fractal images and the relationship between chaotic dynamics and fractal geometry. Self-similar fractals, random fractals with Brownian motion, and fractals generated from dynamical systems. Fractal dimensions. Iterated Function Systems. Chaos in one-dimensional maps. Controlling chaos. Mandelbrot and Julia sets. Computer graphics. Same as MA 325.

CSSE 332 Operating Systems 3R-3L-4C W,S
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F, and CSSE 132 Introduction to Computer Systems 3R-3L-4C F,S or CSSE 232 Computer Architecture I 3R-3L-4C F,W
Corequisites: There are no corequisites for this course.
Students learn fundamental concepts of modern operating systems by studying how and why operating systems have evolved. Topics include CPU scheduling, process synchronization, memory management, file systems, I/O systems, privacy and security, and performance evaluation. Students implement parts of an operating system as a means of exploring the details of some of these topics.

CSSE 333 Database Systems 3R-3L-4C W
Prerequisites: MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W, and CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S or concurrent enrollment in CSSE230
Corequisites: There are no corequisites for this course.
Relational database systems, with emphasis on entity relationship diagrams for data modeling. Properties and roles of transactions. SQL for data definition and data manipulation. Use of contemporary API's for access to the database. Enterprise examples provided from several application domains. The influence of design on the use of indexes, views, sequences, joins, and triggers. Physical level data structures: B+ trees and RAID. Survey of object databases.

CSSE 335 Introduction to Parallel Computing 4R-0L-4C S (odd years)
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S and programming experience
Corequisites: There are no corequisites for this course.
Principles of scientific computation on parallel computers. Algorithms for the solution of linear systems and other scientific computing problems on parallel machines. Course includes a major project on RHIT's parallel cluster. Same as MA 335.

CSSE 351 Computer Graphics 4R-0L-4C F
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Computer graphics algorithms, hardware and software. Line generators, affine transformations, line and polygon clipping, interactive techniques, perspective projection, solid modeling, hidden surface algorithms, lighting models, shading, and graphics standards. Programming assignments and a final project are required.

CSSE 352 Computer Game Development 4R-0L-4C
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
An introduction to designing and developing computer games. Topics include game genres, game design, sprites, game physics, collisions, characters, scripting, graphics, and sound. Students will design and implement their own game using an available game engine.

CSSE 371 Software Requirements Engineering 3R-3L-4C F
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S, and RH 330 Technical & Professional Communication 4R-OL-4C W,S and Junior standing
Corequisites: There are no corequisites for this course.
Basic concepts and principles of software requirements engineering, its tools and techniques, and methods for modeling software systems. Topics include requirements elicitation, prototyping, functional and non-functional requirements, object-oriented techniques, and requirements tracking.

CSSE 372 Software Project Management 4R-0L-4C F
Prerequisites: There are no prerequisites for this course.
Corequisites: CSSE 371 Software Requirements Engineering 3R-3L-4C F

Major issues and techniques of project management. Project evaluation and selection, scope management, team building, stakeholder management, risk assessment, scheduling, quality, rework, negotiation, and conflict management. Professional issues including career planning, lifelong learning, software engineering ethics, and the licensing and certification of software professionals.

CSSE 373 Formal Methods in Specification and Design 4R-0L-4C S
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S, and MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Introduction to the use of mathematical models of software systems for their specification and validation. Topics include finite state machine models, models of concurrent systems, verification of models, and limitations of these techniques.

CSSE 374 Software Design 3R-3L-4C W
Prerequisites: CSSE 371 Software Requirements Engineering 3R-3L-4C F
Corequisites: There are no corequisites for this course.
Introduction to the architecture and design of complete software systems, building on components and patterns. Topics include architectural principles and alternatives, design documentation, and relationships between levels of abstraction.

CSSE 375 Software Construction and Evolution 3R-3L-4C S
Prerequisites: CSSE 374 Software Design 3R-3L-4C W
Corequisites: There are no corequisites for this course.
Issues, methods and techniques associated with constructing software. Topics include detailed design methods and notations, implementation tools, coding standards and styles, peer review techniques, and maintenance issues.

CSSE 376 Software Quality Assurance 4R-0L-4C S
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
Theory and practice of determining whether a product conforms to its specification and intended use. Topics include software quality assurance methods, test plans and strategies, unit level and system level testing, software reliability, peer review methods, and configuration control responsibilities in quality assurance.

CSSE 400 CSSE Seminar 4R-0L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
This course presents an overview of current application areas within computer science and software engineering through the use of practical case studies. Students will undertake their own preparation of one or more case studies and present their results. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 402 Theory and Practice of Garbage Collection 4R-0L-4C S (even years)
Prerequisites: CSSE 332 Operating Systems 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
Garbage collection (GC) is a method of automatically reclaiming dynamically allocated storage that an application no longer needs. In this course, students will explore the classical problems of garbage collection such as detecting unused objects and reclaiming the space allocated to them. Students will survey the GC literature to

become familiar with the current state-of-the-art and future research directions. Students will explore techniques used to implement state-of-the-art garbage collection algorithms and will design and implement garbage collectors for a memory-managed language (e.g.,Java, C#, php, or Python).

CSSE 403 Programming Language Paradigms 4R-0L-4C F (even years)
Prerequisites: CSSE 304 Programming Language Concepts 4R-0L-4C S
Corequisites: There are no corequisites for this course.
A survey of some current and emerging programming languages, focusing on unique language paradigms-ways of structuring solutions or manipulating data. Examples of paradigms include dynamic programming languages, object-oriented programming, highly parallelizable code, and functional programming. Emphasizes developing independent learning techniques that will allow students to acquire skills in new languages quickly. Students will develop basic skills in at least three different languages representing distinct paradigms. They will also be exposed to a selection of other languages. Includes a substantial team project.

CSSE 404 Compiler Construction 4R-0L-4C S
Prerequisites: CSSE 232 Computer Architecture I 3R-3L-4C F,W, and CSSE 304 Programming Language Concepts 4R-0L-4C S, and CSSE 474 Theory of Computation 4R-0L-4C W
Corequisites: There are no corequisites for this course.
Theory and practice of programming language translation. Lexical analysis, syntax analysis, parser generators, abstract syntax, symbol tables, semantic analysis, intermediate languages, code generation, code optimization, run-time storage management, error handling. Students will construct a complete compiler for a small language.

CSSE 413 Artificial Intelligence 4R-0L-4C F
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
Students investigate how to model and implement intelligent behavior using computers. Topics are chosen from how machines can: solve problems; reason and use knowledge; learn from experience; and perceive and act. Students explore these topics by implementing many of the ideas in software. Readings are drawn both from a textbook and from technical papers in recent conferences and journals.

CSSE 432 Computer Networks 4R-0L-4C S
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F
Corequisites: There are no corequisites for this course.
Organization, design, and implementation of computer networks, especially the Internet. Network protocols, protocol layering, flow control, congestion control, error control, packet organization, routing, gateways, connection establishment and maintenance, machine and domain naming, security. Each of the top four layers of the Internet protocol stack: application (FTP, HTTP, SMTP), transport (TCP, UDP), network (IP), link (Ethernet).

CSSE 433 Advanced Database Systems 4R-0L-4C S
Prerequisites: CSSE 333 Database Systems 3R-3L-4C W
Corequisites: There are no corequisites for this course.

Topics selected from object-oriented databases, object-relational databases, query processing, transactions, transaction logging, concurrency control, database recovery, parallel and distributed databases, security and integrity, data mining and data warehousing.

CSSE 435 Robotics Engineering 3R-3L-4C S
Prerequisites: ME 430 Mechatronic Systems 3R-3L-4C F,W or ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
Interdisciplinary course in robotics focusing on communication, software development, kinematics, robot GUI design, sensing, control, and system integration. Labs in the course cover MATLAB GUI development with GUIDE, Denavit-Hartenberg parameters, Arduino programming, Arduino to Android communication, Android app development, and OpenCV4Android image recognition. Students in the course will program an Android + Arduino, 6-wheeled mobile robot with 5 DOF servo arm to participate in an outdoor GPS robotics challenge. Cross-listed with ME 435.

CSSE 442 Computer Security 4R-0L-4C W
Prerequisites: CSSE 332 Operating Systems 3R-3L-4C W,S, and MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
This course introduces ethical, theoretical, and practical issues of information security in computing systems. Implications of relevant professional codes of ethics are a recurring theme of the course. Foundational topics include access control matrices and standard system models, as well as policies for security, confidentiality, and integrity. Implementation issues include key management, cipher techniques, authentication, principles of secure design, representation of identity, access control mechanisms, information flow, life cycle issues, and formal evaluation and certification techniques. Additional topics include malicious logic, vulnerability analysis, and auditing. Computer network attack techniques are discussed and explored in a closed environment to motivate and inform discussion and exploration of computer network defense techniques.

CSSE 443 Distributed Systems & IT Security 3R-3L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Building complex distributed information systems requires a systematic approach. This course covers the analysis of existing distributed information systems and provides the ability to model simple new distributed applications with special attention to the trustworthiness, reliability and security of information systems. Topics covered include the main architectural models of distributed systems, describing simple distributed applications according to architecture and function, defining simple communication protocols, the benefits of using middleware, the risks of using distributed systems, and safety measures. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 444 Real-time Systems 3R-3L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Students will learn the features and specifications of real-time systems. Topics covered include real-time operating systems and programming languages, design patterns for

real-time systems, scheduling, synchronization, hybrid task sets, and applications of real-time systems. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 451 Advanced Computer Graphics 4R-0L-4C W (even years)
Prerequisites: CSSE 351 Computer Graphics 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Advanced topics in computer graphics. Topics will be drawn from current graphics research and will vary, but generally will include ray tracing, radiosity, physically-based modeling, animation, and stereoscopic viewing. Programming assignments and a research project are required.

CSSE 453 Topics in Artificial Intelligence R-0L-4C
Prerequisites: CSSE 413 Artificial Intelligence 4R-0L-4C F Arranged prerequisite
Corequisites: There are no corequisites for this course.
Advanced topics in artificial intelligence. Topics will vary. Past topics have included machine game playing and machine learning. May be repeated for credit if topic is different.

CSSE 461 Computer Vision 4R-0L-4C S (odd years)
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, MA 371 Linear Algebra I 4R-0L-4C F,S* or MA 373 Applied Linear Algebra for Engineers 4R-0L-4C W* *recommended
Corequisites: There are no corequisites for this course.
An introduction to 3D computer vision techniques. Both theory and practical applications will be covered. Major topics include image features, camera calibration, stereopsis, motion, shape from x, and recognition.

CSSE 463 Image Recognition 4R-0L-4C W
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S Junior standing and programming experience
Corequisites: There are no corequisites for this course.
Introduces statistical pattern recognition of visual data; low-level visual feature extraction (color, shape, edges); clustering and classification techniques. Applies knowledge to various application domains through exercises, large programming projects in Matlab, and an independent research project. Familiarity with probability distributions will be helpful, but not required.

CSSE 473 Design and Analysis of Algorithms 4R-0L-4C F
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S, and MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S
Corequisites: There are no corequisites for this course.
Students study techniques for designing algorithms and for analyzing the time and space efficiency of algorithms. The algorithm design techniques include divide-and-conquer, greedy algorithms, dynamic programming, randomized algorithms and parallel algorithms. The algorithm analysis includes computational models, best/average/worst case analysis, and computational complexity (including lower bounds and NP-completeness). Same as MA 473.

CSSE 474 Theory of Computation 4R-0L-4C W

Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S, and MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S
Corequisites: There are no corequisites for this course.
Students study mathematical models by which to answer three questions: What is a computer? What limits exist on what problems computers can solve? What does it mean for a problem to be hard? Topics include models of computation (including Turing machines), undecidability (including the Halting Problem) and computational complexity (including NP-completeness). Same as MA 474.

CSSE 477 Software Architecture 4R-0L-4C F
Prerequisites: CSSE 374 Software Design 3R-3L-4C W or consent of instructor
Corequisites: There are no corequisites for this course.
This is a second course in the architecture and design of complete software systems, building on components and patterns. Topics include architectural principles and alternatives, design documentation, relationships between levels of abstraction, theory and practice of human interface design, creating systems which can evolve, choosing software sources and strategies, prototyping and documenting designs, and employing patterns for reuse. How to design systems which a team of developers can implement, and which will be successful in the real world.

CSSE 479 Cryptography 4R-0L-4C S
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F, and MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Introduction to basic ideas of modern cryptography with emphasis on mathematical background and practical implementation. Topics include: the history of cryptography and cryptanalysis, public and private key cryptography, digital signatures, and limitations of modern cryptography. Touches upon some of the societal issues of cryptography. Same as MA 479.

CSSE 480 Web App Frameworks with AppEngine 3R-3L-4C F
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S, and CSSE 280 Introduction to Web Programming 3R-3L-4C W
Corequisites: There are no corequisites for this course.
Development of desktop and mobile web applications using Google AppEngine. Additional web frameworks include Jinja2, Cloud Datastore, jQuery, Bootstrap, DataTables, Cloud Storage, Cloud Endpoints, and AngularJS. Topics covered using these frameworks include the HTML, CSS, and JavaScript development of client side web apps, sending and receiving REST requests, designing Datastore models, HTML5 and CSS3 features including CSS animations, file storage, Ajax requests, and user OAuth. Emphasis is on hands-on use of these frameworks in web application development. Includes a substantial team project (UI mockups, user stories, development, testing, and presentation).

CSSE 481 Web-Based Information Systems 4R-0L-4C F (odd years)
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
In this course, students learn about several aspects of research: thinking creatively about interesting research problems, researching existing work in a chosen area, and keeping current in a field. Students are exposed to the process of research by writing

a pre-proposal for a project that advances the web. Projects either develop new web-technologies or applications or investigate a topic of importance. Based on feedback received, groups of students write a research proposal which goes through a formal peer review process. Approved projects are pursued for the remainder of the quarter. Students present current research as well as give a final presentation of their group project. Selected web-technologies are introduced; in the past, these have included CGI programming and XML technologies.

CSSE 483 Android Application Development 4R-0L-4C
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
An introduction to programming mobile applications using the Android stack. Topics include the activity lifecycle, resources, layouts, intents for multiple activities, menus, fragments and dialogs, adapters, data persistence via shared preferences, SQLite, and web backends. Emphasis is on hands-on use of these components in application development. Includes a substantial team project (UI mockups, user stories, UML design, development, testing, and presentation).

CSSE 484 iOS Application Development 3R-3L-4C W
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
An introduction to programming mobile applications using the iOS stack. Topics include using X-Code for Swift and Objective-C app development, UI components, Storyboards, view controller actions and outlets, table views, navigation controllers, Core Data, and APIs for backend communication. Emphasis is on hands-on use of these components in application development. Includes a substantial team project (UI mockups, user stories, development, testing, and presentation).

CSSE 487 Senior Research Project I 4C
Prerequisites: RH 330 Technical & Professional Communication 4R-OL-4C W,S and senior standing (Arranged)
Corequisites: There are no corequisites for this course.
Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 488 Senior Research Project II 4C
Prerequisites: CSSE 487 Senior Research Project I 4C W,S Arranged prerequisite
Corequisites: There are no corequisites for this course.
Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 489 Senior Research Project III 4C
Prerequisites: CSSE 488 Senior Research Project II 4C W,S Arranged prerequisite
Corequisites: There are no corequisites for this course.
Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 490 Special Topics in Computer Science 1-4C
Prerequisites: Arranged prerequisite - instructor consent

Corequisites: There are no corequisites for this course.
Selected topics of current interest. May be repeated for credit if topic is different.

CSSE 491 Directed Independent Studies 1-4C
Prerequisites: Arranged prerequisite by consent of instructor and department head
Corequisites: There are no corequisites for this course.
Independent study of an advanced subject not included in regularly offered courses. May be repeated for credit if topic or level is different.

CSSE 492 Undergraduate Research in Computer Science 4C
Prerequisites: Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Research under direction of a faculty member. Presentation of preliminary and final results to departmental seminar. Presentation of work at professional meetings or by publication in professional journals is strongly encouraged. May be repeated for credit if topic or level is different.

CSSE 493 Undergraduate Research in Software Engineering 4C
Prerequisites: Consent of instructor and department head
Corequisites: There are no corequisites for this course.
The Computer Science curriculum prepares students for careers in all areas of the computer industry as well as for graduate studies in computer science and computer related fields. Students have also found a computer science major to be excellent preparation for careers in law, medicine, business administration, industrial engineering, biomedical engineering, and other technical and non-technical fields.

CSSE 494 Senior Thesis I 4C
Prerequisites: RH 330 Technical & Professional Communication 4R-OL-4C W,S Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 495 Senior Thesis II 4C
Prerequisites: CSSE 494 Senior Thesis I 4C W,S Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 496 Senior Thesis III 4C
Prerequisites: CSSE 495 Senior Thesis II 4C W,S Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 497 Senior Capstone Project I 4C F

Prerequisites: CSSE 371 Software Requirements Engineering 3R-3L-4C F and senior standing
Corequisites: There are no corequisites for this course.
For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions, recording the investigation experience in a research report, and delivering the research artifacts to the client.

CSSE 498 Senior Capstone Project II 4C W
Prerequisites: CSSE 374 Software Design 3R-3L-4C W, and CSSE 497 Senior Capstone Project I 4C F
Corequisites: There are no corequisites for this course.
For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions, recording the investigation experience in a research report, and delivering the research artifacts to the client.

CSSE 499 Senior Capstone Project III 4C S
Prerequisites: CSSE 498 Senior Capstone Project II 4C W
Corequisites: There are no corequisites for this course.
For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions,

recording the investigation experience in a research report, and delivering the research artifacts to the client.

CSSE CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

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