Department of Computer Science

Undergraduate Majors (B.S.)

- Computer Science (p. 1)
- Networking and System Administration (p. 2)

Undergraduate Major (B.A.)

- Computer Science (p. 3)

Minor

- Computer Science (p. 4)
- Data Science (p. 4) (also listed in Department of Mathematics and Department of Physics)

Program Certificates

- Computer Science (p. 4)
- Computer Science Education (p. 4)

Notes:

1. Undergraduate students who have been admitted to the university provisionally because of non-satisfaction of the high school mathematics requirements may not enroll in any computer science credit course before this requirement has been met.

2. All courses counting toward a major or minor in the Department of Computer Science must be passed with a grade of C- or better.

3. Prerequisite courses in the Department of Computer Science must be passed with a grade of C before taking a subsequent course.

4. All majors in the Department of Computer Science require a project course (marked with asterisk in the degree statements). The course used to meet this requirement is to be taken in the area of specialization, i.e., an area in which at least three courses are taken.

5. All courses in a prerequisite chain to a course are considered regressive to it - students may not take them for credit after passing the later course. Additionally, CS 1120 (810:056), CS 1130 (810:057), CS 1160 (810:036), CS ED 1310, and CS ED 1320 are regressive to CS 1520 (810:052) and any course having it as prerequisite.

6. A student with a major in the Department of Computer Science cannot also receive a Computer Science minor.

7. A student with a major in the Department of Computer Science cannot also receive a Certificate in Computer Science.

Bachelor of Science Degree Programs

Computer Science Major

The B.S. Computer Science major requires a minimum of 126 total hours to graduate. This total includes Liberal Arts Core requirements and the following specified major requirements, plus electives to complete the minimum of 126 hours.

Required

<table>
<thead>
<tr>
<th>Computer Science:</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 1410 (810:041)</td>
</tr>
<tr>
<td>CS 1510 (810:051)</td>
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<tr>
<td>CS 1520 (810:052)</td>
</tr>
<tr>
<td>CS 1800 (810:080)</td>
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<tr>
<td>CS 2530 (810:053)</td>
</tr>
<tr>
<td>CS 3730/5730 (810:173g)</td>
</tr>
<tr>
<td>Research:</td>
</tr>
<tr>
<td>CS 4800 (810:180)</td>
</tr>
<tr>
<td>Electives</td>
</tr>
<tr>
<td>Mathematics:</td>
</tr>
<tr>
<td>Select four from the following:</td>
</tr>
<tr>
<td>MATH 1420 (800:060)</td>
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<tr>
<td>MATH 1421 (800:061)</td>
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<tr>
<td>MATH 2500 (800:076)</td>
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<tr>
<td>MATH 3440/5440 (800:176g)</td>
</tr>
<tr>
<td>MATH 3530/5530 (800:143g)</td>
</tr>
<tr>
<td>MATH 3752/5752 (800:152g)</td>
</tr>
<tr>
<td>STAT 1772 (800:072)</td>
</tr>
<tr>
<td>Computer Science:</td>
</tr>
<tr>
<td>Eight courses including:</td>
</tr>
<tr>
<td>A specialty of three courses from the Foundations area</td>
</tr>
<tr>
<td>A specialty of three courses from one other area</td>
</tr>
<tr>
<td>One course from each of the remaining two areas</td>
</tr>
<tr>
<td>One of the specialty areas must include a project course (marked with an asterisk *)</td>
</tr>
<tr>
<td>Foundations:</td>
</tr>
<tr>
<td>CS 3530 (810:153)</td>
</tr>
<tr>
<td>CS 3540 (810:154)</td>
</tr>
</tbody>
</table>
Mathematics:
MATH 1420 (800:060) Calculus I 4
MATH 1421 (800:061) Calculus II 4

Computer Science:
CS 1410 (810:041) Computer Organization 3
CS 1510 (810:051) Introduction to Computing 4
CS 1520 (810:052) Data Structures 4
CS 1800 (810:080) Discrete Structures 3
CS 3430/5430 (810:143g) Operating Systems 3
CS 3470/5470 (810:147g) Networking 3
CS 3730/5730 (810:173g) Project Management 1
CS 4400/5400 (810:140g) System Administration 3
CS 4410/5410 (810:141g) System Security 3
CS 4420 Applied Systems Forensics 3
CS 4800 (810:180) Undergraduate Research in Computer Science (1 hr.) 1

Physics:
PHYSICS 4300/5300 (880:152g) Introduction to Electronics 4

Choose ONE of the following sequences: 8
PHYSICS 1511 General Physics I (880:054)
PHYSICS 1512 General Physics II (880:056)

OR
PHYSICS 1701 (880:130) Physics I for Science and Engineering
PHYSICS 1702 (880:131) Physics II for Science and Engineering

Electives: 6

Two courses selected from among the Computer Science "area" courses and 2000-level or above courses meeting the Mathematics requirements.

Total Hours 62
### Bachelor of Arts Degree Programs

#### Computer Science Major

The B.A. Computer Science major requires a minimum of 120 total hours to graduate. This total includes Liberal Arts Core requirements and the following specified major requirements, plus electives to complete the minimum of 120 hours.

#### Required

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 1410 (810:041)</td>
<td>Computer Organization</td>
<td>3</td>
</tr>
<tr>
<td>CS 1510 (810:051)</td>
<td>Introduction to Computing</td>
<td>4</td>
</tr>
<tr>
<td>CS 1520 (810:052)</td>
<td>Data Structures</td>
<td>4</td>
</tr>
<tr>
<td>CS 1800 (810:080)</td>
<td>Discrete Structures</td>
<td>3</td>
</tr>
<tr>
<td>CS 2530 (810:053)</td>
<td>Intermediate Computing</td>
<td>3</td>
</tr>
<tr>
<td>CS 3730/5730</td>
<td>Project Management</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Electives

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1420 (800:060)</td>
<td>Calculus I ^,#</td>
<td>6</td>
</tr>
<tr>
<td>MATH 1421 (800:061)</td>
<td>Calculus II #</td>
<td></td>
</tr>
<tr>
<td>MATH 2500 (800:076)</td>
<td>Linear Algebra for Applications</td>
<td></td>
</tr>
<tr>
<td>MATH 3440/5440</td>
<td>Numerical Analysis</td>
<td></td>
</tr>
<tr>
<td>MATH 3530/5530</td>
<td>Combinatorics</td>
<td></td>
</tr>
<tr>
<td>MATH 3752/5752</td>
<td>Introduction to Probability</td>
<td></td>
</tr>
<tr>
<td>STAT 1772 (800:072)</td>
<td>Introduction to Statistical Methods</td>
<td></td>
</tr>
</tbody>
</table>

Computer Science: 18

Six courses including:

- Three courses from one specialty area

Total Hours 57

^ Has prerequisite of satisfactory score on ALEKS exam or subsequent remediation.

### Computer Science "area" courses and 2000-level or above courses meeting the Mathematics requirement.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>CS 3530 (810:153)</td>
<td>Design and Analysis of Algorithms</td>
<td></td>
</tr>
<tr>
<td>CS 3540 (810:154)</td>
<td>Programming Languages and Paradigms</td>
<td></td>
</tr>
<tr>
<td>CS 3810/5810 (810:181g)</td>
<td>Theory of Computation</td>
<td></td>
</tr>
<tr>
<td>CS 4550/5550 (810:155g)</td>
<td>Translation of Programming Languages *</td>
<td></td>
</tr>
<tr>
<td>CS 4880/5880 (810:188g)</td>
<td>Topics in Computer Science †</td>
<td></td>
</tr>
</tbody>
</table>

Data and Applications:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 3140/5140</td>
<td>Database Systems</td>
<td></td>
</tr>
<tr>
<td>CS 3150/5150 (810:115g)</td>
<td>Information Storage and Retrieval</td>
<td></td>
</tr>
<tr>
<td>CS 3610/5610 (810:161g)</td>
<td>Artificial Intelligence #</td>
<td></td>
</tr>
<tr>
<td>CS 3650/5650 (810:166g)</td>
<td>Computational Biology</td>
<td></td>
</tr>
<tr>
<td>CS 4620/5620 (810:162g)</td>
<td>Intelligent Systems *</td>
<td></td>
</tr>
<tr>
<td>CS 4880/5880 (810:188g)</td>
<td>Topics in Computer Science †</td>
<td></td>
</tr>
</tbody>
</table>

Software Engineering:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 2720 (810:172)</td>
<td>Software Engineering</td>
<td></td>
</tr>
<tr>
<td>CS 3120/5120 (810:112g)</td>
<td>User Interface Design</td>
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</tr>
<tr>
<td>CS 3750/5750 (810:175g)</td>
<td>Software Verification and Validation</td>
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</tr>
<tr>
<td>CS 4740/5740 (810:174g)</td>
<td>Real-Time Embedded Systems *,#</td>
<td></td>
</tr>
<tr>
<td>CS 4880/5880 (810:188g)</td>
<td>Topics in Computer Science †</td>
<td></td>
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</tbody>
</table>

Systems:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 2420 (810:142)</td>
<td>Computer Architecture and Parallel Programming</td>
<td></td>
</tr>
<tr>
<td>CS 3430/5430 (810:143g)</td>
<td>Operating Systems</td>
<td></td>
</tr>
<tr>
<td>CS 3470/5470 (810:147g)</td>
<td>Networking</td>
<td></td>
</tr>
<tr>
<td>CS 4400/5400 (810:140g)</td>
<td>System Administration</td>
<td></td>
</tr>
<tr>
<td>CS 4410/5410 (810:141g)</td>
<td>System Security *</td>
<td></td>
</tr>
<tr>
<td>CS 4420</td>
<td>Applied Systems Forensics *</td>
<td></td>
</tr>
<tr>
<td>CS 4880/5880 (810:188g)</td>
<td>Topics in Computer Science †</td>
<td></td>
</tr>
</tbody>
</table>

Electives 3

One course selected from among the Computer Science “area” courses and 2000-level or above courses meeting the Mathematics requirement.

Total Hours 45
Department of Computer Science

^ MATH 1420 (800:060) has prerequisite of MATH 1140 (800:046), or MATH 1110 (800:043) and MATH 1130 (800:044), or equivalent.

* A project course must be taken as one of the three in the specialty area.

# MATH 1420 (800:060), MATH 1421 (800:061), and CS 4740/5740 (810:174g) are 4-hour courses. CS 3610/5610 (810:161g) is a 4-hour course if taken with lab.

† CS 4880 may be counted in a specialty area with department approval for the specific topic.

Minors

Computer Science Minor

A student with a major in the Department of Computer Science cannot also receive a Computer Science minor.

Required
Computer Science:

- CS 1410 (810:041) Computer Organization 3
- CS 1510 (810:051) Introduction to Computing 4
- CS 1520 (810:052) Data Structures 4
- CS 1800 (810:080) Discrete Structures 3
- CS 2530 (810:053) Intermediate Computing 3

Electives

any Computer Science course that counts toward the Computer Science B.A. major 9

Total Hours 26

Data Science Minor

The Data Science minor is an interdisciplinary program that integrates computer programming, machine learning, statistics, predictive modeling and visualization to provide students with broad based skills for extracting gainful information from data that originate from a variety of sources. A final project (ideally with corporate or non-profit partnerships) will ensure that students employ their skills to solve a real-world problem.

Statistics:

- STAT 1772 (800:072) Introduction to Statistical Methods 3
- STAT 4784/5784 Introduction to Machine Learning 3

Computer Science:

- CS 1510 (810:051) Introduction to Computing 4
- CS 2150 Computing for Data Science 3-6
- or CS 1520 (810:052) Data Structures 4
- & CS 1800 (810:080) and Discrete Structures 3
- or CS 3140/5140 (810:114g) Database Systems 3

Physics:

- PHYSICS 4160/5160 Data Visualization, Modeling and Simulation 3

Required Data Science Project 2-3

CS 4800 (810:180) Undergraduate Research in Computer Science 4
- or MATH 4990 Undergraduate Research in Mathematics (800:195) 4
- or PHYSICS 3000 Undergraduate Research in Physics (880:180) 4

Total Hours 21-25

Program Certificates

The University of Northern Iowa makes available, in addition to traditional programs, the opportunity for students to earn program certificates. Program certificates provide an alternative to programs leading to a degree, a major, or a minor; they certify that an individual has completed a program approved by the university. For information on the following certificates, contact the Department of Computer Science or the Office of the Registrar, which serves as the centralized registry.

Certificate in Computer Science

A student with a major in the Department of Computer Science cannot also receive a Certificate in Computer Science.

Required

Computer Science:

- CS 1520 (810:052) Data Structures 4
- one course from the following: 3-4
  - CS 1120 (810:056) Media Computation
  - CS 1130 (810:030) Visual BASIC Programming
  - CS 1160 (810:036) C/C++ Programming
  - CS ED 1310 Programming Environments for Elementary Education
  - CS ED 1320 Fundamentals of Programming
  - CS 1510 (810:051) Introduction to Computing

Two courses, from ONE of the following groups: 6

Group 1:

- CS 1800 (810:080) Discrete Structures
- CS 2530 (810:053) Intermediate Computing

or Group 2:

- CS 1410 (810:041) Computer Organization
- CS 2420 (810:142) Computer Architecture and Parallel Programming

Total Hours 13-14

Certificate in Computer Science Education

This Computer Science Education certificate is appropriate for students interested in adding experience in computer science to a teaching license. It is for students with a teaching major in a discipline outside of computer science. It consists of the coursework approved by the Iowa Board of Educational Examiners to qualify for the addition of the state's Computer Science endorsement #278 on a state teaching license.

Required:

- CS ED 1320 Fundamentals of Programming 3
- CS ED 2310 Foundational Concepts in Computer Science 3
CS ED 3310/5310 Teaching and Learning Programming 3
CS ED 3320/5320 Data Structures and Algorithms 3
CS ED 4330/5330 Methods for Teaching Computer Science 3

Total Hours 15

Computer Science Education Courses

CS ED 1310. Programming Environments for Elementary Education — 3 hrs.
Introduction to computational thinking and computer programming. Taught as a survey of programming environments used by elementary education teachers. Topics include structure of programming and the study of several programming environments used by students at a variety of age/ability levels. Prerequisite(s): TEACHING 2017. (Fall and Spring)

Introduction to computer programming through a survey of programming environments used by teachers. Topics include structure of programming, study of several programming environments used by students at a variety of age/ability levels, and end-user programming for teachers. (Fall)

CS ED 2310. Foundational Concepts in Computer Science — 3 hrs.
Examine the breadth of the field of computer science beyond the programming of the computers. Topics include data storage and manipulation, computer organization, operating systems, networking and the Internet, software engineering, databases, and artificial intelligence. Give potential teachers a general introduction to commonly taught sub-disciplines in computer science so that they can have informed discussions with students before they study a topic more deeply. Prerequisite(s): TEACHING 2017. (Fall)

CS ED 3310/5310. Teaching and Learning Programming — 3 hrs.
Students will enhance their skill and understanding of programming while examining common programming problems, examples of bad/good code, and common misconceptions/difficulties. Students will examine common paradigms for teaching programming. Students will study broader challenges to learning such as broadening participation, understanding and avoiding bias, and best practices for classroom engagement. Prerequisite(s): CS ED 1320 or equivalent; TEACHING 2017; junior standing. (Spring)

CS ED 3320/5320. Data Structures and Algorithms — 3 hrs.
Introduction to the structure and application of common data structures used in computer science and the algorithms used with/for these structures. Includes an ongoing discussion on algorithm analysis. Also includes significant elements of algorithms, program design, techniques for data storage and retrieval, and data beyond a local text file. Prerequisite(s): CS ED 1320 or equivalent; CS ED 3310/5310; TEACHING 2017; junior standing. (Spring)

CS ED 4330/5330. Methods for Teaching Computer Science — 3 hrs.
Teaching approaches, instructional and assessment strategies, curricular and laboratory materials, and issues in secondary computer science. Students will develop a project, either in a classroom or during an after-school or similar experience that seeks to teach a section of the CS standards. Projects should stress inclusivity and appeal to a diverse group of students. Data will be collected about projects including demographics of participants, aggregate achievement, and analysis of student work samples. Prerequisite(s): CS ED 1320 or equivalent; CS ED 2310; CS ED 3310/5310; CS ED 3320/5320; TEACHING 3128; EDPSYCH 3148 (200:148); junior standing. (Spring)

Computer Science Courses

Introduction to operation, applications, implications of computers, microcomputers, and network communications. Develops skill in current applications and sensitizes students to societal issues related to computing. (Fall and Spring)

Explores use of computational tools to explore data sets, find patterns, and solve complex problems. Topics include representing problems, modeling data, simulating processes, and validating models, with applications in the sciences, social sciences, humanities, and business. (Fall and Spring)

CS 1100 (810:017). Web Development: Client-Side Coding — 3 hrs.
Client-side Web development adhering to recent/current Web standards. Includes by-hand Web page development involving basic HTML, CSS, data acquisition using forms, and JavaScript for data validation and simple Web-based tools. (Fall)

Introduction to computation, algorithmic thinking, data transformation and processing, and programming in the context of media such as images, sound, and video. (Spring)

Programming using the language Visual BASIC. Broad coverage of language syntax, programming practice, and programming problems appropriate to the novice or end-use programmer using a personal computer. (Fall and Spring)

Programming using the C and C++ languages including the object-oriented paradigm. Broad coverage of language syntax and programming practice. Appropriate for developers of general computing applications and systems. Course presumes no prior programming experience. (Fall)

Study of computers in terms of their major functional units. Machine representations of data, digital logic, memory, CPUs, buses, and input/output. Instruction set architectures and their implementations, addressing methods, and sequencing. Assembly language programming. Prerequisite(s) or corequisite(s): CS 1510 (810:051). (Fall and Spring)

CS 1510 (810:051). Introduction to Computing — 4 hrs.
Introduction to software development through algorithmic problem solving and procedural abstraction. Programming in the small. Fundamental control structures, data modeling, and file processing. Significant emphasis on program design and style. (Fall and Spring)

CS 1520 (810:052). Data Structures — 4 hrs.
Introduction to use and implementation of data and file structures such as sets, hashes, stacks, trees, queues, heaps, and graphs. Basic algorithm analysis. Searching and sorting. Basic object-oriented analysis, design, and modeling tools. Prerequisite(s): CS 1510 (810:051) or department approval. Prerequisite(s) or corequisite(s): CS 1800 (810:080) or department approval. (Fall and Spring)
Department of Computer Science

CS 1800 (810:080). Discrete Structures — 3 hrs.
Introduction to logical forms, arguments, predicates, and quantified statements; methods of proof; elementary number theory; counting; sequences; sets; functions; relations; graphs; and Boolean algebra in the context of computer science. Prerequisite(s): CS 1130 (810:030), CS 1160 (810:036), or CS 1510 (810:051). (Fall and Spring)

Development of interactive web sites; server-side scripting; database definition and use; site security; and additional topics as time allows. Prerequisite(s): CS 1100 (810:017) or consent of instructor. (Fall and Spring)

CS 2150. Computing for Data Science — 3 hrs.
Introduction to basic data and file structures for data science, such as sets, lists, matrices, and maps, and the algorithms that use them. Boolean algebra and its role in reasoning about data. Basics of the software development life cycle with emphasis on requirements and testing. Not available for credit to students with credit in CS 1800 (810:080) or CS 1520 (810:052). Prerequisite(s): CS 1510 (810:051); consent of department. (Spring)

Computer architecture of uniprocessor and multiprocessor systems with an emphasis on parallel programming to achieve high performance. Topics include processor design (pipelining and superscalar), memory hierarchy, interconnection networks, performance metrics, parallel program design, and parallel programming tools for multi-core systems, clusters, and graphics processing units. Prerequisite(s): CS 1410 (810:041). (Fall)

Intermediate software development in an object-oriented environment. Further experience with object-oriented analysis and design, including modeling languages. Focus on software reuse through frameworks and patterns and on software development methodology and tools. Prerequisite(s): CS 1510 (810:051); CS 1520 (810:052); CS 1800 (810:080); or department approval. (Fall and Spring)

Study of software life cycle models and their phases—planning, requirements, specifications, design, implementation, testing, and maintenance. Emphasis on tools, documentation, and applications. Prerequisite(s): CS 1520 (810:052); CS 1800 (810:080). (Fall and Spring)

Topics from recent developments in computing appropriate to students with limited computer science background, often relating to relatively sophisticated or technical use of computing or recent developments in programming. May be repeated on different topic. (Variable)

CS 3110. Web Application Development — 3 hrs.
Development of web applications such as content management systems. Involves HTML and CSS coding, client- and server-side scripting, the creation and manipulation of databases to generate web pages, and secure authentication of users. Prerequisite(s): CS 1520 (810:052); CS 1100 (810:017) or COMM 2555 (48C:025). (Variable)

CS 3120/5120 (810:112g). User Interface Design — 3 hrs.
Examination of the theory, design, programming, and evaluation of interactive application interfaces. Topics include human capabilities and limitations, the interface design and engineering process, prototyping and interface construction, interface evaluation, and possibly topics such as data visualization and the World Wide Web. Prerequisite(s): for Computer Science majors: CS 1520 (810:052); CS 1800 (810:080); junior standing. Prerequisite(s) for non-Computer Science majors: junior standing; department approval. (Variable)

CS 3140/5140 (810:114g). Database Systems — 3 hrs.
Storage of, and access to, physical databases; data models, query languages, transaction processing, and recovery techniques; object-oriented and distributed database systems; and database design. Prerequisite(s): CS 1520 (810:052); CS 1800 (810:080); junior standing. Prerequisite(s) for Data Science minors: CS 2150; junior standing. (Fall)

CS 3150/5150 (810:115g). Information Storage and Retrieval — 3 hrs.
Natural language processing; analysis of textual material by statistical, syntactic, and logical methods; retrieval systems models, dictionary construction, query processing, file structures, content analysis; automatic retrieval systems and question-answering systems; and evaluation of retrieval effectiveness. Prerequisite(s): CS 1520 (810:052); CS 1800 (810:080); junior standing. (Spring)

Application of classroom learning to field experience. Credit may not be applied to major or minor. Offered on credit/no credit basis only. May be retaken for up to six credits total. (Fall and Spring)

CS 3340/5340 (810:143g). Operating Systems — 3 hrs.
History and evolution of operating systems; process and processor management; primary and auxiliary storage management; performance evaluation, security, and distributed systems issues; and case studies of modern operating systems. Prerequisite(s): CS 1410 (810:041); CS 1520 (810:052); CS 1800 (810:080); junior standing. (Spring)

CS 3470/5470 (810:147g). Networking — 3 hrs.
Network architectures and communication protocol standards. Topics include communication of digital data, data-link protocols, local-area networks, network-layer protocols, transport-layer protocols, applications, network security, and management. Prerequisite(s): CS 1410 (810:041); CS 1520 (810:052); CS 1800 (810:080); junior standing. Prerequisites for Department of Technology majors: TECH 1037 (330:037); TECH 2041 (330:041); TECH 2042 (330:042); CS 1160 (810:036). (Fall)

CS 3510 (810:151). Topics in Programming — 1 hr.
Quick study of a specified programming language or environment for those with considerable programming experience. Language syntax and semantics, common problems solved using it, and best practices. May be repeated with different topics. Prerequisite(s): CS 1520 (810:052); CS 1800 (810:080). (Spring)

Algorithm design techniques such as dynamic programming and greedy algorithms; complexity analysis of algorithms; efficient algorithms for classical problems; intractable problems and techniques for addressing them; and algorithms for parallel machines. Prerequisite(s): CS 1520 (810:052); CS 1800 (810:080). (Variable)

CS 3540 (810:154). Programming Languages and Paradigms — 3 hrs.
Organization of programming languages; language design issues including syntax, data types, sequence control, and storage management; comparison of language features from object-oriented, imperative, functional, and logical paradigms. Prerequisite(s): CS 1520 (810:052); CS 1800 (810:080); junior standing. (Spring)

CS 3610/5610 (810:161g). Artificial Intelligence — 3 hrs.
Models of intelligent behavior and problem solving; knowledge representation and search methods; learning; topics such as
knowledge-based systems, language understanding, and vision. Prerequisite(s): CS 1520 (810:052); CS 1800 (810:080); junior standing. (Fall)

**CS 3650/5650 (810:166g). Computational Biology — 3 hrs.**
Applications of computer science techniques to biological problems; introduction to computational DNA and protein sequence analysis; dynamic programming; optimal alignment algorithms; DNA sequencing and fragment assembly; gene expression arrays; clustering algorithms; evolutionary trees; multiple alignments; hidden Markov models. Prerequisite(s): CS 1520 (810:052) and CS 1800 (810:080); junior standing. (Spring)

**CS 3730/5730 (810:173g). Project Management — 1 hr.**
Examination of problems of organizing, controlling, managing, and evaluating a software project: software metrics and human input. Prerequisite(s): For Networking and System Administration majors: junior standing. For all other majors: CS 2530 (810:053); junior standing. (Fall and Spring)

**CS 3750/5750 (810:175g). Software Verification and Validation — 3 hrs.**
Taxonomy of software defects and approaches to identifying them, including black box testing, functional testing, control flow testing, data flow testing, software inspection. Introduction to use of static analysis in development of high integrity software. Prerequisite(s): CS 2720 (810:172); junior standing. (Variable)

**CS 3810/5810 (810:181g). Theory of Computation — 3 hrs.**
Topics include regular languages and grammars; finite state automata; context-free languages and grammars; language recognition and parsing; and Turing computability and undecidability. Prerequisite(s): CS 1800 (810:080); junior standing. (Variable)

**CS 4400/5400 (810:140g). System Administration — 3 hrs.**
Major concepts and mechanisms associated with computer system administration. Focus on issues surrounding user management, the configuration of services, and the coordination of distributed resources. Prerequisite(s): CS 3470/5470 (810:147g); junior standing. (Variable)

**CS 4410/5410 (810:141g). System Security — 3 hrs.**
Topics include the need for security services, data integrity, network intrusion and monitoring, configuration of secure services, rootkits, and buffer overflow techniques and remedies. Additional topics include enterprise-wide monitoring, honeypots, and recognizing trends in a networked environment. Prerequisite(s): CS 3470/5470 (810:147g); junior standing. Prerequisite(s) or corequisite(s): CS 3730/5730 (810:173g). (Variable)

**CS 4420. Applied Systems Forensics — 3 hrs.**
Essentials of applied computer system forensics; evidence preserving techniques; reconstruction of storage volumes and deleted volumes and files; identification of evidence in computer memory; encryption; log analysis; generation of forensic reports. Topics are covered in the context of incidence response to compromised systems. Prerequisite(s): CS 1410 (810:041); CS 1520 (810:052); CS 1800 (810:080); CS 3430/5430 (810:143g).

**CS 4550/5550 (810:155g). Translation of Programming Languages — 3 hrs.**
Introduction to analysis of programming languages and construction of translators. Prerequisite(s): CS 2530 (810:053) and one of the following: CS 3530 (810:153), CS 3540 (810:154), CS 3810/5810 (810:181g); junior standing. Prerequisite(s) or corequisite(s): CS 3730/5730 (810:173g). (Variable)

**CS 4620/5620 (810:162g). Intelligent Systems — 3 hrs.**
Design and implementation of programs that apply artificial intelligence techniques to problems such as design, diagnosis, and distributed problem solving. Emphasis on team design and development of large systems. Prerequisite(s): CS 2530 (810:053); CS 3610/5610 (810:161g) or equivalent; junior standing. Prerequisite(s) or corequisite(s): CS 3730/5730 (810:173g). (Variable)

**CS 4740/5740 (810:174g). Real-Time Embedded Systems — 3 hrs.**
Specification, design, and implementation principles and techniques for real-time embedded systems. Topics include programming languages and paradigms, reliability and fault tolerance, concurrent programming, scheduling, and the interaction between hardware and software. Student teams will complete a significant real-time embedded software project. Prerequisite(s): CS 2530 (810:053); CS 2720 (810:172); junior standing. Prerequisite(s) or corequisite(s): CS 3730/5730 (810:173g). (Fall)

**CS 4800 (810:180). Undergraduate Research in Computer Science — 1-3 hrs.**
May be repeated for maximum of 6 hours. (Fall and Spring)

**CS 4880/5880 (810:188g). Topics in Computer Science — 3 hrs.**
Topics of general interest from any area of computer science, including systems, software, or theory. Can be counted in any specialization area, with department approval for individual topics. Prerequisite(s): CS 1520 (810:052); CS 1800 (810:080); junior standing. (Variable)

**CS 6140 (810:214). Database Management Systems — 3 hrs.**
Database system concepts, physical data organization, the network model and the DBTG Proposal, the hierarchical model, the relational model, relational query languages, design theory of relational databases, query optimization, and normalization. Prerequisite(s): consent of instructor. (Variable)

**CS 6400 (810:240). Computer Systems — 3 hrs.**
Survey of issues in computer system analysis and design. Emphasis on relationship between system hardware and software including tools and environments for software development on parallel and distributed computer systems. Prerequisite(s): for Computer Science majors: CS 2420 (810:142) or CS 3430/5430 (810:143g). Prerequisite(s) for non-Computer Science majors: proficiency in a high-level programming language; consent of instructor. (Variable)

**CS 6500 (810:270). Algorithms — 3 hrs.**
Survey of analysis and design of algorithms. Topics include algorithm design techniques, efficient algorithms for classical problems, and intractable problems and techniques for solving them. Prerequisite(s): CS 3530 (810:153). (Variable)

**CS 6800 (810:280). Theoretical Foundations of Computing — 3 hrs.**
Survey of theoretical models of computation and basic theory of computability. Topics include Turing machines, undecidability, NP-completeness, and computational complexity. Consideration of applications of theory to contemporary problems in computing. Prerequisite(s): CS 3810/5810 (810:181g). (Variable)