SOFTWARE DEVELOPMENT MINOR

Description
The software development minor prepares students with skill sets to enable them to meet the growing demand for familiarity and competency with software development. The minor is designed to:

- Enable students from a diverse set of majors and backgrounds to participate.
- Provide a strong foundation in software development to allow them to apply computing throughout their career.

The minor consists of five required courses. The minor’s objectives are anchored around a set of core outcomes, such that students completing the minor will be able to:

- Apply sound software development principles and methodologies to create software systems that solve real-world problems in various disciplines.
- Interact, use, and manage large data sets and solve data-centric problems; organize, visualize, and communicate digital data effectively; and use creative competencies to generate creative solutions.
- Understand the roles of various stakeholders in software development projects, including domain experts, project managers, customers, and developers.
- Contribute one’s expertise to the solution of problems by effectively collaborating and communicating with other stakeholders in software development projects.

College Requirements

College Admission
College Entrance Requirements
Students must have high school credit for (one unit is equal to one high school year):

1. Mathematics – 4 units: 2 of algebra, 1 of geometry, and 1 of precalculus and trigonometry
2. English – 4 units
3. Natural sciences – 3 units that must include 1 unit of physics and 1 unit of chemistry (chemistry requirement waived for students in construction management)
4. Foreign language – 2 units of a single foreign language
5. Social studies – 3 units
6. Students having a composite ACT score of 28 or greater (or equivalent SAT score) will be admitted to the College of Engineering even if they lack any one of the following: trigonometry, chemistry, or physics.
7. Students having an ACT score of 19 or less in English (or equivalent SAT score) must take ENGL 150 Writing and Inquiry or ENGL 151 Writing and Argument.

A total of 16 units is required for admission.

Students must have an ACT (enhanced) score of 24 or greater (or equivalent SAT). Students who lack entrance requirements may be admitted based on ACT scores, high school rank and credits, or may be admitted to pre-engineering status in the Exploratory and Pre-Professional Advising Center. Pre-engineering students are advised within the Exploratory and Pre-Professional Advising Center.

Students for whom English is not their language of nurture must meet the minimum English proficiency requirements of the University.

Students who lack entrance units may complete precollege training by Independent Study through the University of Nebraska–Lincoln Office of On-line and Distance Education, in summer courses, or as a part of their first or second semester course loads while in the Exploratory and Pre-Professional Advising Center or other Colleges at Nebraska.

Students should consult their advisor, their department chair, or Engineering Student Services if they have questions on current policies.

Other Admission Requirements
Students who transfer to the University of Nebraska–Lincoln from other accredited colleges or universities and wish to be admitted to the College of Engineering (COE) must meet COE freshman entrance requirements and have a minimum cumulative GPA of 2.5 and be calculus-ready. Students not meeting either of these requirements must enroll in the Explore Center or another University college until they meet COE admission requirements. Students transferring from UNL, UNO, or UNK to the College of Engineering must be in good academic standing with their institution.

The COE accepts courses for transfer for which a C or better grade was received. Although the University of Nebraska–Lincoln accepts D grades from the University of Nebraska at Kearney and at Omaha, not all majors in the COE accept such low grades. Students must conform to the requirements of their intended major and, in any case, are strongly encouraged to repeat courses with a grade of C- or less.

All transfer students must adopt the curricular requirements of the undergraduate catalog current at the time of transfer to the COE—not that in use when they entered the University of Nebraska–Lincoln. Upon admission to Nebraska, students wishing to pursue degree programs in the COE will be classified and subject to the policies defined in the subsequent section.

Students who were previously admitted to COE and are returning to the College of Engineering must demonstrate a cumulative GPA of 2.5 in order to be readmitted to COE.

College Degree Requirements

Grade Rules
Grade Appeals
In the event of a dispute involving any college policies or grades, the student should appeal to his/her instructor and appropriate department chair or school director (in that order). If a satisfactory solution is not achieved, the student may appeal his/her case through the College Academic Appeals Committee on his/her campus.

Catalog Rule
Students must fulfill the requirements stated in the catalog for the academic year in which they are first admitted at the University of Nebraska–Lincoln. In consultation with advisors, a student may choose to follow a subsequent catalog for any academic year in which they are admitted to and enrolled as a degree-seeking student at Nebraska in the College of Engineering. Students must complete all degree requirements from a single catalog year. The catalog which a student follows for
degree requirements may not be more than 10 years old at the time of graduation.

Requirements for Minor Offered by Department

At least 15 hours of coursework as follows.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCE 120</td>
<td>Learning to Code</td>
<td>3</td>
</tr>
<tr>
<td>CSCE 220</td>
<td>Software Development for Smart-Mobile Systems</td>
<td>3</td>
</tr>
<tr>
<td>CSCE 320</td>
<td>Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>CSCE 311</td>
<td>Data Structures and Algorithms for Informatics</td>
<td>3</td>
</tr>
<tr>
<td>or</td>
<td>Internet Systems and Programming</td>
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</tr>
<tr>
<td>CSCE 493</td>
<td>Innovation Lab Project</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credit Hours: 15

Restriction
A course taken to meet the requirement of a major cannot be counted towards this minor. This minor is not available to students majoring or minoring in computer science, computer engineering, or software engineering.

Grade Rules
C- and D Grades
A grade of C or above is required for all courses in the minor.

Pass/No Pass
Up to 3 hours of CSCE coursework taken Pass/No Pass may be counted toward the minor.

CSCE 100 Introduction to Informatics
Prerequisites: Placement in to MATH 101 or higher
Notes: This course does not count towards a major or minor in Computer Science or a major in Computer Engineering or a major in Software Engineering.
Description: Introduction to the use of data-centric and information technologies-and issues and challenges-in today's applications in sciences, engineering, the humanities, and the arts. Exposure to computational thinking and programming, statistical thinking and research design, data analysis and database techniques, and visualization and creative thinking.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 120 Learning to Code
Prerequisites: Placement in to MATH 101 or higher
Notes: This course does not count towards a major or minor in Computer Science or a major in Computer Engineering or a major in Software Engineering. First course in a sequence for the minor in Software Development.
Description: Introduction to coding in the context of current web development technologies (JavaScript, HTML, CSS). Basic coding skills and an introduction to computing with an emphasis on processing data: data formatting and structure, data manipulation, data presentation and the basics of an interactive program.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 220; CSCE 320

CSCE 101 Fundamentals of Computer Science
Notes: A course in the science of computation suitable for prospective CSCE majors and for non-CSCE majors who desire a deeper understanding of computers and the work of computer scientists. This course may be used to satisfy a technical elective for Computer Science and Computer Engineering majors if taken at UNL prior to CSCE 155, CSCE 156, CSCE 310 and CSCE 361, or for Software Engineering majors, if taken at UNL prior to SOFT 160, SOFT 161, SOFT 260 and SOFT 261.
Description: Introduction to problem solving with computers. Problem analysis and specification, algorithm development, program design, and implementation in a high-level programming environment. Hardware, software, software engineering, networks, and impacts of computing on society.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 101L
ACE: ACE 3 Math/Stat/Reasoning

CSCE 101L Fundamentals of Computing Laboratory
Prerequisites: CSCE 101 or parallel.
Notes: This course does not count towards a major or minor in Computer Science or a major in Computer Engineering or a major in Software Engineering.
Description: A variety of computer oriented exercises using many software tools is presented which supplement and are coordinated with the topics taught in CSCE 101. Students are exposed to programming, operating systems, simulation software, spreadsheets, database software, the Internet, etc. Applications software introduced in the context of tools to explore the computer science topics and as alternatives to traditional programming languages. Emphasis on learning by experiment, with a goal of developing problem solving skills. A major component is the study of a programming language-the choice of which may vary by course section.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Grading Option: Graded with Option

CSCE 107 Introduction to Computing Systems
Prerequisites: Placement in to MATH 101 or higher
Notes: This course does not count towards a major or minor in Computer Science or a major in Computer Engineering or a major in Software Engineering.
Description: Introduction to computer hardware, software, operating systems, computer organization, and the Internet. Basic exposure to programming and software development in a high-level language.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 101L
ACE: ACE 3 Math/Stat/Reasoning

CSCE 120 Learning to Code
Prerequisites: Placement in to MATH 101 or higher
Notes: This course does not count towards a major or minor in Computer Science or a major in Computer Engineering or a major in Software Engineering.
Description: Introduction to coding in the context of current web development technologies (JavaScript, HTML, CSS). Basic coding skills and an introduction to computing with an emphasis on processing data: data formatting and structure, data manipulation, data presentation and the basics of an interactive program.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 220; CSCE 320
CSCE 155A Computer Science I
Prerequisites: MATH 102 or a Math Placement Test score for MATH 103 or higher.
Notes: Credit may be earned in only one CSCE 155 course. Recommended for students majoring in computer science or computer engineering.
Description: Introduction to problem solving with computers. Topics include problem solving methods, software development principles, computer programming, and computing in society.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 156; CSCE 156H; CSCE 235; CSCE 235H; CSCE 311; ECEN 106; ECEN 123; ECEN 224; MECH 300
ACE: ACE 3 Math/Stat/Reasoning

CSCE 155E Computer Science I: Systems Engineering Focus
Prerequisites: MATH 102 or a Math Placement Test score for MATH 103 or higher.
Notes: Credit may be earned in only one CSCE 155 course. Recommended for students interested in systems engineering, such as operating systems, mobile computing, and embedded devices.
Description: Introduction to problem solving with computers. Topics include problem solving methods, software development principles, computer programming, and computing in society.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 156; CSCE 156H; CSCE 235; CSCE 235H; CSCE 311; ECEN 106; ECEN 123; ECEN 224; MECH 300
ACE: ACE 3 Math/Stat/Reasoning

CSCE 155H Honors: Computer Science I
Prerequisites: Good standing in UNL Honors Program; MATH 102 or a Math Placement Test score for MATH 103 or higher.
Notes: Covers the same topics as CSCE 155A, but in greater depth.
Description: Introduction to problem solving with computers. Topics include problem solving methods, software development principles, computer programming, and computing in society.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 156; CSCE 156H; CSCE 235; CSCE 235H; CSCE 311; ECEN 106; ECEN 224; MECH 300
ACE: ACE 3 Math/Stat/Reasoning

CSCE 155N Computer Science I: Engineering and Science Focus
Prerequisites: MATH 102 or a Math Placement Test score for MATH 103 or higher.
Notes: Recommended for students interested in numerical and graphical applications in engineering and science, such as applied physics, working with time-sequence data, and matrix applications.
Description: Introduction to problem solving with computers. Topics include problem solving methods, software development principles, computer programming, and computing in society.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: BSEN 311; CHME 312; CSCE 156; CSCE 156H; CSCE 235; CSCE 235H; CSCE 311; ECEN 106; ECEN 224; MECH 300; MECH 318; MECH 330; MECH 350; MECH 381
ACE: ACE 3 Math/Stat/Reasoning

CSCE 156 Computer Science II
Prerequisites: A grade of "P" or "C" or better in CSCE 155A, CSCE 155E, CSCE 155H, CSCE 155N, or CSCE 155T; coreq: MATH 106.
Notes: Laboratories supplement the lecture material and give an opportunity to practice concepts.
Description: Data structures, including linked lists, stacks, queues, and trees; algorithms, including searching, sorting, and recursion; programming language topics, including object-oriented programming; pointers, references, and memory management; design and implementation of a multilayer application with SQL database.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded with Option
Prerequisite for: CSCE 235; CSCE 310; CSCE 310H; CSCE 322; CSCE 322H; CSCE 378; CSCE 378H; SOFT 162
CSCE 156H Honors: Computer Science II
Prerequisites: Good standing UNL Honors Program. A grade of "P" or "C" or better in CSCE 155A, CSCE 155E, CSCE 155H, CSCE 155N, or CSCE 155T; Coreq: MATH 106.
Notes: Covers the same topics as CSCE 156, but in greater depth. Laboratories supplement the lecture material and give an opportunity to practice concepts.
Description: Data structures, including linked lists, stacks, queues, and trees; algorithms, including searching, sorting, and recursion; programming language topics, including object-oriented programming; pointers, references, and memory management; design and implementation of a multilayer application with SQL database.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded
Prerequisite for: CSCE 310; CSCE 310H; CSCE 322; CSCE 322H; CSCE 378; CSCE 378H; SOFT 162

CSCE 163H Honors: Innovation Processes and Software Engineering Fundamentals
Crosslisted with: RAIK 163H
Prerequisites: Good standing in the University Honors Program; admission to the Jeffrey S. Raikes School of Computer Science and Management.
Description: Introduction to innovation processes for interdisciplinary and team-oriented problem solving of software engineering, business development, and industrial design problems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded
Offered: FALL

CSCE 183H Honors: Computer Problem Solving Essentials
Crosslisted with: RAIK 183H
Prerequisites: Good standing in the University Honors Program; admission to the Jeffrey S. Raikes School of Computer Science and Management.
Description: Introduction to problem solving with computers. Problem analysis and specification, algorithm development, program design, and implementation. JAVA in a Windows platform.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded
Prerequisite for: CSCE 235; CSCE 235H; ECON 215; RAIK 184H, CSCE 184H
ACE: ACE 3 Math/Stat/Reasoning

CSCE 184H Honors: Software Development Essentials
Crosslisted with: RAIK 184H
Prerequisites: Good standing in the University Honors Program; admission to the Jeffrey S. Raikes School of Computer Science and Management; and CSCE/RAIK 183H.
Description: Problem solving with computers. Problem analysis and specification, data structures, relational databases, algorithm development, and program design and implementation. Discrete mathematics topics, propositional and predicate logic, sets, relations, functions, and proof techniques. Software Development Principles.
Credit Hours: 4
Max credits per semester: 4
Max credits per degree: 4
Grading Option: Graded
Prerequisite for: BSAD 372H, RAIK 372H; CSCE 230; CSCE 231; CSCE 283H; CSCE 322; CSCE 322H; CSCE 378; CSCE 378H; SOFT 260H, RAIK 283H

CSCE 191 Special Topics in Computer Science
Prerequisites: Permission.
Notes: Will not count towards a major or minor in computer science and computer engineering. Topics will vary.
Description: Aspects of computers and computing at the freshman level for non-computer science and computer engineering majors and/or minors.
Credit Hours: 1-3
Min credits per semester: 1
Max credits per semester: 3
Max credits per degree: 6
Grading Option: Graded with Option

CSCE 192 Special Topics in Computer Science
Prerequisites: Permission.
Description: Aspects of computers and computing for computer science and computer engineering majors and minors. Topics vary.
Credit Hours: 1-3
Min credits per semester: 1
Max credits per semester: 3
Max credits per degree: 6
Grading Option: Graded with Option

CSCE 194 Independent Study in Computing
Prerequisites: Freshmen standing; permission of the instructor.
Description: Independent study of computer science topics performed under the guidance of a member of the faculty in the Department of Computer Science and Engineering.
Credit Hours: 1-3
Min credits per semester: 1
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Name</th>
<th>Prerequisites</th>
<th>Note(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCE 220</td>
<td>Software Development for Smart-Mobile Systems</td>
<td>CSCE 120</td>
<td>This course does not count towards a major or minor in Computer Science or a major in Computer Engineering or a major in Software Engineering. Second course in a sequence for the minor in Software Development.</td>
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<tr>
<td>CSCE 230</td>
<td>Computer Organization</td>
<td>A grade of “P” or “C” or better in CSCE 235, CSCE 235H, or RAIK 184H.</td>
<td>Laboratories supplement the lecture material and give an opportunity to practice concepts.</td>
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<tr>
<td>CSCE 231</td>
<td>Computer Systems Engineering</td>
<td>Grade of “P” or “C” or better in CSCE 235, CSCE 235H or RAIK 184H.</td>
<td>Introduction to organization and structure of computer systems. Boolean logic, digital arithmetic, processor organization, machine language programming, input/output, memory organization, system support software, communication, and ethics.</td>
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<tr>
<td>CSCE 235</td>
<td>Introduction to Discrete Structures</td>
<td>A grade of “P” or “C” or better in CSCE 155A, CSCE 155E, CSCE 155H, CSCE 155N, CSCE 155T, SOFT 160, SOFT 160H or RAIK 183H; and MATH 106.</td>
<td>Theoretical concepts with programming assignments. CSCE235H covers the same topics as CSCE235, but in greater depth.</td>
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<tr>
<td>CSCE 239</td>
<td>Unix Programming Environment</td>
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<tr>
<td>CSCE 292</td>
<td>Special Topics in Computer Science</td>
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<tr>
<td>CSCE 335</td>
<td>Unix Programming Environment</td>
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<tr>
<td>CSCE 336</td>
<td>Honors: Foundations of Computer Science</td>
<td>Good standing in the University Honors Program; admission to the Jeffrey S. Raikes School of Computer Science and Management; and CSCE/RAIK 184H.</td>
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<tr>
<td>CSCE 351</td>
<td>Special Topics in Computer Science</td>
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<td>CSCE 361</td>
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</table>
CSCE 294 Independent Study in Computing
Prerequisites: Sophomore standing; permission of the instructor.
Description: Independent study of computer science topics performed under the guidance of a member of the faculty in the Department of Computer Science and Engineering.
Credit Hours: 1-3
Max credits per semester: 1
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 310 Data Structures and Algorithms
Prerequisites: Grades of "Pass" or "C" or better in CSCE 156/156H or SOFT 161 and CSCE 235/235H.
Notes: Theoretical concepts with programming assignments.
Description: A review of algorithm analysis, asymptotic notation, and solving recurrence relations. Advanced data structures and their associated algorithms, heaps, priority queues, hash tables, trees, binary search trees, and graphs. Algorithmic techniques, divide and conquer, transform and conquer, space-time trade-offs, greedy algorithms, dynamic programming, randomization, and distributed algorithms. Introduction to computability and NP-completeness.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 351; CSCE 361, CSCE 361H; CSCE 493

CSCE 310H Honors: Data Structures and Algorithms
Prerequisites: Good Standing in UNL Honors Program or by invitation; grades of "P" or "C" or better in CSCE 156/156H or SOFT 161 and CSCE 235/235H.
Description: CSCE 310H covers the same topics as CSCE 310, but in greater depth. For course description, see CSCE 310.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded
Prerequisite for: CSCE 351; CSCE 493

CSCE 311 Data Structures and Algorithms for Informatics
Prerequisites: Grade of "Pass" or "C" or better in CSCE 155A, CSCE 155E, CSCE 155H, CSCE 155N, CSCE 155T, CSCE 320, or SOFT 160.
Notes: CS majors must take CSCE 310. Students may not receive credit for both CSCE 310 and 311.
Description: An introduction to algorithms and data structures for informatics. Foundational coverage of algorithms includes both problems (such as indexing, searching, sorting, and pattern matching) and methods (such as greedy, divide-and-conquer, and dynamic programming). Foundational coverage of data structures includes lists, tables, relational databases, regular expressions, trees, graphs, and multidimensional arrays. The topics will be studied in the context of informatics applications.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 322; CSCE 322H; CSCE 351; CSCE 361, CSCE 361H; CSCE 378; CSCE 378H; CSCE 493; CSCE 493A

CSCE 320 Data Analysis
Prerequisites: A grade of "P" or "C" or better in CSCE 120 or CSCE 220.
Notes: This course does not count towards a major or minor in Computer Science or a major in Computer Engineering or a major in Software Engineering. Third course in a sequence for the minor in Software Development.
Description: Practical experience on how to model data through existing techniques including object-oriented and relational models. These models can then be used at the center of systems to promote efficient and effective data processing and analysis.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 311; CSCE 493

CSCE 322H Honors: Programming Language Concepts
Prerequisites: Good Standing in UNL Honors Program or by invitation; a grade of "P" or "C" or better in CSCE 156, CSCE 156H, CSCE 311, SOFT 161, SOFT 161H, or RAIK 184H.
Description: List-processing, string-processing, and other types of high-level programming languages. Fundamental concepts of data types, control structures, operations, and programming environments of various programming languages. Analysis, formal specification, and comparison of language features.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 322H Honors: Programming Language Concepts
Prerequisites: Good Standing in UNL Honors Program or by invitation; a grade of "P" or "C" or better in CSCE 156, CSCE 156H, CSCE 311, SOFT 161, SOFT 161H, or RAIK 184H.
Description: List-processing, string-processing, and other types of high-level programming languages. Fundamental concepts of data types, control structures, operations, and programming environments of various programming languages. Analysis, formal specification, and comparison of language features.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 335 Digital Logic Design
Crosslisted with: ECEN 370
Prerequisites: ECEN 103/(UNO) ECEN 1030 or CSCE 230
Description: Combinational and sequential logic circuits. MSI chips, programmable logic devices (PAL, ROM, PLA) used to design combinational and sequential circuits. CAD tools. LSI and PLD components and their use. Hardware design experience.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded
Prerequisite for: ECEN 307; ECEN 494
CSCE 336 Embedded Systems
Prerequisites: A grade of "P" or "C" or better in CSCE 230 or CSCE 231.
Description: Introduction to designing, interfacing, configuring, and programming embedded systems. Configure simple embedded microprocessor systems, control peripherals, write device drivers in a high-level language, set up embedded and real-time operating systems, and develop applications for embedded systems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 488

CSCE 351 Operating System Kernels
Prerequisites: A grade of "P" or "C" or better in CSCE 230 or CSCE 231 and CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Design and implementation of operating system kernels. Bootstrapping and system initialization, process context switching, I/O hardware and software, DMA, I/O polling, interrupt handlers, device drivers, clock management. Substantial programming implementing or extending an instructional operating system kernel.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 361 Software Engineering
Crosslisted with: CSCE 361H
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Notes: Requires participation in a group design and implementation of a software project.
Description: Techniques used in the disciplined development of large software projects. Software requirements analysis and specifications, program design, coding and integration testing, and software maintenance. Software estimation techniques, design tools, and complexity metrics.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 461, CSCE 861, SOFT 461; CSCE 486; CSCE 488

CSCE 361H Software Engineering
Crosslisted with: CSCE 361
Prerequisites: Good standing in the University Honors Program. A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Notes: Requires participation in a group design and implementation of a software project.
Description: Techniques used in the disciplined development of large software projects. Software requirements analysis and specifications, program design, coding and integration testing, and software maintenance. Software estimation techniques, design tools, and complexity metrics.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 461, CSCE 861, SOFT 461; CSCE 486; CSCE 488

CSCE 370H Honors: Data and Models II: Data Science Fundamentals
Crosslisted with: RAIK 370H
Prerequisites: Good standing in the University Honors Program or by invitation; admission to the Jeffrey S. Raikes School of Computer Science and Management; and RAIK 270H
Description: Introduction to approaches using data for prediction and learning. Exploration of data for linear and nonlinear data modeling, machine learning, and supportive methods from statistics and numerical methods.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Offered: FALL/SPR

CSCE 378 Human-Computer Interaction
Prerequisites: A grade of "P" or "C" or better in CSCE 156, CSCE 156H, SOFT 161, SOFT 161H, RAIK 184H or CSCE 311.
Notes: MATH/STAT 380 or ECEN 305 recommended. Meeting ACE1 and ACE2 requirements prior to taking this course recommended.
Description: Knowledge and techniques useful in the design of computing systems for human use. Includes models of HCI, human information processing characteristics important in HCI, computer system features, such as input and output devices, dialogue techniques, and information presentation, task analysis, prototyping and the iterative design cycle, user interface implementation, interface evaluation.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 378H Honors: Human-Computer Interaction
Prerequisites: Good standing in the University Honors Program; A grade of "P" or "C" or better in CSCE 156, CSCE 156H, SOFT 161, SOFT 161H, RAIK 184H or CSCE 311.
Notes: MATH/STAT 380 or ECEN 305 recommended. Meeting ACE1 and ACE2 requirements prior to taking this course recommended.
Description: Knowledge and techniques useful in the design of computing systems for human use. Includes models of HCI, human information processing characteristics important in HCI, computer system features, such as input and output devices, dialogue techniques, and information presentation, task analysis, prototyping and the iterative design cycle, user interface implementation, interface evaluation.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 383H Honors: Fundamentals of Software Engineering
Prerequisites: Good standing in the University Honors Program; admission to the Jeffrey S. Raikes School of Computer Science and Management; CSCE/RAIK 284H.
Notes: Fifth course in the Jeffrey S. Raikes School of Computer Science and Management core.
Description: Proper principles and methods of engineering software. Requirements, design, implementation, management and software evolution.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded
CSCE 391 Special Topics in Computer Science  
**Prerequisites:** Permission.  
**Description:** Aspects of computers and computing for non-computer science and computer engineering majors and/or minors. Topics vary.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option

CSCE 392 Special Topics in Computer Science  
**Prerequisites:** Permission.  
**Description:** Aspects of computers and computing for computer science and computer engineering majors and minors. Topics vary.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option

CSCE 394 Independent Study in Computing  
**Prerequisites:** Junior standing; permission of the instructor.  
**Description:** Independent study of computer science topics performed under the guidance of a member of the faculty in the Department of Computer Science and Engineering.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 3  
**Grading Option:** Graded with Option

CSCE 399 Undergraduate Thesis  
**Prerequisites:** Permission.  
**Description:** Independent practice and research leading to a thesis.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded

CSCE 399H Honors Undergraduate Thesis  
**Prerequisites:** Permission.  
**Description:** Independent practice and research leading to a thesis.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded

CSCE 401H Honors: RAIK Design Studio I  
**Crosslisted with:** RAIK 401H, BSAD 401H, SOFT 401H  
**Prerequisites:** Good standing in the University Honors Program or by invitation; admission to the Jeffrey S. Raikes School of Computer Science and Management; RAIK 383H or equivalent.  
**Notes:** First semester in the Jeffrey S. Raikes School of Computer Science and Management design studio  
**Description:** Application of Raikes School core content in a team oriented, project management setting. Complete projects in consultation with private and public sector clients.  
**Credit Hours:** 3  
**Max credits per semester:** 3  
**Max credits per degree:** 3  
**Grading Option:** Graded  
**Offered:** FALL  
**Prerequisite for:** RAIK 402H, BSAD 402H, CSCE 402H, SOFT 402H  
**ACE:** ACE 8 Civic/Ethics/Stewardship

CSCE 402H Honors: RAIK Design Studio II  
**Crosslisted with:** RAIK 402H, BSAD 402H, SOFT 402H  
**Prerequisites:** Good standing in the University Honors Program or by invitation; admission to the Jeffrey S. Raikes School of Computer Science and Management; BSAD/CSCE/SOFT/RAIK 401H.  
**Notes:** Second semester in the Jeffrey S. Raikes School of Computer Science and Management design studio  
**Description:** Application of Raikes School core content in a team oriented, project management setting. Complete projects in consultation with private and public sector clients.  
**Credit Hours:** 3  
**Max credits per semester:** 3  
**Max credits per degree:** 3  
**Grading Option:** Graded  
**Offered:** SPRING  
**Prerequisite for:** RAIK 403H, BSAD 403H, CSCE 403H  
**ACE:** ACE 10 Integrated Product

CSCE 403H Honors: RAIK Design Studio III  
**Crosslisted with:** RAIK 403H, BSAD 403H  
**Prerequisites:** Good standing in the University Honors Program or by invitation; admission to the Jeffrey S. Raikes School of Computer Science and Management; BSAD/CSCE/SOFT/RAIK 402H.  
**Notes:** Third semester of Jeffrey S. Raikes School of Computer Science and Management design studio sequence.  
**Description:** Application of Jeffrey S. Raikes School of Computer Science and Management core content in a team oriented, project management setting. Complete projects in consultation with private and public sector clients.  
**Credit Hours:** 3  
**Max credits per semester:** 3  
**Max credits per degree:** 3  
**Grading Option:** Graded  
**Prerequisite for:** RAIK 404H, BSAD 404H, CSCE 404H
CSCE 404H Honors: RAIK Design Studio IV
Crosslisted with: RAIK 404H, BSAD 404H
Prerequisites: Good standing in the University Honors Program or by invitation; admission to the Jeffrey S. Raikes School of Computer Science and Management; and BSAD/CSCE/SOFT/RAIK 403H.
Notes: Fourth semester in the Jeffrey S. Raikes School of Computer Science and Management design studio sequence.
Description: Application of Raikes School core content in a team oriented, project management setting. Complete projects in consultation with private and public sector clients.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded

CSCE 405H Honors: RAIK Research Studio I
Crosslisted with: RAIK 405H
Prerequisites: Good standing in the University Honors Program or by invitation; admission to the Jeffrey S. Raikes School of Computer Science and Management; RAIK 383H or equivalent.
Notes: First semester of Jeffrey S. Raikes School of Computer Science and Management research studio experience. Students work individually with a sponsoring faculty member from the area of their research and Raikes School faculty.
Description: Application of research principles to solve complex problems through the delivery of innovative, cutting-edge solutions and to gain an understanding of the roles involved.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded
Offered: FALL
Prerequisite for: CSCE 406H, RAIK 406H

CSCE 406H Honors: RAIK Research Studio II
Crosslisted with: RAIK 406H
Prerequisites: RAIK 405H
Notes: Second semester of Jeffrey S. Raikes School of Computer Science and Management research studio experience. Students work individually with a sponsoring faculty member from the area of their research and Raikes School faculty.
Description: Application of research principles to solve complex problems through the delivery of innovative, cutting-edge solutions and to gain an understanding of the roles involved.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded
Offered: SPRING

CSCE 410 Information Retrieval Systems
Crosslisted with: CSCE 810
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Offered: SPRING

CSCE 411 Data Modeling for Systems Development
Crosslisted with: CSCE 811
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Concepts of relational and object-oriented data modeling through the process of data model development including conceptual, logical and physical modeling. Techniques for identifying and creating relationships between discrete data members, reasoning about how data modeling and analysis are incorporated in system design and development, and specification paradigms for data models. Common tools and technologies for engineering systems and frameworks for integrating data. Design and analysis of algorithms and techniques for identification and exploration of data relationships, such as Bayesian probability and statistics, clustering, map-reduce, and web-based visualization.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 412 Data Visualization
Crosslisted with: CSCE 812
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H, MATH 314.
Description: Fundamentals and implementations of data visualization techniques. Programming skills and practices in interactive visualization applications. Visualization foundations, human perception for information processing, and visualization techniques for different data types, such as scalar-field data, vector-field data, geospatial data, multivariate data, graph/network data, and text/document data. Advanced visualization algorithms and topics as time permits.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Offered: FALL/SPRING
CSCE 413 Database Systems
Crosslisted with: CSCE 813
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Notes: Involves practical experience with a working database system.
Description: Data and storage models for database systems; entity/relationship, relational, and constraint models; relational databases; relational algebra and calculus; structured query language; Logical database design: normalization; integrity; distributed data storage; concurrency; security issues. Spatial databases and geographic information systems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 913; CSCE 914

CSCE 421 Foundations of Constraint Processing
Crosslisted with: CSCE 821
Prerequisites: A grade of "P" or "C" or better in CSCE 235 and CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Constraint processing for articulating and solving industrial problems such as design, scheduling, and resource allocation. The foundations of constraint satisfaction, its basic mechanisms (e.g., search, backtracking, and consistency-checking algorithms), and constraint programming languages. New directions in the field, such as strategies for decomposition and for symmetry identification.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 921

CSCE 423 Design and Analysis of Algorithms
Crosslisted with: CSCE 823
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Mathematical preliminaries. Strategies for algorithm design, including divide-and-conquer, greedy, dynamic programming and backtracking. Mathematical analysis of algorithms. Introduction to NP-Completeness theory, including the classes P and NP, polynomial transformations and NP-complete problems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 923; CSCE 924

CSCE 424 Computational Complexity Theory
Crosslisted with: CSCE 824
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 425 Compiler Construction
Crosslisted with: CSCE 825
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Review of program language structures, translation, loading, execution, and storage allocation. Compilation of simple expressions and statements. Organization of a compiler including compile-time and run-time symbol tables, lexical scan, syntax scan, object code generation, error diagnostics, object code optimization techniques, and overall design.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 428 Automata, Computation, and Formal Languages
Crosslisted with: CSCE 828
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Introduction to the classical theory of computer science. Finite state automata and regular languages, minimization of automata. Context free languages and pushdown automata, Turing machines and other models of computation, undecidable problems, introduction to computational complexity.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 430 Computer Architecture
Crosslisted with: CSCE 830
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H; Coreq: MATH/STAT 380, ECEN 305 or RAIK 270H.
Description: Architecture of single-processor (Von Neumann or SISD) computer systems. Evolution, design, implementation, and evaluation of state-of-the-art systems. Memory Systems, including interleaving, hierarchies, virtual memory and cache implementations; Communications and I/O, including bus architectures, arbitration, I/O processors and DMA channels; and Central Processor Architectures, including RISC and Stack machines, high-speed arithmetic, fetch/execute overlap, and parallelism in a single-processor system.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 435 Cluster and Grid Computing
Crosslisted with: CSCE 835
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Notes: Designed for CSCE and non-CSCE students who have an interest in building or programming clusters to enhance their computationally-intense research.
Description: Build and program clusters. Cluster construction, cluster administration, cluster programming, and grid computing.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
CSCE 436 Advanced Embedded Systems
Crosslisted with: CSCE 936
Prerequisites: A grade of "P" or "C" or better in CSCE 231, CSCE 236 or ECEN 220.
Description: Embedded hardware design techniques; transceiver design and low-power communication techniques; sensors and distributed sampling techniques; embedded software design and embedded operating systems; driver development; embedded debugging techniques; hardware and software architectures of embedded systems; and design, development, and implementation of embedded applications.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 438 Internet of Things
Crosslisted with: CSCE 838
Prerequisites: CSCE 230 or CSCE 231; SOFT 260, CSCE 310, CSCE 310H, CSCE 311 or equivalent; senior or graduate standing or instructor permission.
Description: Theoretical and practical insight into the Internet of Things (IoT). Basics of IoT, including devices and sensors, connectivity, cloud processing and storage, analytics and machine learning, security, business models as well as advanced topics such as localization, synchronization, connected vehicles, and applications of IoT. Includes a group project that provides hands-on interaction with IoT.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 439 Robotics: Algorithms and Applications
Crosslisted with: CSCE 839
Prerequisites: A grade of "P" or "C" or better in CSCE 231, CSCE 236 or ECEN 220 and CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Fundamental theory and algorithms for real world robot systems. Design and build a robot platform and implement algorithms in C++ or other high level languages. Topics include: open and closed loop control, reactive control, localization, navigation, path planning, obstacle avoidance, dynamics, kinematics, manipulation and grasping, sensing, robot vision processing, and data fusion.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 440 Numerical Analysis I
Crosslisted with: CSCE 840, MATH 440, MATH 840
Prerequisites: CSCE 155A, CSCE 155E, CSCE 155H, CSCE 155N, CSCE 155T, or SOFT 160; MATH 107.
Notes: Credit toward the degree may be earned in only one of the following: CSCE/MATH 440/840 and MECH 480/880.
Description: Principles of numerical computing and error analysis covering numerical error, root finding, systems of equations, interpolation, numerical differentiation and integration, and differential equations. Modeling real-world engineering problems on digital computers. Effects of floating point arithmetic.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 942, MATH 942

CSCE 441 Approximation of Functions
Crosslisted with: CSCE 841, MATH 441, MATH 841
Prerequisites: MATH 221/MATH 221H and MATH 314/MATH 314H.
Description: Polynomial interpolation, uniform approximation, orthogonal polynomials, least-first-power approximation, polynomial and spline interpolation, approximation and interpolation by rational functions.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 942, MATH 942
Groups: Advanced Mathematics Courses

CSCE 447 Numerical Linear Algebra
Crosslisted with: CSCE 847, MATH 447, MATH 847
Prerequisites: MATH 314.
Description: Mathematics and algorithms for numerically stable matrix and linear algebra computations, including solution of linear systems, computation of eigenvalues and eigenvectors, singular value decomposition, and QR decomposition.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 942, MATH 942
Groups: Advanced Mathematics Courses

CSCE 451 Operating Systems Principles
Crosslisted with: CSCE 851
Prerequisites: A grade of "P" or "C" or better in CSCE 230, CSCE 230H or CSCE 231 and CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 455, CSCE 855
CSCE 454 Human-Robot Interaction
Crosslisted with: CSCE 854
Prerequisites: A grade of "P" or "C" or better in CSCE 156, CSCE 156H, SOFT 161, SOFT 161H, RAIK 184H or CSCE 311.
Notes: Meeting ACE1 and ACE2 requirements prior to taking this course is recommended. Non-CSCE majors may discuss qualifications with the instructor.
Description: Introduction to the area of human-robot interaction through the reading and discussion of current peer-reviewed articles on topic to include teleoperation, social robotics, and open questions with field-based or aerial robotic systems. Areas covered include: research methods, experimental design, and identification of problems/open questions.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Offered: FALL/SPR

CSCE 455 Distributed Operating Systems
Crosslisted with: CSCE 855
Prerequisites: CSCE 451/851.
Description: Organization and structure of distributed operating systems. Control, communication and synchronization of concurrent processes in the context of distributed systems. Processor allocation and scheduling. Deadlock avoidance, detection, recovery in distributed systems. Fault tolerance. Distributed file system concepts and structure.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CHME 496, CHME 896

CSCE 456 Parallel Programming
Crosslisted with: CSCE 856
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H, or RAIK 283H.
Description: Introduction to the fundamentals of parallel computation and applied algorithm design. Methods and models of modern parallel computation; general techniques for designing efficient parallel algorithms for distributed and shared memory multiprocessor machines; principles and practice in programming an existing parallel machine.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 457 Systems Administration
Crosslisted with: CSCE 857
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Introduction to basic concepts of system administration. Operating systems and networking overview. User and resource management. Networking, systems and internet related security. System services and common applications, web services, database services, and mail servers. Basic scripting in shell, Perl, and Expect. Systems administration on UNIX® platform.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 458 Molecular and Nanoscale Communication
Crosslisted with: CSCE 858
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H; STAT 380, ECEN 305 or RAIK 270H.
Notes: Completing CSCE 462/862 and CSCE 465/865 prior to taking this course is recommended. Exceptions can be granted on a per-student basis by the instructor.
Description: Overview of nanoscale communication options. Focus on bio-inspired communication through molecule exchange and biochemical reactions. Different techniques to realize nanomachines will be surveyed in the course, with particular attention to the tools provided by synthetic biology for the programming of biological cooperative systems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 459 Genetically Engineered Systems
Crosslisted with: CSCE 859
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H; STAT 380, ECEN 305 or RAIK 270H.
Notes: Completing CSCE/MATH 440/840, MATH 432/832, MATH 439/839, and CSCE 471/871 prior to taking this course is recommended. Exceptions can be granted on a per-student basis by the instructor.
Description: Introduction to the field of synthetic biology, and its interdisciplinary foundational concepts. Presents the technologies at the basis of synthetic biology, together with the engineering concepts that underlie the design, modeling, and realization of genetically engineered systems. Surveys examples of cutting edge applications.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 460 Software Engineering for Robotics
Crosslisted with: SOFT 460, CSCE 860
Prerequisites: SOFT 261 or RAIK 383H or CSCE 361
Description: Application of software engineering practices and principles to autonomous robotic systems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded
Offered: FALL/SPR

CSCE 461 Advanced Topics in Software Engineering
Crosslisted with: CSCE 861, SOFT 461
Prerequisites: A grade of "P" or "C" or better in CSCE 361, CSCE 361H, SOFT 261, SOFT 261H or RAIK 383H.
Description: Advanced or emerging techniques in software engineering. Topics include but not limited to design methodology, software dependability, and advanced software development environments.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

Notes:
- Completing CSCE/MATH 440/840, MATH 432/832, MATH 439/839, and CSCE 471/871 prior to taking this course is recommended. Exceptions can be granted on a per-student basis by the instructor.
- A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H; STAT 380, ECEN 305 or RAIK 270H is recommended. Exceptions can be granted on a per-student basis by the instructor.

CSCE 462/862 and CSCE 465/865 Prior to taking this course is recommended. Exceptions can be granted on a per-student basis by the instructor.
CSCE 462 Communication Networks
Crosslisted with: CSCE 862
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H; STAT 380, ECEN 305 or RAIK 270H.  
Credit Hours: 3  
Max credits per semester: 3  
Max credits per degree: 3  
Grading Option: Graded with Option  
Prerequisite for: CSCE 952; CSCE 953

CSCE 463 Data and Network Security
Crosslisted with: CSCE 863
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.  
Description: Concepts and principles of data and network security. Focuses on practical aspects and application of crypto systems in security protocols for networks such as the Internet. Topics include: applications of cryptography and cryptosystems for digital signatures, authentication, network security protocols for wired and wireless networks, cyberattacks and countermeasures, and security in modern computing platforms.  
Credit Hours: 3  
Max credits per semester: 3  
Max credits per degree: 3  
Grading Option: Graded with Option

CSCE 464 Internet Systems and Programming
Crosslisted with: CSCE 864
Prerequisites: A grade of "P" or C or better in CSCE 156, SOFT 161, RAIK 184H or CSCE 311 or equivalent programming experience.  
Notes: A grade of "Pass" or C or better in CSCE 156, SOFT 161, RAIK 184H or CSCE 311 or equivalent programming experience.  
Description: Paradigms, systems, and languages for Internet applications. Client-side and server-side programming, object-based and event-based distributed programming, and multi-tier applications. Coverage of specific technologies varies.  
Credit Hours: 3  
Max credits per semester: 3  
Max credits per degree: 3  
Grading Option: Graded with Option

CSCE 465 Wireless Communication Networks
Crosslisted with: CSCE 865
Prerequisites: A grade of "P" or "C" or better in STAT 380, ECEN 305 or RAIK 270H  
Description: Discussion of theoretical and practical insight to wireless communications and wireless networking, current practices, and future trends. Wireless network architectures, mobility management, radio propagation, modulation, power control, antennas, channel access, pricing, and standards.  
Credit Hours: 3  
Max credits per semester: 3  
Max credits per degree: 3  
Grading Option: Graded with Option

CSCE 466 Software Design and Architecture
Crosslisted with: SOFT 466, CSCE 866
Prerequisites: A grade of "P" or "C" or better in CSCE 361, CSCE 361H, SOFT 261, SOFT 261H or RAIK 383H.  
Notes: Letter grade only.  
Description: Introduction to the concepts, principles, and state-of-the-art methods in software design and architecture. Topics include application of software engineering process models and management approaches for the design and architecture of large-scale software systems, trade-offs of designing for qualities such as performance, security, and dependability, and techniques and tools for analyzing and evaluating software architectures.  
Credit Hours: 3  
Max credits per semester: 3  
Max credits per degree: 3  
Grading Option: Graded

CSCE 467 Testing, Verification and Analysis
Crosslisted with: SOFT 467, CSCE 867
Prerequisites: A grade of "P" or "C" or better in CSCE 361, CSCE 361H, SOFT 261, SOFT 261H or RAIK 383H.  
Notes: Letter grade only.  
Description: In-depth coverage of problems related to software quality, and approaches for addressing them. Topics include testing techniques, dynamic and static program analysis techniques, and other approaches for verifying software qualities. Tool support for performing testing, verification, and analysis will also be studied.  
Credit Hours: 3  
Max credits per semester: 3  
Max credits per degree: 3  
Grading Option: Graded

CSCE 468 Requirements Elicitation, Modeling and Analysis
Crosslisted with: SOFT 468, CSCE 868
Prerequisites: A grade of "P" or "C" or better in CSCE 361, CSCE 361H, SOFT 261, SOFT 261H or RAIK 383H.  
Notes: Letter grade only.  
Description: In-depth coverage of processes, methods and techniques for determining, or deciding, what a proposed software system should do. Topics include the requirements engineering process, identification of stakeholders, requirements elicitation techniques, methods for informal and formal requirements documentation, techniques for analyzing requirements models for consistency and completeness, and traceability of requirements across system development and evolution. Tool support for modeling functional and non-functional requirements to support elicitation and analysis will be studied.  
Credit Hours: 3  
Max credits per semester: 3  
Max credits per degree: 3  
Grading Option: Graded
CSCE 470 Computer Graphics
Crosslisted with: CSCE 870
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H; MATH 314
Description: Display and recording devices; incremental plotters; point, vector, and character generation; grey scale displays, digitizers and scanners, digital image storage; interactive and passive graphics; pattern recognition; data structures and graphics software; the mathematics of three dimensions; homogeneous coordinates; projections and the hidden-line problem.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 471 Computational Methods in Bioinformatics
Crosslisted with: CSCE 871
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Introduction to computational methods for tackling challenges in biological data analysis and modeling and understanding complex systems at the molecular and cellular level. The main topics include bio-sequence analysis, motif finding, structure prediction, phylogenetic inference, regulation network modeling, and high-throughput omics data analysis.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Offered: SPRING
Prerequisite for: CSCE 971

CSCE 472 Digital Image Processing
Crosslisted with: CSCE 872
Prerequisites: A grade of "P" or C or better in CSCE 156, SOFT 161, RAIK 184H or CSCE 311 or equivalent programming experience.
Notes: A grade of "Pass" or C or better in CSCE 156, SOFT 161, RAIK 184H or CSCE 311 or equivalent programming experience.
Description: Digital imaging systems, digital image processing, and low-level computer vision. Data structures, algorithms, and system analysis and modeling. Digital image formation and presentation, image statistics and descriptions, operations and transforms, and system simulation. Applications include system design, restoration and enhancement, reconstruction and geometric manipulation, compression, and low-level analysis for computer vision.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 473 Computer Vision
Crosslisted with: CSCE 873
Prerequisites: CSCE 156, SOFT 161, or CSCE 311 or equivalent programming experience.
Notes: A grade of "Pass" or C or better in CSCE 156, SOFT 161, RAIK 184H or CSCE 311 or equivalent programming experience.
Description: High-level processing for image understanding and high-level vision. Data structures, algorithms, and modeling. Low-level representation, basic pattern-recognition and image-analysis techniques, segmentation, color, texture and motion analysis, and representation of 2-D and 3-D shape. Applications for content-based image retrieval, digital libraries, and interpretation of satellite imagery.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 474 Introduction to Data Mining
Crosslisted with: CSCE 874
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H; STAT 380, ECEN 305 or RAIK 270H.
Notes: Requires the completion of a project involving the application of data mining techniques to real-world problems.
Description: Data mining and knowledge discovery methods and their application to real-world problems. Algorithmic and systems issues. Statistical foundations, association discovery, classification, prediction, clustering, spatial data mining and advanced techniques.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 475 Multiagent Systems
Crosslisted with: CSCE 875
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Distributed problem solving and planning, search algorithms for agents, distributed rational decision making, learning multiagent systems, computational organization theory, formal methods in Distributed Artificial Intelligence, multiagent negotiations, emergent behaviors (such as ants and swarms), and Robocup technologies and real-time coalition formation.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 476 Introduction to Artificial Intelligence
Crosslisted with: CSCE 876
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Description: Introduction to basic principles, techniques, and tools now being used in the area of machine intelligence. Languages for AI programming introduced with emphasis on LISP. Lecture topics include problem solving, search, game playing, knowledge representation, expert systems, and applications.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 976
CSCE 477 Cryptography and Computer Security
Crosslisted with: CSCE 877
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H; MATH 314.
Description: Introductory course on cryptography and computer security. Topics: classical cryptography (substitution, Vigenere, Hill and permutation ciphers, and the one-time pad); Block ciphers and stream ciphers; The Data Encryption Standard; Public-key cryptography, including RSA and El-Gamal systems; Signature schemes, including the Digital Signature Standard; Key exchange, key management and identification protocols.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 478 Introduction to Machine Learning
Crosslisted with: CSCE 878
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Notes: STAT 380, ECEN 305, or RAIK 270H recommended.
Description: Introduction to the fundamentals and current trends in machine learning. Possible applications for game playing, text categorization, speech recognition, automatic system control, date mining, computational biology, and robotics. Theoretical and empirical analyses of decision trees, artificial neural networks, Bayesian classifiers, genetic algorithms, instance-based classifiers and reinforcement learning.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 479 Introduction to Deep Learning
Crosslisted with: CSCE 879
Prerequisites: A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.
Notes: Completing STAT 380, ECEN 305, or RAIK 270 prior to taking this course is recommended.
Description: Fundamentals and current trends in deep learning. Backpropagation, activation functions, loss functions, choosing an optimizer, and regularization. Common architectures such as convolutional, autoencoders, and recurrent. Applications such as image analysis, text analysis, sequence analysis, and reinforcement learning.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Offered: SPRING

CSCE 486 Computer Science Professional Development
Prerequisites: A grade of "Pass" or "C" or better in SOFT 261, CSCE 361 or CSCE 361H
Notes: Must be taken exactly one semester before CSCE 487.
Description: Preparation for the senior design project. Professional practice through familiarity with current tools, resources, and technologies. Professional standards, practices and ethics, and theoral and written report styles used specifically in the field of computer science.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 487; CSCE 487H
ACE: ACE 8 Civic/Ethics/Stewardship

CSCE 487 Computer Science Senior Design Project
Prerequisites: CSCE 486
Notes: Should be taken in the immediate next term after CSCE 486.
Description: A substantial computer science project requiring design, planning and scheduling, teamwork, written and oral communications, and the integration and application of technical and analytical aspects of computer science and software engineering.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 487; CSCE 487H
ACE: ACE 10 Integrated Product

CSCE 487H Honors Computer Science Senior Design Project
Prerequisites: CSCE 486 or CSCE 486H.
Notes: Should be taken in the immediate next term after CSCE 486 or CSCE 486H.
Description: A substantial computer science project requiring design, planning and scheduling, teamwork, written and oral communications, and the integration and application of technical and analytical aspects of computer science and software engineering.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option

CSCE 488 Computer Science Professional Development
Prerequisites: CSCE 236; A grade of "Pass" or "C" or better in CSCE 361 or CSCE 361H; formal admission to the College of Engineering; prereq or coreq: JGEN 300.
Notes: Must be taken exactly one semester before CSCE 489.
Description: Preparation for the senior design project. Professional practice through familiarity and practice with current tools, resources, and technologies; professional standards, practices, and ethics; and oral and written report styles used in the computer engineering field.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 489; CSCE 489H
ACE: ACE 10 Integrated Product

CSCE 489 Computer Engineering Professional Development
Prerequisites: CSCE 236; A grade of "Pass" or "C" or better in CSCE 361 or CSCE 361H; formal admission to the College of Engineering; prereq or coreq: JGEN 300.
Notes: Must be taken exactly one semester before CSCE 489.
Description: Preparation for the senior design project. Professional practice through familiarity and practice with current tools, resources, and technologies; professional standards, practices, and ethics; and oral and written report styles used in the computer engineering field.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Grading Option: Graded with Option
Prerequisite for: CSCE 489; CSCE 489H
ACE: ACE 8 Civic/Ethics/Stewardship
CSCE 489 Computer Engineering Senior Design Project  
**Prerequisites:** CSCE 488 (taken exactly one semester previous).  
**Description:** A substantial computer engineering project requiring hardware-software co-design, planning and scheduling, teamwork, written and oral communications, and the integration and application of technical and analytical aspects of computer science and computer engineering.  
**Credit Hours:** 3  
**Max credits per semester:** 3  
**Max credits per degree:** 3  
**Grading Option:** Graded with Option  
ACE: ACE 10 Integrated Product  
CSCE 489H Honors Computer Engineering Senior Design Project  
**Prerequisites:** CSCE 488 or CSCE 488H (taken exactly one semester previous).  
**Description:** A substantial computer engineering project requiring hardware-software co-design, planning and scheduling, teamwork, written and oral communications, and the integration and application of technical and analytical aspects of computer science and computer engineering.  
**Credit Hours:** 3  
**Max credits per semester:** 3  
**Max credits per degree:** 3  
**Grading Option:** Graded with Option  
Offered: SPRING  
ACE: ACE 10 Integrated Product  
CSCE 492 Special Topics in Computer Science  
**Crosslisted with:** CSCE 892  
**Prerequisites:** Senior or graduate standing.  
**Description:** Aspects of computers and computing not covered elsewhere in the curriculum presented as the need arises.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option  
CSCE 492H Honors Special Topics in Computer Science  
**Prerequisites:** Permission.  
**Description:** Topics vary  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option  
CSCE 493A Interdisciplinary Capstone  
**Prerequisites:** CSCE 311  
**Notes:** Does not apply toward any requirements for the Computer Science or Computer Engineering degree. Required for the Informatics minor.  
**Description:** Innovative team projects executed under the guidance of members of the faculty of the Department of Computer Science and Managing Director of the CSCE Innovation Lab. Work in teams and collaboration with CSE research faculty and sponsors that include private sectors and UNL faculty to design and develop real-world systems to solve interdisciplinary problems.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded  
CSCE 495 Internship in Computing Practice  
**Prerequisites:** Permission.  
**Notes:** Requires a detailed project proposal and final report.  
**Description:** Experiential learning in conjunction with an approved industrial or government agency under the joint supervision of an outside sponsor and a faculty advisor.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option  
CSCE 498 Computer Problems  
**Crosslisted with:** CSCE 898  
**Prerequisites:** Senior or graduate standing.  
**Description:** An independent project executed under the guidance of a member of the faculty of the Department of Computer Science. Solution and documentation of a computer problem demanding a thorough knowledge of either the numerical or nonnumerical aspects of computer science.  
**Credit Hours:** 1-6  
**Min credits per semester:** 1  
**Max credits per semester:** 6  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option  
CSCE 493 Innovation Lab Project  
**Prerequisites:** CSCE 310, CSCE 310H, CSCE 311, or CSCE 320  
**Description:** Innovative team projects executed under the guidance of members of the faculty of the Department of Computer Science and Managing Director of the CSCE Innovation Lab. Students will work in teams and collaborate with CSE research faculty, supervising MS students, and sponsors that include private sectors and UNL faculty to design and develop real-world systems.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option  
CSCE 493A Interdisciplinary Capstone  
**Prerequisites:** CSCE 311  
**Notes:** Does not apply toward any requirements for the Computer Science or Computer Engineering degree. Required for the Informatics minor.  
**Description:** Innovative team projects executed under the guidance of members of the faculty of the Department of Computer Science and Managing Director of the CSCE Innovation Lab. Work in teams and collaboration with CSE research faculty and sponsors that include private sectors and UNL faculty to design and develop real-world systems to solve interdisciplinary problems.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded  
CSCE 495 Internship in Computing Practice  
**Prerequisites:** Permission.  
**Notes:** Requires a detailed project proposal and final report.  
**Description:** Experiential learning in conjunction with an approved industrial or government agency under the joint supervision of an outside sponsor and a faculty advisor.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option  
CSCE 498 Computer Problems  
**Crosslisted with:** CSCE 898  
**Prerequisites:** Senior or graduate standing.  
**Description:** An independent project executed under the guidance of a member of the faculty of the Department of Computer Science. Solution and documentation of a computer problem demanding a thorough knowledge of either the numerical or nonnumerical aspects of computer science.  
**Credit Hours:** 1-6  
**Min credits per semester:** 1  
**Max credits per semester:** 6  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option  
CSCE 493A Interdisciplinary Capstone  
**Prerequisites:** CSCE 311  
**Notes:** Does not apply toward any requirements for the Computer Science or Computer Engineering degree. Required for the Informatics minor.  
**Description:** Innovative team projects executed under the guidance of members of the faculty of the Department of Computer Science and Managing Director of the CSCE Innovation Lab. Work in teams and collaboration with CSE research faculty and sponsors that include private sectors and UNL faculty to design and develop real-world systems to solve interdisciplinary problems.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded  
CSCE 495 Internship in Computing Practice  
**Prerequisites:** Permission.  
**Notes:** Requires a detailed project proposal and final report.  
**Description:** Experiential learning in conjunction with an approved industrial or government agency under the joint supervision of an outside sponsor and a faculty advisor.  
**Credit Hours:** 1-3  
**Min credits per semester:** 1  
**Max credits per semester:** 3  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option  
CSCE 498 Computer Problems  
**Crosslisted with:** CSCE 898  
**Prerequisites:** Senior or graduate standing.  
**Description:** An independent project executed under the guidance of a member of the faculty of the Department of Computer Science. Solution and documentation of a computer problem demanding a thorough knowledge of either the numerical or nonnumerical aspects of computer science.  
**Credit Hours:** 1-6  
**Min credits per semester:** 1  
**Max credits per semester:** 6  
**Max credits per degree:** 6  
**Grading Option:** Graded with Option