

# ARTIFICIAL INTELLIGENCE MINOR

## Description

The Artificial Intelligence minor prepares students from any discipline to exploit AI techniques and tools in solving problems in their chosen field by developing core computational skills and competencies in state-of-the-practice AI and data analysis tools. The program also builds interdisciplinary problem-solving skills that are applicable and advantageous both in academia and in industry. The minor's objectives and outcomes enable the students completing this minor to:

1. Build core, foundational capabilities and knowledge in computational techniques, programming and artificial intelligence;
2. Interact and use existing AI-based techniques to implement creative computational solutions to data-centric, domain-specific problems;
3. Develop an understanding of the academic, industrial, and societal implications of AI; and
4. Contribute one's expertise to the solution of interdisciplinary problems by effectively collaborating and communicating with experts in other disciplines.

## College Requirements

### College Admission

#### College Entrance Requirements

Students must meet both the University and College of Engineering entrance requirements. The following includes both the University and College of Engineering 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, computer engineering, computer science, data science, or software engineering)
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. Students without test scores who are missing a full unit of trigonometry/pre-calculus/calculus or chemistry or physics will be evaluated through College Review.
7. Students having an ACT score of 19 or less in English (or equivalent SAT score) or a grade lower than B in high school English, must take ENGL 150 Writing and Inquiry or ENGL 151 Writing for Change.

A total of 16 units is required for admission.

Engineering requires that student performance meet one of the following standards: composite ACT of 24, SAT of 1180, ACT Math subscore of 24, SAT Math subscore of 580, or a 3.5 cumulative GPA.

Any domestic first-year student who does not gain admission to Engineering but does gain admission to the University of Nebraska-Lincoln (UNL) will be reviewed through College Review. College Review is conducted through the College Review Committee which considers factors beyond standardized testing. Any first-year student who is not admitted through college review is placed in Pre-Engineering (PENG) with the Exploratory and Pre-Professional Advising Center (Explore Center). Students in the Explore Center can transfer to the College of Engineering once college admission requirements are met.

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 Explore Center or other colleges at UNL.

Students should consult their advisor, their department chair, or Engineering Student Services (ESS) 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 first-year student entrance requirements, 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 UNO, UNL, 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 from colleges outside of the NU system. Although the University of Nebraska–Lincoln and the College of Engineering in general accepts C- and D grades from the University of Nebraska Kearney and the University of Nebraska 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.

Students who were previously admitted to COE and are returning to the College of Engineering must demonstrate a cumulative GPA of 2.5 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 their instructor, and appropriate department chair or school director (in that order). If a satisfactory solution is not achieved, the student may appeal their case through the College Academic Appeals Subcommittee.

## 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.

Students who have transferred from a community college may be eligible to fulfill the requirements as stated in the catalog for an academic year in which they were enrolled at the community college prior to attending the University of Nebraska-Lincoln. This decision should be made in consultation with the student's College of Engineering academic advising team (e.g., ESS professional advisor and the chief faculty advisor for the student's declared degree program). The chief faculty advisor has the final authority for this decision. Eligibility is based on a) enrollment in a community college during the catalog year the student wishes to utilize, b) maintaining continuous enrollment of at least 12 credit hours per semester at the previous institution for at least 2 semesters, and c) continuous enrollment at the University of Nebraska-Lincoln within 1 calendar year from the student's last term at the previous institution. #Students must complete all degree requirements from a single catalog year and within the timeframe allowable for that catalog year.

## Requirements for Minor Offered by Department

At least eighteen (18) hours of coursework, including nine (9) foundation hours, six (6) Core AI hours, and three (3) Applied AI hours.

### Foundation Courses

CSCE 155A	Computer Science I	3
or CSCE 155E	Computer Science I: Systems Engineering Focus	
or CSCE 155H	Honors: Computer Science I	
or CSCE 155N	Computer Science I: Engineering and Science Focus	
or CSCE 155T	Computer Science I: Informatics Focus	
CSCE 311	Data Structures and Algorithms for Informatics	3
CSCE 320	Data Analysis	3
Credit Hours Subtotal:		9

### Core Artificial Intelligence Courses <sup>1</sup>

Select 6 credit hours from the following:		6
CSCE 410	Information Retrieval Systems	
CSCE 420	Introduction to Natural Language Processing	
CSCE 421	Foundations of Constraint Processing	
CSCE 422	Introduction to Computational Game Theory	
CSCE 475	Multiagent Systems	
CSCE 476	Introduction to Artificial Intelligence	
CSCE 478	Introduction to Machine Learning	
CSCE 479	Introduction to Deep Learning	
Credit Hours Subtotal:		6

### Applied Artificial Intelligence Courses <sup>1</sup>

Select 3 credit hours from the following:		3
CSCE 411	Data Modeling for Systems Development	
CSCE 413	Database Systems	
CSCE 417	Artificial Intelligence For Social Good	
CSCE 438	Internet of Things	

CSCE 471	Computational Methods in Bioinformatics	
CSCE 472	Digital Image Processing	
CSCE 473	Computer Vision	
CSCE 474	Introduction to Data Mining	
CSCE 492	Special Topics in Computer Science	
CSCE 493	Innovation Lab Project	
Credit Hours Subtotal:		3
<b>Total Credit Hours</b>		<b>18</b>

<sup>1</sup> Up to three (3) credit hours of Core or Applied AI courses, not listed as above, such as particular special topics courses, seminar courses, independent study courses, and honors courses with a relevant topic may be applied toward the minor by permission of the Advisor.

## Grade Rules

### C- and D Grades

A grade of C or above is required for all courses in the minor.

### Pass/No Pass

No course taken Pass/No Pass will 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 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:** CIVE 201; CIVE 202; CSCE 101L

**ACE:** ACE 3 Math/Stat/Reasoning

**Course and Laboratory Fee:** \$35

### 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

**Course and Laboratory Fee:** \$10

### 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 155A Computer Science I

**Prerequisites:** MATH 102 or a Math Placement Test score for MATH 103 or higher. Credit toward the degree may be earned in only one of: CSCE 155, CSCE 155A, CSCE 155E/ECEN 155E, CSCE 155H, CSCE 155N, or CSCE 155T.

**Notes:** 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:** CIVE 201; CSCE 156, ECEN 156; CSCE 156H; CSCE 235; CSCE 235H; CSCE 311; CSCE 320; CSCE 352; CSCE 802; ECEN 106; ECEN 123; ECEN 224; MECH 300; ROBO 303

**Course and Laboratory Fee:** \$35

### CSCE 155E Computer Science I: Systems Engineering Focus

**Crosslisted with:** ECEN 155E

**Prerequisites:** MATH 102 or a Math Placement Test score for MATH 103 or higher. Credit toward the degree may be earned in only one of: CSCE 155, CSCE 155A, CSCE 155E/ECEN 155E, CSCE 155H, CSCE 155N, or CSCE 155T.

**Notes:** 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:** CIVE 201; CSCE 156, ECEN 156; CSCE 156H; CSCE 235; CSCE 235H; CSCE 311; CSCE 320; CSCE 336; CSCE 352; CSCE 802; ECEN 106; ECEN 123; ECEN 220; ECEN 224; MECH 300; ROBO 303

**Course and Laboratory Fee:** \$10

### 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. Credit toward the degree may be earned in only one of: CSCE 155, CSCE 155A, CSCE 155E/ECEN 155E, CSCE 155H, CSCE 155N, or CSCE 155T.

**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:** CIVE 201; CSCE 156, ECEN 156; CSCE 156H; CSCE 235; CSCE 235H; CSCE 311; CSCE 320; CSCE 352; CSCE 802; ECEN 106; ECEN 224; MECH 300; ROBO 303

**Course and Laboratory Fee:** \$35

### CSCE 155N Computer Science I: Engineering and Science Focus

**Prerequisites:** MATH 102 or a Math Placement Test score for MATH 103 or higher. Credit toward the degree may be earned in only one of: CSCE 155, CSCE 155A, CSCE 155E/ECEN 155E, CSCE 155H, CSCE 155N, or CSCE 155T.

**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; CIVE 201; CSCE 156, ECEN 156; CSCE 156H; CSCE 235; CSCE 235H; CSCE 311; CSCE 320; CSCE 802; ECEN 106; ECEN 224; MECH 300; MECH 318; MECH 330; MECH 350; MECH 381; ROBO 303

**Course and Laboratory Fee:** \$35

**CSCE 155T Computer Science I: Informatics Focus**

**Prerequisites:** MATH 102 or a Math Placement Test score for MATH 103 or higher. Credit toward the degree may be earned in only one of: CSCE 155, CSCE 155A, CSCE 155E/ECEN 155E, CSCE 155H, CSCE 155N, or CSCE 155T.

**Notes:** Recommended for students interested in data and information processing, such as library and database applications, online commerce, and bioinformatics.

**Description:** Introduction to computers and 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, ECEN 156; CSCE 156H; CSCE 235; CSCE 235H; CSCE 311; CSCE 320; CSCE 352; CSCE 802; ECEN 106; ECEN 224; MECH 300; ROBO 303

**CSCE 156 Computer Science II**

**Crosslisted with:** ECEN 156

**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

**Offered:** FALL/SPR

**Prerequisite for:** CSCE 235; CSCE 310; CSCE 310H; CSCE 322; CSCE 322H; CSCE 378; CSCE 378H; CSCE 453H, RAIK 453H; SOFT 162

**Course and Laboratory Fee:** \$35

**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. Credit toward the degree cannot be earned in both CSCE 156 and CSCE 156H.

**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; CSCE 453H, RAIK 453H; SOFT 162

**Course and Laboratory Fee:** \$35

**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 164 Introduction to Computer Engineering**

**Crosslisted with:** ECEN 164

**Notes:** Project-based introduction to the computer engineering field.

**Description:** Introduction to basic concepts and skills needed in computer engineering. Practical application of basic computing concepts through an introduction to programming an embedded system.

**Credit Hours:** 2

**Max credits per semester:** 2

**Max credits per degree:** 2

**Grading Option:** Graded with Option

**Offered:** SPRING

**Prerequisite for:** ECEN 220; ECEN 370, CSCE 335

**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; CSCE 352; RAIK 184H, CSCE 184H; SCMA 335

**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, ECEN 230; CSCE 231; CSCE 322; CSCE 322H; CSCE 377; CSCE 378; CSCE 378H; CSCE 453H, RAIK 453H; 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

**Course and Laboratory Fee:** \$10

**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

**CSCE 220 Software Development for Smart-Mobile Systems**

**Prerequisites:** CSCE 120

**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. Second course in a sequence for the minor in Software Development.

**Description:** Practical experience on building larger scale applications and familiarity with the tools, environments (e.g., Android or iOS), and requirements to develop software for current smart-mobile devices such as phones and tablets.

**Credit Hours:** 3

**Max credits per semester:** 3

**Max credits per degree:** 3

**Grading Option:** Graded with Option

**Prerequisite for:** CSCE 453H, RAIK 453H

**CSCE 230 Computer Organization**

**Crosslisted with:** ECEN 230

**Prerequisites:** A grade of 'P' or 'C' or better in CSCE 235, CSCE 235H, or RAIK 184H.

**Notes:** Laboratories supplement the lecture material and give an opportunity to practice concepts.

**Description:** 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.

**Credit Hours:** 4

**Max credits per semester:** 4

**Max credits per degree:** 4

**Grading Option:** Graded with Option

**Offered:** FALL

**Prerequisite for:** CSCE 336; CSCE 351, ECEN 351; CSCE 362; ECEN 370, CSCE 335

**Course and Laboratory Fee:** \$20

**CSCE 231 Computer Systems Engineering**

**Prerequisites:** Grade of "P" or "C" or better in CSCE 235, CSCE 235H or RAIK 184H.

**Description:** Introduction to organization, structure, and applications of computer systems. Boolean Logic, Digital Arithmetic, Processor Organization, C Programming, Machine Language Programming, Input/Output, Memory Organization and Management, Building Embedded System Application.

**Credit Hours:** 4

**Max credits per semester:** 4

**Max credits per degree:** 4

**Grading Option:** Graded with Option

**Prerequisite for:** CSCE 336; CSCE 351, ECEN 351; CSCE 362

**Course and Laboratory Fee:** \$20

**CSCE 235 Introduction to Discrete Structures**

**Prerequisites:** 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.

**Notes:** Theoretical concepts with programming assignments.

**Description:** Survey of elementary discrete mathematics. Elementary graph and tree theories, set theory, relations and functions, propositional and predicate logic, methods of proof, induction, recurrence relations, principles of counting, elementary combinatorics, and asymptotic notations.

**Credit Hours:** 3

**Max credits per semester:** 3

**Max credits per degree:** 3

**Grading Option:** Graded with Option

**Prerequisite for:** CSCE 230, ECEN 230; CSCE 231; CSCE 310; CSCE 310H; CSCE 362; CSCE 377; SOFT 260

**Course and Laboratory Fee:** \$20

**CSCE 235H Honors: Introduction to Discrete Structures**

**Prerequisites:** 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. Credit toward the degree cannot be earned in both CSCE 235 and CSCE 235H.

**Notes:** Theoretical concepts with programming assignments. Covers the same topics as CSCE 235, but in greater depth.

**Description:** Survey of elementary discrete mathematics. Elementary graph and tree theories, set theory, relations and functions, propositional and predicate logic, methods of proof, induction, recurrence relations, principles of counting, elementary combinatorics, and asymptotic notations.

**Credit Hours:** 3

**Max credits per semester:** 3

**Max credits per degree:** 3

**Grading Option:** Graded with Option

**Prerequisite for:** CSCE 230, ECEN 230; CSCE 231; CSCE 310; CSCE 310H; CSCE 362; CSCE 377; SOFT 260

**Course and Laboratory Fee:** \$20

**CSCE 251 Unix Programming Environment**

**Crosslisted with:** ECEN 251

**Notes:** Familiarity with at least one high-level programming language.

**Description:** Introduction to the Unix operating system. Unix file system. Unix tools and utilities. Shell programming.

**Credit Hours:** 1

**Max credits per semester:** 1

**Max credits per degree:** 1

**Grading Option:** Graded with Option

**Offered:** FALL

**Course and Laboratory Fee:** \$25

**CSCE 291 Special Topics in Computer Science**

**Prerequisites:** Permission.

**Notes:** Will not count towards a major or minor in computer science and computer engineering. Topics vary.

**Description:** Aspects of computers and computing 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 292 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 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

**Min credits per semester:** 1

**Max credits per semester:** 3

**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/CSCE 156H or SOFT 161 and CSCE 235/CSCE 235H. Credit toward the degree may be earned in only one of CSCE 310 or CSCE 311

**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, ECEN 351; CSCE 360; CSCE 361, CSCE 361H; CSCE 493

**Course and Laboratory Fee:** \$20

**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/CSCE 156H or SOFT 161 and CSCE 235/CSCE 235H. Credit toward the degree cannot be earned in CSCE 310 and CSCE 310H.

**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, ECEN 351; CSCE 360; CSCE 361, CSCE 361H; CSCE 493

**Course and Laboratory Fee:** \$20

**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. Credit toward the degree may be earned in only one of CSCE 310 or CSCE 311

**Notes:** CSE majors must take CSCE 310.

**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, ECEN 351; CSCE 360; CSCE 361, CSCE 361H; CSCE 377; CSCE 378; CSCE 378H; CSCE 386; CSCE 453H, RAIK 453H; CSCE 484; CSCE 493; CSCE 493A

**CSCE 320 Data Analysis**

**Prerequisites:** A grade of "P" or "C" or better in CSCE 155A, CSCE 155E, CSCE 155H, CSCE 155N, or CSCE 155T.

**Description:** Practical experience in modeling and analysis of large datasets through data mining and machine learning techniques. Use of models to promote efficient and effective data processing and analysis, including artificial intelligence-based applications.

**Credit Hours:** 3

**Max credits per semester:** 3

**Max credits per degree:** 3

**Grading Option:** Graded with Option

**Offered:** FALL

**Prerequisite for:** CSCE 311; CSCE 493

**CSCE 322 Programming Language Concepts**

**Prerequisites:** 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

**Course and Laboratory Fee:** \$40

**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. Credit toward the degree cannot be earned in CSCE 322 and CSCE 322H.

**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

**Offered:** FALL/SPR

**CSCE 335 Digital Logic Design**

**Crosslisted with:** ECEN 370

**Prerequisites:** ECEN 103 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 327; ECEN 333; ECEN 481; ECEN 483

**CSCE 336 Embedded Systems**

**Prerequisites:** A grade of "P" or "C" or better in CSCE 155E or 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:** 4

**Max credits per semester:** 4

**Max credits per degree:** 4

**Grading Option:** Graded with Option

**Offered:** SPRING

**Prerequisite for:** CSCE 488; CSCE 488H

**Course and Laboratory Fee:** \$40

**CSCE 351 System Resource Management**

**Crosslisted with:** ECEN 351

**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:** An introduction to management of computing resources, including CPUs, shared memory, I/O devices, address spaces, and threads of execution, with a focus on implementation.

**Credit Hours:** 3

**Max credits per semester:** 3

**Max credits per degree:** 3

**Grading Option:** Graded with Option

**Offered:** FALL

**Course and Laboratory Fee:** \$40

**CSCE 352 Exploring Virtual Reality**

**Prerequisites:** CSCE 155A/CSCE 155E/CSCE 155T/CSCE 155H, SOFT 160, RAIK 183H, or equivalent.

**Notes:** Requires familiarity with a high-level programming language.

**Description:** Introduction to designing, developing and producing virtual reality and immersive experiences. Work in interdisciplinary teams to produce a virtual reality/immersive project, game or storytelling experience.

**Credit Hours:** 3

**Max credits per semester:** 3

**Max credits per degree:** 3

**Grading Option:** Graded with Option

**CSCE 360 Software Security in Practice**

**Prerequisites:** A grade of "P" or "C" or higher in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H, or RAIK 283H

**Description:** Introduction to web application security risks and associated mitigation strategies, along with cloud-based resource management, and security basics on cloud application hosting.

**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 486H; CSCE 488; CSCE 488H**Course and Laboratory Fee:** \$20**CSCE 361H Software Engineering****Crosslisted with:** CSCE 361**Prerequisites:** Good Standing in UNL Honors Program or by invitation; 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 486H; CSCE 488; CSCE 488H**Course and Laboratory Fee:** \$20**CSCE 362 Fundamentals of Communication Systems****Prerequisites:** A grade of "P" or "C" or better in CSCE 230, CSCE 231 or CSCE 235.**Description:** Covers fundamentals of digital communication systems, in particular, various source and channel coding techniques and channel properties, and touches upon concepts from information theory that are used to determine and quantify transmission of information through a channel. Includes a comparison between analog and digital modulation techniques, with a special focus on the latter (e.g., PSK (BPSK, QPSK), PAM, QAM, FSK, etc.). Covers constellation mapping and detection techniques.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**Offered:** FALL/SPR**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**Prerequisite for:** BSAD 371H, RAIK 371H**CSCE 377 Fundamentals of Cybersecurity****Prerequisites:** A grade of "P" or "C" or better in CSCE 235 or CSCE 311 or RAIK 184H.**Description:** Introduction to security concepts, fundamental security properties, basic cryptographic building blocks, and their application to build secure protocols and systems.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**Offered:** FALL/SPR**Course and Laboratory Fee:** \$35**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:** STAT 380 or ECEN 305 recommended. Meeting ACE 1 and ACE 2 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**Course and Laboratory Fee:** \$20**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. Credit toward the degree cannot be earned in CSCE 378 and CSCE 378H.**Notes:** STAT 380/RAIK 270H or ECEN 305 recommended. Meeting ACE 1 and ACE 2 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 386 Practice and Professional Development: Design and Implementation**

**Prerequisites:** Grade of "Pass" or "C" in CSCE 311.

**Description:** Studies in data science practice and professional development. Data science topics include data-centric and model-driven approaches; information and knowledge structures, organization, and access; searching and mining; and visualization. Professional development involves instruction in career development, entrepreneurship, professional ethics, and professional communications.

**Credit Hours:** 3

**Max credits per semester:** 3

**Max credits per degree:** 3

**Grading Option:** Graded with Option

**Offered:** FALL

**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. Credit toward the degree cannot be earned in both CSCE 399 and CSCE 399H.

**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 284H/SOFT 261H 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

**Experiential Learning:** Case/Project-Based Learning

**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

**Experiential Learning:** Case/Project-Based Learning

**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

**Experiential Learning:** Case/Project-Based Learning

**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**Experiential Learning:** Case/Project-Based Learning**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 284H/SOFT 261H 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.**Description:** Outline of the general information retrieval problem, functional overview of information retrieval. Deterministic models of information retrieval systems; conventional Boolean, fuzzy set theory, p-norm, and vector space models. Probabilistic models. Text analysis and automatic indexing. Automatic query formulation. System-user adaptation and learning mechanisms. Intelligent information retrieval. Retrieval evaluation. Review of new theories and future directions. Practical experience with a working experimental information retrieval system.**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/SPR

**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**Course and Laboratory Fee:** \$40**CSCE 415 Computational Linguistics****Crosslisted with:** CSCE 815**Prerequisites:** Standing of junior class or above; one of CSCE 310, CSCE 311 or SOFT 260.**Description:** Covers the fundamentals of language modeling, parsing, machine translation, computational and statistical methods in comparative linguistics, laws of phonological change and language evolution, language families and script families, ancient scripts, computational methods for script comparison and the analysis of script evolution.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**Offered:** FALL/SPR**Prerequisite for:** CSCE 915**CSCE 417 Artificial Intelligence For Social Good****Crosslisted with:** CSCE 817**Prerequisites:** A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H. Graduate prerequisite CSCE 802.**Description:** Analyzes studies that address societal challenges through machine learning (ML) and, more broadly, artificial intelligence (AI). Focuses on selected research categorized under AI for Social Good (AI4SG), spanning areas such as agriculture, education, environmental sustainability, healthcare, social care, public safety, and transportation.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**Offered:** FALL/SPR**CSCE 420 Introduction to Natural Language Processing****Crosslisted with:** CSCE 820**Prerequisites:** A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H. Graduate prerequisite: CSCE 802.**Description:** Introduction to fundamental concepts and techniques in Natural Language Processing.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**Offered:** FALL/SPR**CSCE 421 Foundations of Constraint Processing****Crosslisted with:** CSCE 821**Prerequisites:** A grade of "P" or "C" or better in 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**Course and Laboratory Fee:** \$10**CSCE 422 Introduction to Computational Game Theory****Crosslisted with:** CSCE 822**Prerequisites:** A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H. Graduate prerequisite CSCE 802.**Description:** Introduction to essential tools for modeling and analyzing strategic interactions between self-interested agents. Covers key solution concepts used to predict decision-making behavior and examines the computational aspects of these solutions. Explores applications of game theory in areas such as security and social sciences.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**Offered:** SPRING**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 955**Course and Laboratory Fee:** \$20**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.**Description:** Turing machine model of computation: deterministic, nondeterministic, alternating, probabilistic. Complexity classes: Time and space bounded, deterministic, nondeterministic, probabilistic. Reductions and completeness. Complexity of counting problems. Non-uniformity. Lower bounds. Interactive proofs.**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**Course and Laboratory Fee:** \$20**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**Course and Laboratory Fee:** \$20**CSCE 429 Information Theory****Crosslisted with:** CSCE 829**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.**Description:** Deals with the foundations of information theory, as well as the more practical aspects of information coding. Information measures are first introduced, and then applied to the analysis of the theoretical performance achievable in data compression and propagation over noisy channels.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**Offered:** SPRING**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: 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**Prerequisite for:** CSCE 955**Course and Laboratory Fee:** \$20**CSCE 431 Hardware and Software Acceleration for Machine Learning****Crosslisted with:** CSCE 831**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:** Overview of the hardware and software acceleration techniques, including basics of deep learning, deep learning frameworks, hardware accelerators, co-optimization of algorithms and hardware, training and inference, support for state-of-the-art deep learning networks.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**Offered:** FALL**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 836

**Prerequisites:** A grade of "P" or "C" or better in CSCE 231, CSCE 336 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

**Course and Laboratory Fee:** \$40

**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

**Course and Laboratory Fee:** \$20

**CSCE 439 Robotics: Algorithms and Applications**

**Crosslisted with:** CSCE 839

**Prerequisites:** A grade of "P" or "C" or better in CSCE 231, CSCE 336 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

**Offered:** FALL/SPR

**Course and Laboratory Fee:** \$50

**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. Credit toward the degree may be earned in only one of the following: CSCE 440/MATH 440 and MECH 480

**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

**Course and Laboratory Fee:** \$20

**CSCE 443 Cybersecurity for Big Data, Cloud and Cryptocurrencies**

**Crosslisted with:** CSCE 843

**Prerequisites:** A grade of "P" or "C" or better in CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H.

**Notes:** Labs will be conducted on academic cloud and compute environments as well as public clouds.

**Description:** Covers the cybersecurity threat landscape and the mitigation strategies for Big Data, Cloud environments and Cryptocurrencies.

Discusses emerging technologies and frameworks such as End-to-end encryption, Blockchains, Smart Contracts, OpenID Connect and OAuth2.0 as promising solutions to ensure data confidentiality and privacy.

**Credit Hours:** 3

**Max credits per semester:** 3

**Max credits per degree:** 3

**Grading Option:** Graded with Option

**Offered:** FALL

**CSCE 445 Eye Tracking in Usability and Software Engineering**

**Crosslisted with:** CSCE 845

**Prerequisites:** SOFT 261 or CSCE 361.

**Description:** Create and evaluate new and existing human computer interfaces in the context of software engineering. Interdisciplinary applications of eye tracking in various areas of software engineering, biometrics, and psychology among others will be presented. Learn how to design, conduct, and analyze a technically sound eye tracking empirical study for software engineering problems in a group setting.

**Credit Hours:** 3

**Max credits per semester:** 3

**Max credits per degree:** 3

**Grading Option:** Graded with Option

**Offered:** SPRING

**CSCE 451 Operating Systems Principles****Crosslisted with:** CSCE 851**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:** Organization and structure of operating systems. Control, communication, and synchronization of concurrent processes. Processor and job scheduling. Memory organization and management including paging, segmentation, and virtual memory. Resource management. Deadlock avoidance, detection, recovery. File system concepts and structure. Protection and security. Substantial programming.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**Prerequisite for:** CSCE 455, CSCE 855**Course and Laboratory Fee:** \$20**CSCE 453H Honors: User Interfaces****Crosslisted with:** RAIK 453H**Prerequisites:** A grade of "P" or "C+" or higher in CSCE 156, CSCE 156H, CSCE 220, CSCE 311, RAIK 184H, SOFT 161, or SOFT 161H. Good standing in the University Honors Program.**Notes:** Enrolled students are expected to have advanced communication skills and a high commitment to conscientiousness. Students who are not in the University Honors Program but nonetheless meet these requirements may request permission of the instructor to enroll. Meeting ACE1 and ACE2 requirements prior to taking this course is recommended.**Description:** Introduction to the areas of user interfaces and user experience through reading and hands-on experiences. Areas covered include the psychology and physiology of design, the process of interface design, cultural values and accessibility, designing for beauty and delight, and dynamic evaluation strategies.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**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**Course and Laboratory Fee:** \$20**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**Course and Laboratory Fee:** \$10**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**Offered:** FALL/SPR

**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 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. Meeting ACE 1 and ACE 2 requirements prior to taking this course is recommended. Non-CSCE majors may discuss qualifications with 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

**Offered:** FALL/SPR

**CSCE 460 Software Engineering for Robotics**

**Crosslisted with:** SOFT 460, CSCE 860

**Prerequisites:** SOFT 261 or RAIK 284H 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

**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 284H.

**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

**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.

**Description:** Introduction to the architecture of communication networks and the rudiments of performance modeling. Circuit switching, packet switching, hybrid switching, protocols, local and metro area networks, wide area networks and the Internet, elements of performance modeling, and network programming. Network security, asynchronous transfer mode (ATM), optical, wireless, cellular, and satellite networks, and their performance studies.

**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 955

**Course and Laboratory Fee:** \$20

**CSCE 463 Data and Network Security**

**Crosslisted with:** CSCE 863, ECEN 487, ECEN 887

**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

**Offered:** SPRING

**CSCE 464 Internet Systems and Programming**

**Crosslisted with:** CSCE 864

**Prerequisites:** A grade of "Pass" 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

**Prerequisite for:** CSCE 954

**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 284H.

**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 284H.**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**Course and Laboratory Fee:** \$20**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 284H.**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 469 Secure Software Engineering****Crosslisted with:** SOFT 469, CSCE 869**Prerequisites:** SOFT 261, CSCE 361, RAIK 284H, or graduate standing.**Description:** Introduction to concepts, principles and state-of-the-art methods in creating and maintaining secure software systems.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**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**Course and Laboratory Fee:** \$20**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 "Pass" 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**Course and Laboratory Fee:** \$10**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**Course and Laboratory Fee:** \$40

**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

**Course and Laboratory Fee:** \$40

**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, data 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

**Course and Laboratory Fee:** \$50

**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/RAIK 270H or ECEN 305 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

**Course and Laboratory Fee:** \$50

**CSCE 480H Honors: Generative AI - Applications, Ethics, and Research**

**Crosslisted with:** RAIK 480H, CSCE 880

**Prerequisites:** Good standing in the University Honors Program; CSCE 320 or RAIK 370H. Familiarity with machine learning is recommended.

**Description:** Focuses on research and discussion to examine recent developments in and the implementations of Generative Artificial Intelligence (AI) systems. Covers ethical implications and potential broader impacts, while applying them to various domains, culminating in a class project. Specific concepts covered include core generative technologies ranging from variational autoencoders (VAEs), generative adversarial networks (GANs), and transformer-based models like large language models (LLMs) and diffusion image generation; key related concepts in terms of data considerations, model parameters and hyperparameters, finetuning and prompt engineering techniques; and practical use cases in terms of technology and industry through research paper reviews and case study discussions.

**Credit Hours:** 3

**Max credits per semester:** 3

**Max credits per degree:** 3

**Grading Option:** Graded with Option

**Offered:** FALL

**CSCE 484 Data Science Professional Development****Prerequisites:** CSCE 311**Description:** Preparation for the senior design project. Professional practice through familiarity with current tools, resources, and technologies. Professional standards, practices and ethics, and the oral and written report styles used specifically in the field of data science.**Credit Hours:** 3**Max credits per semester:** 3**Max credits per degree:** 3**Grading Option:** Graded with Option**Offered:** FALL**CSCE 486 Computer Science Professional Development****Prerequisites:** A grade of "Pass" or "C" or better in SOFT 261, SOFT 261H, CSCE 361, or CSCE 361H. JGEN 200.**Notes:** Must be taken exactly one semester before CSCE 487 or CSCE 487H.**Description:** Preparation for the senior design project. Professional practice through familiarity with current tools, resources, and technologies. Professional standards, practices and ethics, and the oral 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**Course and Laboratory Fee:** \$10**Experiential Learning:** Case/Project-Based Learning**CSCE 486H Honors Computer Science Professional Development****Prerequisites:** A grade of "Pass" or "C" or better in SOFT 261, SOFT 261H, CSCE 361, or CSCE 361H. JGEN 200. Credit toward the degree cannot be earned in CSCE 486 and CSCE 486H.**Notes:** Must be taken exactly one semester before CSCE 487 or CSCE 487H.**Description:** Preparation for the senior design project. Professional practice through familiarity with current tools, resources, and technologies. Professional standards, practices and ethics, and the oral 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**Offered:** FALL**Prerequisite for:** CSCE 487H**ACE:** ACE 8 Civic/Ethics/Stewardship**Experiential Learning:** Case/Project-Based Learning**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:** SOFT 403; SOFT 403H**ACE:** ACE 10 Integrated Product**Course and Laboratory Fee:** \$40**Experiential Learning:** Case/Project-Based Learning**CSCE 487H Honors Computer Science Senior Design Project****Prerequisites:** CSCE 486 or CSCE 486H. Credit toward the degree cannot be earned in both CSCE 487 and CSCE 487H.**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**Offered:** SPRING**Prerequisite for:** SOFT 403H**ACE:** ACE 10 Integrated Product**Experiential Learning:** Case/Project-Based Learning**CSCE 488 Computer Engineering Professional Development****Prerequisites:** CSCE 336; 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 or CSCE 489H.**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**Course and Laboratory Fee:** \$10**Experiential Learning:** Case/Project-Based Learning

**CSCE 488H Honors Computer Engineering Professional Development**

**Prerequisites:** CSCE 336; 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. Credit toward the degree cannot be earned in CSCE 488 and CSCE 488H.

**Notes:** Must be taken exactly one semester before CSCE 489 or CSCE 489H.

**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

**Offered:** FALL

**Prerequisite for:** CSCE 489H

**ACE:** ACE 8 Civic/Ethics/Stewardship

**Experiential Learning:** Case/Project-Based Learning

**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

**Course and Laboratory Fee:** \$40

**Experiential Learning:** Case/Project-Based Learning

**CSCE 489H Honors Computer Engineering Senior Design Project**

**Prerequisites:** CSCE 488 or CSCE 488H (taken exactly one semester previous). Credit toward the degree cannot be earned in both CSCE 489 and CSCE 489H.

**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

**Experiential Learning:** Case/Project-Based Learning

**CSCE 492 Special Topics in Computer Science**

**Crosslisted with:** CSCE 892

**Prerequisites:** CSCE 310/CSCE 310H, CSCE 311, SOFT 260/SOFT 260H/RAIK 283H, 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

**Course and Laboratory Fee:** \$40

**CSCE 492H Honors Special Topics in Computer Science**

**Prerequisites:** Permission. Credit toward the degree cannot be earned in both CSCE 492 and CSCE 492H.

**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 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

**Experiential Learning:** Case/Project-Based Learning

**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

**Experiential Learning:** Case/Project-Based Learning

**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

**Experiential Learning:** Internship/Co-op

**CSCE 498 Computer Problems**

**Crosslisted with:** CSCE 898

**Prerequisites:** Senior or graduate standing.

**Description:** Independent project executed under the guidance of a member of the faculty of the School of Computing. 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