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.

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 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.
5. Serve as business or technical leaders in organizations, industries, and disciplines.

Software Engineering Student Outcomes

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

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

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, https://www.abet.org, under the commission's General Criteria and Program Criteria for Software and Similarly Named Engineering Programs.

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, CSSE280, CSSE304, CSSE332, CSSE333, CSSE371, CSSE372, CSSE373, CSSE374, CSSE375, CSSE376,

CSSE477, CSSE497, CSSE498, CSSE499; ECE233, MA111, MA112, MA113, MA221, MA276, MA374, MA381; PH111, PH112, CHEM111; HUMH190, ENGLH290; RHIT100.

2. Eight credits of additional software engineering courses numbered between 300 and 492 and designated as software engineering electives. The student's academic advisor must approve the course used to satisfy this requirement. Use of software engineering courses numbered 490 through 492 to fulfill this requirement must be approved by the department head. Credits used to satisfy any requirements for a minor or secondary major pursued by a student cannot also be used to satisfy SE elective requirements for the student's primary or secondary major in Software Engineering. Credits used by a student pursuing a secondary major in SE that are intended to satisfy the SE elective requirement can only be used to satisfy technical or free elective requirements within the student's primary major or not used towards any requirements within the primary major.
3. Four additional credits of technical electives, consisting of any courses in biology, chemistry, engineering (except software engineering and engineering management), geology, mathematics, biomathematics, or physics.
4. Four additional credits of courses offered by the Department of Mathematics excluding MA351 MA356. The student's academic advisor must approve the coursesused to satisfy this requirement.
5. Four credits of science electives, which can be any CHEM, GEOL, PH, or BIO courses not already required for the software engineering major.
6. 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.
7. Twelve credits of free elective courses.These courses must have the approval of the student's academic advisor. Free electives may be selected from any Rose-Hulman course.
8. A total of 192 credits.

DATA SCIENCE MAJOR (SECOND MAJOR ONLY)

Data Science is open to all students as a second major; this means that the student will have some other discipline as their primary major. Students whose primary major is in Computer Science, Software Engineering or Mathematics will find the Data Science program the easiest since there is considerable overlap between those programs and the Data Science requirements Students from other disciplines are also encouraged to participate, but will have to take more courses. All students are encouraged to take the individual courses in the program, regardless of whether they wish to fulfill the second major requirements. Learn more about Data Science requirements.

Minor in Software Engineering

Advisor: CSSE Department Head

Students majoring in Computer Science may not receive a Software Engineering minor.

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, and courses identified as Software Engineering (SE) electives.

Plan of Study

Freshman

Fall

Course	Credit
CSSE 120 Introduction to Software Development	4
MA 111 Calculus I	5
PH 111 Physics I	4
HUM H190 First-Year Writing Seminar	4
RHIT 100 Foundations for Rose-Hulman Success	1
	Total Credits: 18

Winter

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

Spring

Course	Credit
CSSE 132 Introduction to Computer Systems Design	4
MA 113 Calculus III	5
ECE 233 Introduction to Digital Systems	4
Science Elective	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
CSSE 232 Computer Architecture I	4

CSSE 280 Introduction to Web Programming	4
MA 221 Matrix Algebra & Differential Equations I	4
MA 276 Introduction to Proofs	4
	Total Credits: 16

Winter

Course	Credit
CSSE 230 Data Structures & Algorithm Analysis	4
MA 374 Combinatorics	4
ENGL H290 Technical & Professional Communication	4
CSSE 332 Operating Systems	4
	Total Credits: 16

Spring

Course	Credit
CSSE 376 Software Quality Assurance	4
MA Elective	4
CSSE 333 Database Systems	4
HSSA Elective	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
CHEM 111 General Chemistry I	3
CHEM 111L Gen Chemistry I Lab	1
	Total Credits: 16

Winter

Course	Credit
CSSE 374 Software Design	4

CSSE 304 Programming Lang. Concepts	4
Tech Elective	4
HSSA Elective	4
	Total Credits: 16

Spring

Course	Credit
CSSE 373 Formal Methods in Specification & Design	4
CSSE 375 Software Construction & Evolution	4
HSSA Elective	4
Free elective	4
	Total Credits: 16

Senior

Fall

Course	Credit
CSSE 477 Software Architecture	4
CSSE 497 Senior Capstone Project I	4
HSSA Elective	4
SE elective	4
	Total Credits: 16

Winter

Course	Credit
CSSE 498 Senior Capstone Project II	4
HSSA Elective	4
Free Elective	4
SE Elective	4
	Total Credits: 16

Spring

Course	Credit
CSSE 499 Senior Capstone Project III	4
HSSA 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 programming with an emphasis on problem solving. Problems may include visualizing data, interfacing with external hardware or solving problems from a variety of engineering disciplines. Programming concepts covered include data types, variables, control structures, arrays, and data I/O. Software development concepts covered include testing, debugging, incremental development, understanding requirements, and version control systems.

CSSE 132 Introduction to Systems Programming 3R-3L-4C F,S
Prerequisites: CSSE 120
Corequisites: There are no corequisites for this course.
Provides students with understanding of computer system level issues and their impact on the design and use of computer systems. Students will study low-level programming (assembly) and memory operations, representation of various types of data and programs in memory, and resource/efficiency trade-offs. System requirements such as resource management, security, communication and synchronization are studied and basic systems tools for these tasks are implemented. Course topics will be explored using a variety of hands-on assignments and projects.

CSSE 140 Practical Security I 0R-1L-1C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This is an entry-level introduction to exploiting and securing computer systems, networks, and web sites. This shallow introduction exposes students to various applied cybersecurity topics including Firewalls, SSH, passwords, web security, and basic unix system administration. Through a series of hands-on exercises, students will relate these topics to practical ways to secure computers.

CSSE 141 Practical Security II 0R-1L-1C W
Prerequisites: CSSE 140
Corequisites: There are no corequisites for this course.
A second-level introduction to exploiting and securing computer systems, networks, and web sites. This class continues the introduction to applied cybersecurity topics including basic Cryptography, network protocol analysis, reverse engineering, steganography, forensics, and more unix system administration. Students are also introduced to capture-the-flag exercises, which are widely practiced cybersecurity skill competitions.

CSSE 142 Practical Security III 2L-2C Term F
Prerequisites: CSSE 141
Corequisites: There are no corequisites for this course.
A third-level class on exploiting and securing computer systems, networks, and web sites. This class continues the introduction to applied cybersecurity topics and focus on applying concepts learned in CSSE140/141 to security competitions such as capture-the-flag events. This class exposes students to strategy used in security competitions, teamwork skills for effective competition, and construction of set of exercises used for running a CTF event. Students will work in teams to solve security-oriented problems, apply their skills to create competition challenges/exercises for use in CSSE 141 and for competition training, practice for security competitions, and participate in or run a few security competitions.

CSSE 145 Cybersecurity Seminar 2R-0L-2C Varies
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course provides exposure to leading-edge industrial and academic experts in Cybersecurity and Digital Privacy. Topics including the societal, economic, scientific, and psychological impacts of modern areas of cybersecurity and privacy are examined from both practical and theoretical points of view. Students in this class will attend live and view remote or recorded talks from industry/academic experts, read emergent papers on Cybersecurity and Digital Privacy, participate in discussions or debate about the topics, and reflect on the impacts these topics have on their major area of study. May be repeated for credit with approval from the course instructor when topics are different.

CSSE 193 Preparation for Careers in Computer 1R-0L-1C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students learn about the nature of graduate school, the application process to graduate school as well as the importance of developing a portfolio or independent work, including scientific papers. Students will learn about research opportunities in the department, the institute, and at other institutions, such as REUs.

CSSE 199 Professional Experience 1R-0L-1C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

CSSE 212 MSPP – Multicore Systems Programming and Performance 3R-3L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
The development of powerful multicore applications requires the knowledge of basic parallelization strategies and their software-technical implementation. Additionally, knowledge of the hardware and methods for analysis and optimization of performance are mandatory. Lab exercises will be based on Nvidia's Jetson Nano multicomputer, which additionally is equipped with a powerful GPU (Graphics Processing Unit). 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
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 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 F,W,S

Prerequisites: MA 112, and CSSE 220, with a grade of C or better

Corequisites: There are no corequisites for this course.

This course reinforces and extends students' ability to independently design, develop, and debug object-oriented software that uses correct, clear, and efficient algorithms and data structures. Students study and implement classical data structures such as list, stack, queue, tree, priority queue, hash table, graph, set, and dictionary. Formal efficiency analysis is used to evaluate the complexity of algorithms for these data structures. Students gain proficiency in writing recursive methods. Students design and implement software individually.

CSSE 232 Computer Architecture I 3R-3L-4C F,W

Prerequisites: ECE 233, and CSSE 120

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 240 Principles of Cybersecurity 4R-0L-4C W

Prerequisites: CSSE 120, and HUM H190

Corequisites: There are no corequisites for this course.

This course introduces ethical, theoretical, and practical issues of information security in interconnected systems of computers. Implications of relevant professional codes of ethics are a recurring theme of the course, as are societal and human impacts on computer system security. 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 system attack techniques are observed and evaluated in a closed environment to motivate and inform discussion and exploration of computer network defense techniques.

CSSE 241 Computing in a Global Society 2R-6L-4C

Prerequisites: CSSE 220, There are no prerequisites for this course.

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 242 Programming in the Community Variable Credit (1 or 2 credits) F, W, S

Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Programming in the Community is a unique course where Rose-Hulman students learn how to become teachers in Computer Science for younger students. As the name suggests, students will go teach CS material to K-12 students at their local school. Students will be assigned to a teaching team to take turns leading and helping follow along projects for the K-12 students. Students are expected to join a weekly instructor meeting on Teams, then take two teaching trips into the community per week (40 to 50 minute lessons). Transportation can be arranged for students unable to travel to the school. Students of any major are welcome to join. This class is a very real-world experience. It is a great way to learn leadership and teaching skills while doing great community service. May be repeated up to 12 credit hours.

CSSE 280 Introduction to Web Programming 3R-3L-4C F, W

Prerequisites: CSSE 220, There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.

Introduction to the client-side and server-side mechanisms for creating dynamic web applications with persistent data storage. Browser-server interaction via HTTP. Static web page creation using current markup and styling languages. Client-side programming with modern scripting languages and the DOM. Server-side programming with emerging web programming languages and frameworks. Persistent data storage with a state-of-the-art database management system. Asynchronous client-server communication via HTTP requests. Development and consumption of REST APIs. Deployment of web applications to cloud platforms or platform as a service providers. Security considerations. This course provides breadth of knowledge of many tools/ technologies rather than deep knowledge of any particular tool/technology. No previous experience with Web development is required.

CSSE 286 Introduction to Machine Learning 4R-0L-4C

Prerequisites: Prior programming experience

Corequisites: There are no corequisites for this course.

An introduction to machine learning (ML) systems, with a focus especially on Artificial Intelligence-based systems, versus statistical ones. The course is designed to be useful to students with a basic knowledge of programming and software systems, whether or not they are computer science majors. During the course, students try different machine learning algorithms on data from problems in a domain of interest to them, comparing results with that of other students taking the class, as well as comparing the outcomes of the different algorithms on their own data. A goal of the course is learning how to gain real predictive value from “big data.”

CSSE 290 Special Topics in Computer Science 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 F,W

Prerequisites: CSSE 230, There are no prerequisites for this course.

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 313 Artificial Intelligence 4R-0L-4C F

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

In this course, we will study modern AI systems, their current accomplishments, positive as well as negative, issues surrounding their training, and their inner workings. We will formalize those systems as pattern recognizers and distinguish them from classical, symbol-manipulating AI. We will study how these systems become so incredibly powerful through a data driven feature learning. We will look at how they represent knowledge and study their reasoning abilities. We will additionally spend some time discussing the projected impact of anticipated systems and study the building of beneficial AI systems.

CSSE 314 Bio-Inspired Artificial Intelligence 4R-0L-4C F

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

Students learn about theories and methodologies of artificial intelligence (AI) inspired by biological processes. To deepen their understanding of topics, students read, discuss as well as create and refine bio-inspired AI systems such as evolutionary algorithms, cellular automata, neural networks, evolutionary robotics, and/or swarm intelligence algorithms. Topics are covered in an interdisciplinary manner through the integration of key principles from cognitive science and artificial life. The concept of intelligence is repeatedly explored through the study of systems that adapt across vastly different scales of time and space.

CSSE 315 Natural Language Processing 4R-0L-4C F or W

Prerequisites: CSSE 230, and either MA 223 or MA 381

Corequisites: There are no corequisites for this course.

This course offers foundational knowledge of Natural Language Processing, a vital element of modern AI systems. The core topics include the processing of linguistic data and feature engineering (NLP), language understanding (NLU), and language generation (NLG). Through practice, students develop proficiency in Deep Learning for NLP and Large Language Models. The course also covers critical examination of language model biases and strategies for their mitigation.

CSSE 332 Operating Systems 4R-0L-4C W,S

Prerequisites: CSSE 220, and CSSE 132 or ECE 230

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.

Prerequisite Notes:
CSSE 220 and either CSSE 132 or ECE230

CSSE 333 Database Systems 3R-3L-4C W,S

Prerequisites: CSSE 230

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

Prerequisites: MA 221 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 340 Foundations of Cybersecurity 4R-0L-4C W

Prerequisites: CSSE 132, and CSSE 280

Corequisites: There are no corequisites for this course.

This course introduces ethical, theoretical, and practical issues of information security in interconnected systems of computers. Implications of relevant professional codes of ethics are a recurring theme of the course, as are societal and human impacts on computer system security. 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 system attack techniques are discussed and explored in a closed environment to motivate and inform discussion and exploration of computer network defense techniques.

CSSE 343 Cybercrime and Digital Forensics 2R-2L-4C

Prerequisites: ENGL H100, and either CSSE 132, or Senior Class Standing

Corequisites: There are no corequisites for this course.

This course introduces students to “cybercrime,” how police investigate these crimes, and what forensics techs use to uncover digital evidence. Students will examine the laws, technologies, tools, and procedures used in the investigation and prosecution of computer crimes through case studies, discussions, ethical debates, and hands-on laboratory exercises that uncover and analyze digital evidence. This class covers topics including: basics of criminal law, collection and chain of evidence, search & seizure procedures, digital trail discovery, data recovery, and smartphone investigation.

CSSE 351 Computer Graphics 4R-0L-4C F

Prerequisites: MA 221, and CSSE 220, There are no prerequisites for this course.

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

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, and ENGL H290, and CSSE 333 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 230
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, and MA 276
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 230 and Junior standing
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
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
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 386 Data Mining with Programming 4R-0L-4C
Prerequisites: CSSE 220, and CSSE 280, and MA 221, and either MA 223 or MA 381
Corequisites: There are no corequisites for this course.
An introduction to data mining for large data sets, including data preparation, exploration, aggregation/reduction, and visualization. Elementary methods for classification, association, and cluster analysis are covered. Significant attention will be given to presenting and reporting data mining results. Students may not get credit for both this course and also the MA 384 Data Mining course.

CSSE 393 Research Skills 1R-0L-1C S
Prerequisites: CSSE 193
Corequisites: There are no corequisites for this course.

Students will learn key research skills, including how to read a scientific paper, how to review a scientific paper using various review guidelines, how to develop an annotated bibliography, how to develop a poster presentation, and how to develop an oral presentation of scientific work. Students will additionally be introduced to research tools, such as Latex, and Mendeley. Students will create a Senior Thesis or Senior Research Project Proposal as part of the course.

CSSE 394 Research Lab 1 1R-0L-1C F

Prerequisites: CSSE 393

Corequisites: There are no corequisites for this course.

Students practice and engage in the scientific review process by presenting their own work and by reviewing other students' work and responding to feedback on their work. Work to be reviewed includes oral presentations and an end-of-term draft of their work. Additionally, students will engage with several ethical conundrums that pertain to the research process.

CSSE 395 Research Lab 2 1R-0L-1C W

Prerequisites: CSSE 394

Corequisites: There are no corequisites for this course.

Students continue to practice and engage in the scientific review process by presenting their own work and by reviewing other students' work and responding to feedback on their work. Work to be reviewed includes oral presentations and an end-of-term draft of their work. Additionally, students will engage in a writing exchange, and they will continue to engage with ethical conundrums that pertain to the research process.

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 403 Programming Language Paradigms 4R-0L-4C F (even years)

Prerequisites: CSSE 304

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 (odd years)

Prerequisites: CSSE 232, and CSSE 304, and CSSE 474

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 415 Machine Learning 4R-0L-4C S

Prerequisites: MA 221, and either MA 223 or MA 381, and either CHE 310 or CSSE 220 or ECE 230 or MA 332 or MA 386, There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
An introduction to machine learning. Topics include: error metrics, accuracy vs interpretability trade-off, feature selection, feature engineering, bias-variance trade-off, under-fitting vs. overfitting, regularization, cross-validation, the bootstrap method, the curse of dimensionality and dimensionality reduction using the singular value decomposition. Both parametric and nonparametric methods are covered including: k-nearest neighbors, linear and logistic regression, decision trees and random forests, and support vector machines. Same as MA415.

Prerequisite Notes:
Prerequisite Clarification for CSSE415:
Junior Standing and MA221,
and either MA223 or MA381,
and one of CHE310, CSSE220, ECE230, MA332, MA386 (or ME323 or ME327).

CSSE 416 Deep Learning 4R-0L-4C See Dept
Prerequisites: See below
Corequisites: There are no corequisites for this course.
An introduction to deep learning using both fully-connected and convolutional neural networks. Topics include: least squares estimation and mean square error, maximum likelihood estimation and cross-entropy, convexity, gradient descent and stochastic gradient descent algorithms, multivariate chain rule and gradient computation using back propagation, linear vs nonlinear operations, convolution, over-fitting vs under-fitting and hyper-parameter optimization, L2, early stopping and dropout regularization, data augmentation and transfer learning. Same as MA416.

Prerequisite Notes:

MA 212 or MA 221, and either MA 223 or MA 381, and either CHE 310 or CSSE 220 or ECE 230 or MA 332 or MA 386 or ME 327

CSSE 432 Computer Networks 4R-0L-4C S
Prerequisites: CSSE 220, There are no prerequisites for this course.
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
Corequisites: There are no corequisites for this course.
This course covers advanced topics in the design and development of database management systems and their modern applications. Topics to be covered include query processing and, in relational databases, transaction management and concurrency control, eventual consistency, and distributed data models. This course introduces students to NoSQL databases and provides students with experience in determining the right database system for the right feature. Students are also

exposed to polyglot persistence and developing modern applications that keep the data consistent across many distributed database systems.

CSSE 434 Introduction to the Hadoop Ecosystem 4R-0L-4C

Prerequisites: CSSE 230 *Some Experience with SQL recommended

Corequisites: There are no corequisites for this course.

This advanced course examines emergent Big Data techniques through hands-on introductions to the various technologies and tools that make up the Hadoop ecosystem. Topics covered include internals of MapReduce and the Hadoop Distributed File system (HDFS), internals of the YARN distributed operating system, MapReduce for data processing, transformation & analysis tools for data at scale (processing terabytes and petabytes of information quickly), scheduling jobs using workflow engines, data transfer tools & real time engines for data processing.

CSSE 435 Robotics Engineering 3R-3L-4C S

Prerequisites: ME 430 or ECE 230

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 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

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 4R-0L-4C

Prerequisites: CSSE 313
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: MA 221, and CSSE 220, *Also recommended (but not required) either MA371 or MA373.
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 221 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 W
Prerequisites: CSSE 230, and MA 276, and MA 374
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 S
Prerequisites: CSSE 230, and MA 276, and MA 374
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 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: MA 276, and CSSE 220, There are no prerequisites for this course.
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 Cross-Platform Development 3R-3L-4C F

Prerequisites: CSSE 230

Corequisites: There are no corequisites for this course.

Programming cross-platform mobile applications that target Android, iOS, and web mobile devices using programmatic UIs, layouts, reusable components, and data persistence via cloud backends. Emphasis is on hands-on use of these components in application development. Includes a substantial team project including UI mockups, design, development, testing, and presentation.

CSSE 487 Senior Research Project I 4C

Prerequisites: ENGL H290, CSSE 393 and senior standing

Corequisites: CSSE 394

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

Corequisites: CSSE 395

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

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: 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: 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 1-4C

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 1-4C

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: ENGL H290, CSSE 393 Consent of instructor and department head

Corequisites: CSSE 394

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 Consent of instructor and department head

Corequisites: CSSE 395

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 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, CSSE 374* 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 371, CSSE 374, and CSSE 497

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 371, CSSE 374, and CSSE 498

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.

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