COMPUTER SCIENCE

Chair
John Glick, PhD

Faculty
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John Glick, PhD
Mark Heckman, PhD
Eric Jiang, PhD
Gordon Romney, PhD

Computer science is the system of principles and theory which deals with what computers do. It studies the nature of computation. For any given problem, it asks whether the answer can be computed, and, if so, what are the most efficient and practical ways to do the computation. (Often the methods that are best for machines are quite different from those that are practical for human beings.)

Computers are machines that manipulate abstract symbols according to specified rules. Therefore, computer science relies heavily on abstract reasoning and mathematics. The mathematics involved is usually quite different, however, from traditional mathematics. Much of it has been developed recently in response to the development of computers.

As an academic discipline within the liberal arts tradition, computer science has ties with many other disciplines. The natural sciences provide the physical principles upon which computers are built. Computer science serves the sciences, engineering and business in providing the means to perform complex calculations and to analyze large amounts of data. Psychology and philosophy share with computer science the desire to understand the nature of reason, language and intelligence.

The most important skills needed by a prospective computer scientist are an excellent command of one’s native language and the ability to think in a mathematical way.

The Computer Science Major (BS)

Preparation for the Major

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>COMP 110</td>
<td>Computational Problem Solving</td>
<td>3.5</td>
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<tr>
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<td>4</td>
</tr>
<tr>
<td>MATH 262</td>
<td>Discrete Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>or MATH 260</td>
<td>Foundations of Higher Mathematics</td>
<td></td>
</tr>
<tr>
<td>MATH 320</td>
<td>Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>ISYE 330</td>
<td>Engineering Probability and Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Natural Science</td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

Total Units: 37

Notes:
1) At least 15 of the upper-division units in the major must be completed at USD.
2) Permission from the chair of computer science and the dean of the Shiley-Marcos School of Engineering is required before enrolling in CYBR 501 or CYBR 502.
3) Students may not receive credit towards their undergraduate degree for both COMP 365 and CYBR 501 or CYBR 502.

Major Requirements

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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</tr>
</thead>
<tbody>
<tr>
<td>COMP 305</td>
<td>Object-Oriented Design and Programming</td>
<td>3</td>
</tr>
<tr>
<td>COMP 370</td>
<td>Automata, Computability and Formal Languages</td>
<td>3</td>
</tr>
<tr>
<td>COMP 480</td>
<td>Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>COMP 491</td>
<td>Senior Project I</td>
<td>3</td>
</tr>
<tr>
<td>COMP 492</td>
<td>Senior Project II</td>
<td>3</td>
</tr>
</tbody>
</table>

Systems Courses

Select one of the following courses:

- COMP 300 Principles of Digital Hardware
- COMP 310 Operating Systems
- COMP 375 Networking

Upper-Division Elective Courses

Select nine upper-division units from the following:

- COMP 340 Numerical Analysis
- COMP 341 Numerical Analysis II
- COMP 345 Database Management Systems Design
- COMP 350 Computer Graphics
- COMP 360 Principles of Programming Languages
- COMP 365 Principles of Information Security
- COMP 380 Neural Networks
- COMP 382 Introduction to Data Mining
- COMP 421 Embedded Software Development
- COMP 422 Advanced Embedded Software Development
- COMP 494 Special Topics in Computer Science
- COMP 499 Independent Study
- CYBR 501 Introduction to Cybersecurity Concepts and Tools
- CYBR 502 Cybersecurity Network Defense

Total Units: 31

Additional Requirements:

All computer science majors must satisfy the core curriculum specified by the university and the Connect Career Readiness Program (https://www.sandiego.edu/engineering/resources/careers/connect).
**Recommended Program of Study: Computer Science (BS)**

**First Year**

**Semester I**
- COMP 110: Computational Problem Solving 3.5
- MATH 150: Calculus I 4
- Core Curriculum 9

**Semester II**
- COMP 120: Programming Abstractions and Methodologies 3.5
- MATH 151: Calculus II 4
- MATH 262: Discrete Mathematics 3
- Core Curriculum and Electives 6

**Second Year**

**Semester I**
- COMP 280: Introduction to Computer Systems 3.5
- ISYE 330: Engineering Probability and Statistics 3
- Core Curriculum 9-11.5

**Semester II**
- COMP 230: Advanced Computational Problem Modeling 3.5
- COMP Systems Course 3.5
- MATH 320: Linear Algebra 3
- Core Curriculum and Electives 6.5-8.5

**Third Year**

**Semester I**
- COMP 305: Object-Oriented Design and Programming 3
- COMP Systems Course or Upper-Division COMP Elective 3-3.5
- Core Curriculum and Electives 9-12

**Semester II**
- COMP 480: Algorithms 3
- COMP Systems Course or Upper-Division COMP Elective 3-3.5
- Upper-Division COMP Elective 3
- Core Curriculum and Electives 6

**Senior Year**

**Semester I**
- COMP 491: Senior Project I 3
- COMP 370: Automata, Computability and Formal Languages 3
- Core Curriculum and Electives 9-12

**Semester II**
- COMP 492: Senior Project II 3
- Upper-Division COMP Elective 3
- Core Curriculum and Electives 9-12

### Concentrations in Computer Science (9 - 9.5 units)

Concentrations allow majors to develop a level of depth in a particular area of computer science. Courses taken toward a concentration may also apply to the upper-division elective requirements of the major. Concentrations are optional, and so are not required by the computer science major. Participation in the cyber security concentration requires approval of the chair of computer science and the dean of the Shiley-Marcos School of Engineering.

#### Concentration in Embedded Software Development
- COMP 421: Embedded Software Development 3
- COMP 422: Advanced Embedded Software Development 3
- One of the following courses: 3-3.5
  - COMP 365: Principles of Information Security
  - COMP 375: Networking

Total Units 9-9.5

#### Concentration in Cyber Security
- CYBR 501: Introduction to Cybersecurity Concepts and Tools 3
- CYBR 502: Cybersecurity Network Defense 3
- One of the following: 3-3.5
  - COMP 375: Networking
  - An additional CYBR course

Total Units 9-9.5

Notes:
1) Permission from the chair of computer science and the dean of the Shiley-Marcos School of Engineering is required before enrolling in 500-level CYBR courses.
2) Students applying COMP 375 to the Embedded Software Development, or Cyber Security concentration may not use COMP 375 to also satisfy the systems course requirement in the computer science major.
3) Students completing the Cyber Security concentration by taking nine units of 500-level CYBR classes must be enrolled in the Combined Undergraduate Computer Science and MS in Cyber Security Engineering program at the time the third CYBR course is taken.

**Combined BS or BA Computer Science and Master of Science in Cyber Security Engineering (MSCSE) Program**

A student who has applied, accepted, and indicated that they will enter the MSCSE program, can apply up to twelve 500-level CYBR units to both their undergraduate degree requirements in Computer Science, and to the requirements of the MSCSE program. Those units shall include CYBR 501 and CYBR 502, and any of the following CYBR courses: 503, 504, 506, 508, 510, and 512.

The MSCSE program requires 30 units (computer science majors do not need to take a 6-unit course in software, operating systems, and networking fundamentals that would bring the unit count to 36), and MSCSE students take 6 units per semester. So a student who completes 12 units as an undergraduate can complete the remaining 18 units in three terms (summer, fall, and spring). Thus, a student can earn a BS or BA in computer science plus an MS in Cyber Security Engineering in 4 years of undergraduate coursework plus 1 year of graduate coursework.

### The Computer Science Major (BA)

**Preparation for the Major**

**Required Courses**
- COMP 110: Computational Problem Solving 3.5
- COMP 120: Programming Abstractions and Methodologies 3.5
- COMP 230: Advanced Computational Problem Modeling 3.5
- COMP 280: Introduction to Computer Systems 3.5
- MATH 150: Calculus I 4
- MATH 260: Foundations of Higher Mathematics 3
Computer Science

Elective Math Course
Select one of the following:  
<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISYE 330</td>
<td>Engineering Probability and Statistics</td>
<td>3</td>
</tr>
<tr>
<td>MATH 320</td>
<td>Linear Algebra</td>
<td>3</td>
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</tbody>
</table>

Total Units 24

Major Requirements

<table>
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<tr>
<td>COMP 491</td>
<td>Senior Project I</td>
<td>3</td>
</tr>
<tr>
<td>COMP 492</td>
<td>Senior Project II</td>
<td>3</td>
</tr>
</tbody>
</table>

Systems Course
Select one of the following courses:  
<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP 300</td>
<td>Principles of Digital Hardware</td>
<td></td>
</tr>
<tr>
<td>COMP 310</td>
<td>Operating Systems</td>
<td></td>
</tr>
<tr>
<td>COMP 375</td>
<td>Networking</td>
<td></td>
</tr>
</tbody>
</table>

Upper-Division Elective Courses
Select nine upper-division units from the following:  
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<thead>
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<th>Code</th>
<th>Title</th>
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<tbody>
<tr>
<td>COMP 340</td>
<td>Numerical Analysis</td>
<td></td>
</tr>
<tr>
<td>COMP 341</td>
<td>Numerical Analysis II</td>
<td></td>
</tr>
<tr>
<td>COMP 345</td>
<td>Database Management Systems Design</td>
<td></td>
</tr>
<tr>
<td>COMP 350</td>
<td>Computer Graphics</td>
<td></td>
</tr>
<tr>
<td>COMP 360</td>
<td>Principles of Programming Languages</td>
<td></td>
</tr>
<tr>
<td>COMP 365</td>
<td>Principles of Information Security</td>
<td></td>
</tr>
<tr>
<td>COMP 370</td>
<td>Automata, Computability and Formal Languages</td>
<td></td>
</tr>
<tr>
<td>COMP 380</td>
<td>Neural Networks</td>
<td></td>
</tr>
<tr>
<td>COMP 382</td>
<td>Introduction to Data Mining</td>
<td></td>
</tr>
<tr>
<td>COMP 421</td>
<td>Embedded Software Development</td>
<td></td>
</tr>
<tr>
<td>COMP 422</td>
<td>Advanced Embedded Software Development</td>
<td></td>
</tr>
<tr>
<td>COMP 494</td>
<td>Special Topics in Computer Science</td>
<td></td>
</tr>
<tr>
<td>COMP 499</td>
<td>Independent Study</td>
<td></td>
</tr>
<tr>
<td>CYBR 501</td>
<td>Introduction to Cybersecurity Concepts and Tools</td>
<td></td>
</tr>
<tr>
<td>CYBR 502</td>
<td>Cybersecurity Network Defense</td>
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Total Units 24.5

Notes:
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3) Students may not receive credit towards their undergraduate degree for both COMP 365 and CYBR 501 or CYBR 502.

Additional Requirements:
All computer science majors must satisfy the core curriculum specified by the university and the Connect Career Readiness Program (https://www.sandiego.edu/engineering/resources/careers/connect).

Recommended Program of Study: Computer Science (BA)

First Year

<table>
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<th>Semester I</th>
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<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>COMP 110</td>
<td>Computational Problem Solving</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>MATH 150</td>
<td>Calculus I</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Core Curriculum</td>
<td></td>
<td>9</td>
<td></td>
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</table>

Second Year

<table>
<thead>
<tr>
<th>Semester I</th>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP 120</td>
<td>Programming Abstractions and Methodologies</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>Core Curriculum</td>
<td></td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>MATH 262</td>
<td>Discrete Mathematics</td>
<td>3</td>
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<tr>
<td>or 260</td>
<td>Foundations of Higher Mathematics</td>
<td></td>
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Third Year

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<th>Semester I</th>
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<th>Title</th>
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<tbody>
<tr>
<td>COMP 280</td>
<td>Introduction to Computer Systems</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>ISYE 330</td>
<td>Engineering Probability and Statistics</td>
<td>3</td>
<td></td>
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<td>or MATH 320</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Core Curriculum and Electives</td>
<td></td>
<td>12-14.5</td>
<td></td>
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Senior Year

<table>
<thead>
<tr>
<th>Semester I</th>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP 491</td>
<td>Senior Project I</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Upper-Division COMP Elective</td>
<td></td>
<td>3</td>
<td></td>
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<td>Core Curriculum and Electives</td>
<td></td>
<td>9-12</td>
<td></td>
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<table>
<thead>
<tr>
<th>Semester II</th>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP 492</td>
<td>Senior Project II</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Upper-Division COMP Elective</td>
<td></td>
<td>3</td>
<td></td>
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<td>Core Curriculum and Electives</td>
<td></td>
<td>9-12</td>
<td></td>
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Concentrations in Computer Science (9 - 9.5 units)

Concentrations allow majors to develop a level of depth in a particular area of computer science. Courses taken toward a concentration may also apply to the upper-division elective requirements of the major. Concentrations are optional, and so are not required by the computer science major. Participation in the cyber security concentration requires approval of the chair of computer science and the dean of the Shiley-Marcos School of Engineering.

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<tbody>
<tr>
<td>COMP 421</td>
<td>Embedded Software Development</td>
<td>3</td>
</tr>
<tr>
<td>COMP 422</td>
<td>Advanced Embedded Software Development</td>
<td>3</td>
</tr>
<tr>
<td>One of the following courses:</td>
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<td>COMP 422</td>
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<td>3</td>
</tr>
<tr>
<td>One of the following courses:</td>
<td></td>
<td>3-3.5</td>
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Additional Requirements:
All computer science majors must satisfy the core curriculum specified by the university and the Connect Career Readiness Program (https://www.sandiego.edu/engineering/resources/careers/connect).
The information science minor is intended for students who have a special interest in the analysis, design, implementation, and use of computer-based information systems and organizations. Minimum requirements for the minor in information science are:

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<td>COMP 230</td>
<td>Advanced Computational Problem Modeling</td>
<td>3.5</td>
</tr>
<tr>
<td>ITMG 350</td>
<td>Management Information Systems</td>
<td>3</td>
</tr>
</tbody>
</table>

Nine additional units \(^1\)

Notes:
1. At least 6 of which are in upper division courses chosen from:
   1. the computer science offerings listed in this course catalog, excluding COMP 100 and COMP 498. COMP 345 is highly recommended.
   2. ITMG 350 Management Information Systems

Comp 100 | INTRODUCTORY COMPUTER PROGRAMMING
Units: 3 Repeatability: No
An elementary introduction to computer programming and applications for non-majors and non-minors. Computer organization; problem solving; algorithms; structured programming in a simple computer language; computer applications; and current issues and trends in computer science. This course does not satisfy any of the requirements for the computer science major or minor and is not a substitute for COMP 150.

COMP 110 | COMPUTATIONAL PROBLEM SOLVING
Units: 3.5 Repeatability: No
Prerequisites: MATH 115 with a minimum grade of C- or MATH 150 or MATH 151
An introduction to computational problem solving using the Python programming language. Students will learn the basic elements of programming (e.g. conditionals, loops, inputs/outputs), modular program design, and the basics of data abstraction through object-oriented programming.

COMP 120 | PROGRAMMING ABSTRACTIONS AND METHODOLOGIES
Units: 3.5 Repeatability: No
Prerequisites: COMP 110 with a minimum grade of C-
A continued exploration of computational problem solving, with a focus on using abstraction to manage program complexity. Students will learn to use both functional and data abstractions, analyze the time and space complexity of algorithms, and utilize functional, object-oriented, and event-driven paradigms within their programs.

COMP 150 | COMPUTER PROGRAMMING I
Units: 3
Prerequisites: MATH 115 with a minimum grade of C- or Passing the appropriate departmental placement test within the previous year or MATH 130 with a minimum grade of C- or MATH 150 with a minimum grade of C-
Algorithms and programming in a selected computer language; expressions, statements, basic data types; sequence, decision, iteration; functions and procedures; arrays; recursion; file input and output; loop invariants; syntax analysis; and program design, documentation, validation, and debugging. Prereq: MATH 115 with a minimum grade of C-, or pass Level 2 mathematics placement exam. COMP 100 is not a prerequisite.
COMP 151 | COMPUTER PROGRAMMING II
Units: 3 Repeatability: No
Prerequisites: COMP 150 with a minimum grade of C-
Continuation of COMP 150. Basic data structures, including lists, stacks, queues, and binary trees; abstract data types; sorting and searching algorithms; exception handling; event driven programming.

COMP 160 | PROGRAMMING LANGUAGES
Units: 1-3 Repeatability: Yes (Can be repeated for Credit)
Prerequisites: COMP 110 with a minimum grade of C-
Introduction to a particular high-level programming language such as C, C++, Java, Ruby, MATLAB, and Maple. Programming assignments appropriate to the language studied. This course does not satisfy any of the requirements for the major in computer science.

COMP 230 | ADVANCED COMPUTATIONAL PROBLEM MODELING
Units: 3.5 Repeatability: No
Prerequisites: (COMP 120 with a minimum grade of C- or COMP 151 with a minimum grade of C-) and (MATH 160 with a minimum grade of C- or MATH 260 with a minimum grade of C- or MATH 222 with a minimum grade of C- or MATH 262 with a minimum grade of C-)
Advanced data structures (e.g. graphs, priority queues, quad trees, etc.) from the perspective of solving advanced computational problems. Students will learn to program in the Java programming language using object-oriented features such as inheritance, interfaces and generics.

COMP 280 | INTRODUCTION TO COMPUTER SYSTEMS
Units: 3.5 Repeatability: No
Prerequisites: COMP 120 with a minimum grade of C- or COMP 151 with a minimum grade of C-
Introduction to computer systems; data representation; machine/assembly languages; memory organization; virtual memory; and concurrency.

COMP 285 | DATA STRUCTURES & ALGORITHMS
Units: 3
Prerequisites: (COMP 151 with a minimum grade of C- and MATH 160 with a minimum grade of C-)
Data structures, algorithm analysis and general programming design and applications; balanced trees, hashing, priority queues, sets, and graphs; more on sorting and searching; Prerequisite: COMP 151 with a grade of C- or better and MATH 160 with a grade of C- or better.

COMP 294 | SPECIAL TOPICS IN COMPUTER SCIENCE
Units: 1-4 Repeatability: Yes (Can be repeated for Credit)
Special topics course in areas of special interest to computer science. May be repeated for credit with a different topic.

COMP 299 | INDEPENDENT STUDY
Units: 1-3 Repeatability: Yes (Can be repeated for Credit)
Individual study including library or laboratory research or program writing. A written report is required. Project proposal must be submitted and approved prior to enrollment. May be repeated for credit.

COMP 300 | PRINCIPLES OF DIGITAL HARDWARE
Units: 3.5 Repeatability: No
Prerequisites: MATH 160 with a minimum grade of C- and COMP 280 with a minimum grade of C-
Combinational and sequential logic, registers, arithmetic units. Introduction to computer architecture. Three lectures and one laboratory per week.

COMP 305 | OBJECT-ORIENTED DESIGN AND PROGRAMMING
Units: 3 Repeatability: No
Prerequisites: COMP 230 with a minimum grade of C- or COMP 285 with a minimum grade of C-
Classes, encapsulation, inheritance, polymorphism, class derivation, abstract classes, namespaces, function overloading and overriding, function name overload resolution, container classes, template classes; unified modeling language (UML); constructing conceptual models, system sequence diagrams; design patterns; case studies.

COMP 310 | OPERATING SYSTEMS
Units: 3.5 Repeatability: No
Prerequisites: COMP 280 with a minimum grade of C-
Principles of computer operating systems; process management; memory management; file systems; protection; deadlock. Concurrent programming.

COMP 340 | NUMERICAL ANALYSIS
Units: 3 Repeatability: No
Prerequisites: (COMP 110 with a minimum grade of C- or MATH 150 with a minimum grade of C-) and (MATH 151 with a minimum grade of C-
Approximate computations and round-off errors; Taylor expansions; numerical solution of equations and systems of equations; systems of linear equations; numerical integration; numerical solution of differential equations; interpolation; and problem solving on the computer.

COMP 341 | NUMERICAL ANALYSIS II
Units: 3
Prerequisites: (COMP 110 with a minimum grade of C- or MATH 150 with a minimum grade of C- and MATH 320 with a minimum grade of C- and MATH 330 with a minimum grade of C-) and (COMP 230 with a minimum grade of C- or COMP 285 with a minimum grade of C-
Estimation of eigenvalues and eigenvectors of matrices; numerical solutions of differential equations, existence, and stability theory; and computer lab assignments. Prerequisite: MATH 250, 320, 330 (may be taken concurrently), and COMP 340, all with a grade of C- or better. Cross-listed as MATH 341.

COMP 345 | DATABASE MANAGEMENT SYSTEMS DESIGN
Units: 3 Repeatability: No
Prerequisites: COMP 230 with a minimum grade of C- or COMP 285 with a minimum grade of C-
Introduction to database concepts; data models; query facilities; and file organization and security.

COMP 350 | COMPUTER GRAPHICS
Units: 3 Repeatability: No
Prerequisites: (COMP 230 with a minimum grade of C- or COMP 285 with a minimum grade of C- and MATH 320 with a minimum grade of C-
The development of high-level, device-independent graphics routines; basic line drawing algorithms, text design, and other graphics primitives; 2-D representations of coordinate systems, image segmentation, and windowing.

COMP 355 | DIGITAL MODELING AND SIMULATION
Units: 3
Prerequisites: MATH 151 with a minimum grade of C- and COMP 305 with a minimum grade of C-
Mathematical modeling; probabilistic and deterministic simulations; pseudo-random number generators; event generators; queuing theory; game theory; and continuous models involving ordinary and partial differential equations. Prerequisite: COMP 305 with a grade of C- or better and MATH 151 with a grade of C- or better.
COMP 360 | PRINCIPLES OF PROGRAMMING LANGUAGES  
Units: 3  Repeatability: No  
Prerequisites: (COMP 230 with a minimum grade of C- or COMP 285 with a minimum grade of C-) and (MATH 160 with a minimum grade of C- or MATH 222 with a minimum grade of C-) or (MATH 260 with a minimum grade of C- or MATH 262 with a minimum grade of C-)  
The organization of programming languages with emphasis on language semantics; language definition, data types, and control structures of various languages.

COMP 365 | PRINCIPLES OF INFORMATION SECURITY  
Units: 3  Repeatability: No  
Prerequisites: COMP 280 with a minimum grade of C-  
Introduction to fundamental concepts in cyber security: policies, threats, vulnerabilities, risk and controls; Identification and authentication; Access control; Cryptographic mechanisms: Ciphers, hashes, message authentication codes, and digital certificates; Malware, infection vectors, and mitigations; Attacks on various application domains, such as web applications; Tools and techniques for developing secure software.

COMP 370 | AUTOMATA, COMPUTABILITY AND FORMAL LANGUAGES  
Units: 3  Repeatability: No  
Prerequisites: (COMP 230 with a minimum grade of C- or COMP 285 with a minimum grade of C-) and (MATH 160 with a minimum grade of C- or MATH 260 with a minimum grade of C- or MATH 262 with a minimum grade of C-)  
Finite state machines; formal grammars; computability and Turing machines.

COMP 375 | NETWORKING  
Units: 3.5  Repeatability: No  
Prerequisites: COMP 280 with a minimum grade of C-  
Introduction to the design and implementation of computer and communication networks. The focus is on the concepts and the fundamental design principles that have contributed to the global Internet's success. Topics covered will include MAC layer design (Ethernet/802.11), the TCP/IP protocol stack, routing algorithms, congestion control and reliability, and applications (HTTP, FTP, etc.) and advanced topics such as peer-to-peer networks and network simulation tools. Recent trends in networking such as multimedia networking, mobile/cellular networks and sensor networks will also be discussed. Prereq: COMP 280 with a grade of C- or better.

COMP 380 | NEURAL NETWORKS  
Units: 3  Repeatability: No  
Prerequisites: (COMP 230 with a minimum grade of C- or COMP 285 with a minimum grade of C-) and MATH 320 with a minimum grade of C-  
A study of the fundamental concepts, architectures, learning algorithms and applications of various artificial neural networks, including perceptron, Kohonen self organizing maps, learning vector quantization, backpropagation, and radial basis functions.

COMP 382 | INTRODUCTION TO DATA MINING  
Units: 3  Repeatability: No  
Prerequisites: (COMP 230 with a minimum grade of C- or COMP 285 with a minimum grade of C-) and ISYE 330 with a minimum grade of C-  
The course provides a comprehensive introduction to data mining with a primary focus on fundamental concepts, algorithms and applications of association analysis, classification and clustering modeling. It will also cover ethical issues related to data mining.

COMP 421 | EMBEDDED SOFTWARE DEVELOPMENT  
Units: 3  Repeatability: No  
Prerequisites: COMP 280 with a minimum grade of C-  
Development of "bare metal" embedded software, running on a microcontroller with no operating system support. Real-time requirements for finishing tasks within a fixed interval of time and for responding to asynchronous events are emphasized, along with techniques for writing reliable code for a memory-constrained microcontroller. All code is written in C using freely available development tools.

COMP 422 | ADVANCED EMBEDDED SOFTWARE DEVELOPMENT  
Units: 3  Repeatability: No  
Prerequisites: COMP 421 with a minimum grade of C- or GENG 421 with a minimum grade of C-  
Development of embedded software (firmware) using a real-time operating system (RTOS). Development of an application as a set of independent threads that communicate with each other via message queues and semaphores.

COMP 465W | SOFTWARE ENGINEERING  
Units: 3  
Core Attributes: Writing-Pre F17 CORE  
Prerequisites: COMP 305 with a minimum grade of C-  
Theoretical and practical aspects of software development; project planning; requirements and specification; general and detailed design; implementation; validation and verification; formal documentation. Students will participate in developing documentation for a large software project. Prereq: COMP 305 with a minimum grade of C- or better.

COMP 480 | ALGORITHMS  
Units: 3  Repeatability: No  
Prerequisites: or MATH 262 with a minimum grade of C-  
Advanced theory of algorithms. Topics may include: algorithm analysis; algorithm design techniques; and computational complexity.

COMP 491 | SENIOR PROJECT I  
Units: 3  Repeatability: No  
Prerequisites: COMP 305  
Students will develop professional skills in realistic software design and engineering, including human/computer interface design techniques, software architecture, teamwork, and project management, incorporating technical and non-technical considerations. Work will prepare students for implementing, testing and documenting the project in COMP 492, Senior Project II.

COMP 492 | SENIOR PROJECT II  
Units: 3  Repeatability: No  
Core Attributes: Advanced Integration  
Prerequisites: COMP 491 or COMP 465W  
This course is the second semester of the required two semester senior capstone experience for the computer science majors. In this course, students working in teams integrate their training in computer science and other disciplines, to implement, test, and document a significant piece of software based on a design developed in the first semester of the capstone experience, COMP 491. Students document their work, and demonstrate it in multiple public venues.

COMP 494 | SPECIAL TOPICS IN COMPUTER SCIENCE  
Units: 1-4  Repeatability: Yes (Can be repeated for Credit)  
Special topics course in areas of special interest to computer science. May be repeated for credit with a different topic.

COMP 495 | SENIOR PROJECT  
Units: 2  Repeatability: No  
Prerequisites: COMP 465W or COMP 491  
The course involves participation in a capstone senior project of substantial interest to computer scientists. Emphasis is on the design and implementation of computer systems for real-world problems. A final written report and oral presentation in the presence of other students and faculty are required.
COMP 496 | UNDERGRADUATE RESEARCH
Units: 0.5-3 Repeatability: Yes (Can be repeated for Credit)
Faculty-directed undergraduate research in computer science. Problem proposal must be submitted and approved prior to enrollment. Written report required. Upper division standing in engineering. Prior approval by department chair is required. May be repeated for credit.

COMP 498 | INTERNSHIP
Units: 1-3 Repeatability: Yes (Can be repeated for Credit)
Core Attributes: Law - Experiential
Practical experience in the application of the principles of computer science. Students will be involved in a software or hardware project. Enrollment is arranged on an individual basis according to the student’s interest, background, and the availability of positions. A written report is required. Units may not normally be applied toward the major or minor in computer science. COMP 498 may be repeated for a total of three units.

COMP 499 | INDEPENDENT STUDY
Units: 1-3 Repeatability: Yes (Can be repeated for Credit)
Individual study including library or laboratory research or program writing. A written report is required. Project proposal must be submitted and approved prior to enrollment. May be repeated for credit.