Computer and Information Science

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Computer science, the study of computation, offers students the challenge and excitement of a dynamically evolving science whose discoveries and applications affect every aspect of modern life. Computer science is a rich intellectual field where practitioners apply a computational approach to address a wide variety of interesting and challenging problems. Computer scientists are engaged in research in core areas of theoretical computer science, computer systems design, algorithms, and programming languages, as well as more application-oriented areas such as databases and networking.

The Department of Computer and Information Science (CIS) is committed to a strong research program and a rewarding educational experience for undergraduate and graduate students.

The department offers instruction and opportunities for research in the following areas:

- Artificial Intelligence
- Assistive Technology
- Computational Science
- Computer Vision
- Cyber Security and Privacy
- High-Performance Computing
- Human-Computer Interaction
- Machine Learning
- Natural Language Processing
- Networking and Systems
- Parallel and Distributed Computing
- Performance Analysis
- Programming Languages and Compilers
- Scientific Visualization
- Software Engineering
- Theoretical Computer Science

The department offers bachelor’s, master’s and doctoral degrees; in addition, two undergraduate minors and a selection of service courses are offered for students who want introductory exposure to computers and computer applications. The computer science programs at the university are continually evolving as the discipline matures and as students’ needs change.

Facilities

The Department of Computer and Information Science is housed in Deschutes Hall, which holds faculty and graduate student offices and extensive laboratory space for research and instruction.

Undergraduate majors may use campus computing labs staffed by CIS undergraduate tutors and lab assistants. Undergraduate majors taking upper-division courses and graduate students share a collaborative computing lab for the exclusive use of CIS students. Graduate and undergraduate students engaged in active research also have access to the computing facilities of the associated research lab.

The cognitive modeling and eye-tracking laboratory features multiple Eyegaze eye trackers and a Tobii eye tracker, used to collect and analyze the eye movements people make during human-computer interactions, and to develop eye-controlled user interfaces for people with disabilities.

Research in high-performance computing and computational science is supported by resources in the Oregon Advanced Computing Institute for Science and Society (OACISS) and the University of Oregon’s Research Advanced Computing Services. The Talapas cluster provides a large-scale computational and storage resource to support research computing across the university.

The Advanced Integration and Mining Laboratory fosters research on discovering useful patterns from the mountain of data on biology, health, medicine, neuroscience, physiology, and social networks and on integrating data from structurally and semantically heterogeneous resources such as databases, online social networks, and the World Wide Web.

Oregon Networking Research Group (ONRG) conducts cutting-edge research in several areas of computer networking and networked systems including Internet measurements, multi-cloud computing, network telemetry systems, machine learning for networking, network security, social computing, and programmable optics. Research at ONRG is currently funded by federal agencies (e.g., NSF, NIH, etc.), industry (e.g., Ripple, Broadcom, Cisco, etc.), and foundations (e.g., Internet Society Foundation).

The Network & Security Research Laboratory features hardware and software facilities devoted to experimentation, simulation, and analysis of various computer networking techniques (such as Internet routing, software-defined networking, online social networking, and Internet of things), malicious network attacks (such as distributed denial-of-service attacks, traffic hijacking, Internet worms, botnets, social bots, phishing), and network defense solutions (such as firewalls, anti-phishing solutions, distributed denial-of-service defense, IP spoofing prevention, Internet routing security, Internet privacy protection, and Internet of things security and privacy).

The Research Group on Computing and Data-Understanding at Extreme Scale (CDUX) pursues problems in scientific visualization, high-performance computing, scientific computing, and computer graphics, and especially focuses on problems where these areas intersect. The group performs research for the Department of Energy, the National Science Foundation, and private companies, delivered in widely used software tools such as the VisIt visualization tool, and helps develop new tools, like VTK-m, a library for many-core visualization and analysis.

The High-Performance Computing Laboratory conducts research in several areas, including optimizing compilers, performance modeling and optimization, parallel algorithms, and software engineering. Example projects include static and dynamic analysis of software for building application performance models, ensuring software quality, or detecting security vulnerabilities; using machine learning and other approaches to model run-time characteristics of software; developing data mining techniques to study and improve HPC software engineering processes; applying natural language processing methods to study and improve HPC software developer productivity; designing new algorithms or
improving existing ones in several application areas, including large-scale
dynamic graphs, computational physics, and computational biology.

In addition, the university is a member of Internet2, a high-speed network
connecting major research institutions.

Honors Program
The Computer and Information Science department offers an honors
program to their undergraduate majors. After obtaining advance approval,
students in the degree program are eligible to attain honors in computer
science by meeting the honors requirements of the department, including
writing a thesis.

Careers
The undergraduate program is designed to prepare students for
professional careers or graduate study. The field of computer science,
which has become increasingly interdisciplinary over the past decade,
offers a rich array of opportunities in fields as disparate as medicine,
manufacturing, and the media as well as the computer industry.

Graduates come away with confidence that they can specify, design, and
build large software systems; analyze the effectiveness of computing
techniques for a specific problem; and work effectively in problem-
solving teams. The master of arts (MA) and master of science (MS)
degree programs prepare students for higher-level positions in the areas
described above as well as for teaching positions in community colleges.
The PhD degree program trains students as scientists for advanced
research in specialized areas of computer science and for teaching in
universities.

Faculty
Zena M. Ariola, professor (programming languages, lambda calculus,

Hank Childs, professor (scientific visualization, high-performance
computing, computer graphics). BS, 1999, PhD, 2006, California, Davis.
(2013)

Jee W. Choi, assistant professor (high-performance computing, scientific
computation, data analytics). BS, 2000, PhD, 2015, Georgia Institute of
Technology. (2019)

Phil Colbert, instructor (education, healthcare, environmental sciences,
IoT, full stack development, CIT Minor). BS, 1990 CSU Chico; MS, 2008,
CSU Chico. (2014)

Dejing Dou, professor (artificial intelligence, data mining, natural
(2004)

Brittany Erickson, assistant professor (scientific computing, computational
seismology, high performance computing). BS, 2004, MS, 2006, PhD,
2010, California, Santa Barbara. (2018)

Ramakrishnan Durairajan, assistant professor (computer networking,
multi-cloud computing, Internet data science, programmable optics,
cybersecurity). BS, 2010, College of Engineering, Guindy; MS, 2014,

Stephen F. Fickas, professor (software engineering, formal modeling of
distributes systems, digital humanities). BS, 1971, Oregon State; MS,
1973, Massachusetts; PhD, 1983, California, Irvine. (1983)

Kathleen Freeman Hennessy, senior instructor; director of undergraduate
studies. BS, 1982, Bucknell; PhD, 1993, Oregon. (2011)

Anthony J. Hornof, professor (human-computer interaction, assistive
technology, cognitive modeling). BA, 1988, Columbia; MS, 1996, PhD,

Lei Jiao, assistant professor (networking and distributed computing,
performance modeling and evaluation, algorithm design and application).
(2016)

Jun Li, professor (computer and network security, network architectures
and protocols, distributed systems). BS, 1992, Peking; ME, 1995,
Chinese Academy of Sciences; MS, 1998, PhD, 2002, California, Los
Angeles. (2002)

Yingjiu (Joe) Li, professor (cyber security and privacy). BS, 1990, Dalian
University of Technology; PhD, 2003, George Mason University. (2019)

Daniel Lowd, associate professor (machine learning, data mining, artificial
intelligence). BS, 2003, Harvey Mudd College; MS, 2005, PhD, 2010,
Washington (Seattle). (2009)

Allen D. Malony, professor (parallel processing, performance evaluation,
neuroinformatics). BS, 1980, MS, 1982, California, Los Angeles; PhD,

Thanh H. Nguyen, assistant professor (artificial intelligence, multi-agent
systems, machine learning ). BS, 2010, Hanoi University of Science and
Technology; PhD, 2016, University of Southern California. (2018)

Boyana Norris, associate professor (high-performance computing,
compilers, performance analysis and optimization, software engineering,
data science). BS, 1995, Wake Forest; PhD, 2000, Illinois, Urbana-
Champaign. (2013)

Reza Rejaie, professor (computer networks, networking systems, Internet
measurement). BS, 1991, Sharif University of Technology; MS, 1996,

Humphrey Shi, assistant professor (Computer Vision, Machine Learning,
AI Systems & Applications). BS, 2005, Tsinghua University; PhD, 2017,
University of Illinois at Urbana-Champaign. (2019)

Joseph Sventek, professor (complex event processing, Internet of

Dave Wilkins, instructor. BA, 1965, Whitman College; MS, 1971, Oregon.
(2010)

Eric D. Wills, senior instructor. BS, 2000, MS, 2002, PhD, 2008, Oregon.
(2010)

Christopher B. Wilson, associate professor (computational complexity,
models of computation). BS, 1978, Oregon; MS, 1980, PhD, 1984,
Toronto. (1984)

Michal Young, associate professor (software engineering, software test
and analysis). BA, 1983, Oregon; MS, 1985, PhD, 1989, California,
Irvine. (1997)
Emeriti
Eugene M. Luks, professor emeritus. BS, 1960, City University of New York, City College; PhD, 1966, Massachusetts Institute of Technology. (1983)
Andrzej Proskurowski, professor emeritus. MS, 1967, Warsaw University of Technology; PhD, 1974, Royal Institute of Technology, Stockholm. (1975)
Kent A. Stevens, professor emeritus. BS, 1969, MS, 1971, California, Los Angeles; PhD, 1979, Massachusetts Institute of Technology. (1982)
The date in parentheses at the end of each entry is the first year on the University of Oregon faculty.

Affiliated Faculty

Participating
Heidi Kaufman, English
Amy K. Lobben, geography
Marc Schlossberg, planning, public policy and management
McKay M. Sohliberg, special education and clinical sciences
Sanjay Srivastava, psychology
Jeffrey Stolet, music
Don M. Tucker, psychology
• Bachelor of Arts
• Bachelor of Science
• Computer and Information Science Minor
• Computer Information Technology Minor

Undergraduate Studies
The Department of Computer and Information Science offers a major and a minor in computer and information science, a major in mathematics and computer science, and a minor in computer information technology.

The computer and information science major is intended for students who want to study computers and computation with strong mathematical and scientific foundations. The mathematics and computer science major emphasizes formal and abstract problem solving complemented by computational methods and computer technologies. This program, administered jointly with the Department of Mathematics, is described in the Mathematics and Computer Science section of this catalog. Both of these majors lead to the bachelor of arts (BA) or bachelor of science (BS) degrees.

Students majoring in computer and information science may choose to focus their studies in one of several areas of specialization, or tracks, which build on the standard CIS core requirements. Each track specifies a set of coordinated choices for fulfilling upper-division computer science and other elective requirements. Current computer science tracks include foundations, software development, computer networks, database and informatics, multimedia, computational science, and security.

Preparation
High school students who plan to major in computer and information science should pursue a strong academic program, including substantial work in mathematics, the sciences, and writing. Courses in algebra, geometry, trigonometry, and more advanced topics should be included. Courses in computer programming or computer technology are useful but not required. Upon arrival at the university, students should consult with an advisor to determine the entry-level course best suited to the student's background.

Transfer and Second Baccalaureate Students
Transfer and second baccalaureate students should consult the online Interactive Transfer Catalog as well as an advisor to determine whether computer science, mathematics, and science courses they have taken fulfill the major requirements. Completing only general-university requirements prior to transferring to the University of Oregon will not be sufficient preparation to complete a CIS degree in two years.

Students attending community college in Oregon are encouraged to obtain the associate of arts Oregon transfer degree or the associate of science Oregon transfer degree in computer science before entering the University of Oregon. While earning this degree, community college transfer students should take discrete mathematics and computer science. In addition, calculus and laboratory science are recommended.

Bachelor of Arts Degree Requirements
To earn a BA in computer and information science, majors must complete the requirements for a BS and also demonstrate proficiency in a second language. Computer and information science majors must complete at least 60 credits of CIS courses, of which 24 must be earned in residence at the University of Oregon. In addition, majors must complete 28 credits in mathematics, 12 credits in the sciences, and 4 credits of technical or business writing. The specific requirements for the CIS major fall into five categories: core courses, track and elective courses, mathematics, writing, and science.

Computer Science I (CIS 210), Computer Science II (CIS 211), Computer Science III (CIS 212), Elements of Discrete Mathematics I (MATH 231), and Elements of Discrete Mathematics II (MATH 232) must be passed with grades of B– or better before students can take the upper-division core courses. Courses required for the major must be taken for a letter grade; upper-division electives in CIS courses numbered 410 or higher (12 credits) must also be taken for a letter grade. Upper-division courses must be passed with a grade of C– or better.
Bachelor of Science Degree Requirements

To earn a BS in computer and information science, majors must complete at least 60 credits of CIS courses, of which 24 must be earned in residence at the University of Oregon. In addition, majors must complete 28 credits in mathematics, 12 credits in the sciences, and 4 credits of technical or business writing. The specific requirements for the CIS
major fall into five categories: core courses, track and elective courses, mathematics, writing, and science.

Computer Science I (CIS 210), Computer Science II (CIS 211), Computer Science III (CIS 212), Elements of Discrete Mathematics I (MATH 231), and Elements of Discrete Mathematics II (MATH 232) must be passed with a grade of B– or better before students can take the upper-division core courses. Courses required for the major must be taken for a letter grade; upper-division electives in CIS courses numbered 410 or higher (12 credits) must also be taken for a letter grade. Upper-division courses must be passed with a grade of C– or better.

### Core Courses: Lower Division
- CIS 210–212: Computer Science I-III, 12 credits
- MATH 231–232: Elements of Discrete Mathematics I-II, 8 credits

### Core Courses: Upper Division
- CIS 313: Intermediate Data Structures, 4 credits
- CIS 314: Computer Organization, 4 credits
- CIS 315: Intermediate Algorithms, 4 credits
- CIS 330: C/C++ and Unix, 4 credits
- CIS 415: Operating Systems, 4 credits
- CIS 422: Software Methodology I, 4 credits
- CIS 425: Principles of Programming Languages, 4 credits

### Core Courses: Mathematics
Select one of the following: 8 credits
- MATH 251–252: Calculus I-II
- MATH 261–262: Calculus with Theory I-II
- MATH 246–247: Calculus for the Biological Sciences I-II

Select two of the following: 8 credits
- MATH 347: Fundamentals of Number Theory I
- or MATH 351: Elementary Numerical Analysis II
- or MATH 391: Fundamentals of Abstract Algebra I
- MATH 253: Calculus III
- or MATH 263: Calculus with Theory III
- MATH 341: Elementary Linear Algebra
- MATH 343: Statistical Models and Methods
- or MATH 401: Statistical Methods I
- or MATH 349: Probability and Statistics for Data Science

### Core Courses: Science
Select 12 credits from the following: 1

#### Biology
- CH 111: Introduction to Chemical Principles
  - or CH 113: The Chemistry of Sustainability
  - or CH 221: General Chemistry I
  - or CH 224H: Advanced General Chemistry I
- BI 211, 213: General Biology I,III
  - or BI 211–212: General Biology I-II

#### Chemistry
- CH 221–223: General Chemistry

### Electives: Upper Division
Upper-division CIS courses in student's chosen track (track information below) 12 credits
Upper-division CIS courses in student's chosen track, honors thesis, capstone project, or other upper-division courses 8 credits
Upper-division mathematics or theoretical computer science course 4 credits

### Core Course: Writing

- WR 320: Scientific and Technical Writing, 4 credits
- or WR 321: Business Communications, 4 credits

### Experimental Course: [Topic] (CIS 410)

### Seminar: [Topic]

### Special Studies: [Topic]

### Total Credits: 104

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1. To support interdisciplinary study, students on any track are encouraged to complete a minor (typically 24–32 credits) or major in a computing-related field. Students who complete a minor (other than computer information technology or mathematics) or another major (including mathematics) in a computing-related field may, with the approval of the Undergraduate Education Committee, replace the CIS laboratory science requirement with the completed minor or major.

2. Students are encouraged to complete the accompanying lab courses.

3. Physics is recommended for networks track students.

4. If Experimental Course: [Topic] (CIS 410) courses are applied, they must have different topic subtitles to satisfy this requirement.

5. A maximum of 8 credits in upper-division courses numbered less than 410, or DSCI 311. CIS courses numbered 400–499 may be taken for a maximum of 4 credits when used to satisfy this requirement. Special Studies: [Topic] (CIS 399), Seminar: [Topic] (CIS 407), and Experimental Course: [Topic] (CIS 410) courses must have different topic subtitles to satisfy this requirement. CIS 399 and CIS 410 courses must have a prerequisite of CIS 313 and have regular weekly class meetings and homework assignments.
The mathematics elective is selected from upper-division mathematics courses with a prerequisite of Calculus II (MATH 252) or higher, or from theoretical computer science courses. A list of theoretical computer science courses is available in the computer science office or the department website.

Upper-Division Electives
In addition to the core CIS, mathematics, science, and writing courses, computer and information science majors must complete 20 credits of upper-division computer science and 4 credits of upper-division mathematics or theoretical computer science. Students complete at least 12 of their upper-division CIS credits with courses from their selected track; the 8 remaining upper-division credits may be additional track courses, an honors thesis, capstone project, or other upper-division electives.

A maximum of 8 credits in upper-division CIS courses with numbers less than 410 may be applied to the upper-division electives requirement. Courses numbered 400–409 may be taken for a maximum of 4 credits when used to satisfy this requirement. (Courses numbered 399, 407, or 410 may be repeated only with different course subtitles.) Special Studies: [Topic] (CIS 399) and Experimental Course: [Topic] (CIS 410) courses used as upper-division electives must have a prerequisite of CIS 313 and have regular weekly class meetings and homework assignments.

The mathematics elective is selected from upper-division mathematics courses with a prerequisite of MATH 252 or higher, or from theoretical computer science courses. A list of courses is available in the computer science office or at the department website.

Tracks
Tracks highlight areas of specialization within the department and guide student elective choices. Each track has an approved list of CIS courses, available from the computer science office or the department website. Tracks may also include recommended science or mathematics courses or a recommended minor in another field.

Foundations Track
The foundations track is the most general track, allowing a student to choose a set of electives tailored to his or her interests and intended choice of career.

Software Development Track
The software development track prepares students for careers in software engineering, software project management, software quality assurance, and other areas involving the creation of software. Course work focuses on solving problems related to the cost of development as well as the quality of the software delivered in complex software projects.

Computer Networks Track
The computer networks track prepares students for careers as network systems administrators, network protocol developer-programmers, or network security specialists in a wide range of environments, including educational institutions, business enterprises, and government agencies, as well as for advanced graduate studies and research in the field of computer networks. Course work encompasses most aspects of network theory and practice.

Database and Informatics Track
The database and informatics track prepares students for careers in database application programming, database design, doctoral work in business administration, and graduate work in informatics and database theory. Course work includes data structures, data architecture, and data mining.

Business Information Systems Track
Graduates in the business information systems track are qualified to work as analysts, managers, developers, or consultants, and to enter leadership-development programs. Completion of this track, combined with professional work experience and economics courses, prepares students to enter the Lundquist College of Business MBA program at the University of Oregon, and MBA programs at other universities.

Computational Science Track
The computational science track prepares students to apply computational and mathematical techniques to the analysis and management of scientific data. Course work in this track combines depth in applied and formal aspects of computer science.

Security Track
The security track provides a foundation in topics and concepts relating to the security of computer systems and networks. It prepares students to work as security analysts and provides a highly desirable skill set for all employers, ranging from software engineers to administrators, in both the private and government sectors. It also provides a foundation for further graduate study and research in security. Course work encompasses a strong understanding of computer systems and networks and their security, and can be tailored to a more theoretical or more applied focus.

Preparation for the Major
Students who take Computer Science I (CIS 210) are expected to have completed Elementary Functions (MATH 112) or the equivalent. Students who do not have the required mathematical background are strongly encouraged to take one or more introduction to programming courses such as Introduction to Programming and Problem Solving (CIS 122) along with their math preparation courses. Students who are unsure about their level of preparation for CIS 210 should meet with an advisor.

Sequence of Courses for Students Prepared for CIS 210

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 231–232</td>
<td>Elements of Discrete Mathematics I-II</td>
</tr>
<tr>
<td>CIS 210–212</td>
<td>Computer Science I-III</td>
</tr>
<tr>
<td><strong>Total Credits:</strong></td>
<td><strong>20</strong></td>
</tr>
</tbody>
</table>

Sequence of Courses for Students Preparing for CIS 210

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
</tr>
<tr>
<td>MATH 112</td>
<td>Elementary Functions</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>4</td>
</tr>
<tr>
<td>CIS 122</td>
<td>Introduction to Programming and Problem Solving</td>
</tr>
<tr>
<td>CIS 111</td>
<td>Introduction to Web Programming</td>
</tr>
</tbody>
</table>
must be at a technical level beyond
earn upper-division elective credit for an internship, the work experience
the University Career Center and other agencies to identify internship
throughout the academic year. Students may also use the services of
students to place them in internship positions in the summer and
complement to academic course work. The department works with
Practical work experience in the software industry is seen as a valuable
Internships
department office. To graduate with departmental honors, a student must
and
Computer Organization (CIS 314). Mathematics and CIS core courses and at least 12 credits of CIS upper division elective
courses numbered 410 or higher must be taken for letter grades and
passed with grades of C– or better. Other courses used to satisfy the
major requirements may be taken for letter grades or pass/no pass.
Grades of C– or better or P must be earned in these courses. At least 12
of the CIS upper-division credits applied to the degree must be taken in
residence at the university. A student who receives two grades below C–
in the upper-division core, or three grades below C– in any CIS upper-
division courses, will be removed from the major.

Mathematics and Computer Science
The Department of Computer and Information Science and the
Department of Mathematics jointly offer an undergraduate major in
mathematics and computer science, leading to a bachelor of arts
or a bachelor of science degree. This program is described in the
Mathematics and Computer Science section of this catalog. This major
prepares students for a wide range of careers in the high tech industry,
for advanced graduate study, and for careers as middle school and high
school teachers.

Honors Program
Students with a GPA of 3.50 or higher in computer and information
science and a cumulative GPA of 3.50 or higher, or a GPA of 3.75 or
higher in computer and information science and a cumulative GPA of
3.25 or higher, are encouraged to apply to the department honors
program after completing Intermediate Data Structures (CIS 313),
Computer Organization (CIS 314), Intermediate Algorithms (CIS 315),
and C/C++ and Unix (CIS 330). The application form is available in the
department office. To graduate with departmental honors, a student must
write a thesis under the supervision of a faculty member.

Internships
Practical work experience in the software industry is seen as a valuable
complement to academic course work. The department works with
students to place them in internship positions in the summer and
throughout the academic year. Students may also use the services of
the University Career Center and other agencies to identify internship
opportunities. Majors may receive academic credit for internships. To
earn upper-division elective credit for an internship, the work experience
must be at a technical level beyond Intermediate Data Structures
(CIS 313) and be sponsored by a CIS faculty member. A contract signed
by the faculty sponsor, internship supervisor, and the student must be
filed with the department before the internship begins.

Research
Faculty members in the computer and information science department
receive grants from government, industry, and private sources to
conduct research in their areas of expertise. Undergraduate majors
are encouraged to take part in the various research groups in the
department. Most students begin approaching faculty members for such
opportunities while taking the 300-level courses. Research can be used
to fulfill upper-division electives, as part of an honors thesis, or in some
cases as a paid internship.

Awards and Honor Societies
The Erwin and Gertrude Juilfs Scholarship in Computer and Information
Science, in honor of Erwin and Gertrude Juilfs, is awarded to one or more
students who show exceptional promise for achievement as evidenced by
grade point average, originality of research, or other creative activities.

The Geoffrey Eric Wright Outstanding Junior Award, in honor of CIS
student Geoffrey Wright, is a scholarship for students displaying high-
quality academic performance, commitment to learning, and a promise of
further outstanding achievement in computer and information science and
its applications.

The J. Donald Hubbard Scholarship in Computer and Information
Science, in honor of J. Donald Hubbard, recognizes an undergraduate
or graduate student who shows outstanding promise in the fields of
computer-human interaction, computer graphics, or multimedia.

The Phillip Seeley Scholarship in Computer and Information Science
has been established as a permanent endowment to provide a source of
income supporting a scholarship for outstanding undergraduate CIS
students. This scholarship is based on overall quality of academic work,
commitment to learning, and potential for further academic achievement.
Preference is given to resident Oregon students with financial need, as
determined by the UO Office of Student Financial Aid and Scholarships.

Students with outstanding academic accomplishments may be invited to
become members of Upsilon Pi Epsilon, the international honor society in
computer science.

Minor Requirements

Computer and Information Science Minor
The minor in computer and information science introduces the theories
and techniques of computer science and develops programming skills
that are applicable to the student’s major. It is a strong complement to a
major in any of the sciences and in related fields such as multimedia arts.
Students from all majors have found their career opportunities enhanced
through the CIS minor.

Before enrolling in upper-division courses, students planning a minor in
computer and information science must file an application form with the
department. Each student should consult with a CIS faculty advisor to
plan the minor program.

Computer Science I (CIS 210), Computer Science II (CIS 211), Computer
Science III (CIS 212), Elements of Discrete Mathematics I (MATH 231),
and Elements of Discrete Mathematics II (MATH 232) must be passed.
with grades of B− or better before students can take the upper-division core courses.

### Bachelor of Arts in Computer and Information Science

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Year</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIS 122</td>
<td>Introduction to Programming and Problem Solving</td>
<td>4</td>
</tr>
<tr>
<td>MATH 112</td>
<td>Elementary Functions</td>
<td>4</td>
</tr>
<tr>
<td>First term of second-language sequence</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>General-education course in social science</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Credits</strong></td>
<td></td>
<td><strong>17</strong></td>
</tr>
<tr>
<td><strong>Winter</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIS 210</td>
<td>Computer Science I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 231</td>
<td>Elements of Discrete Mathematics I</td>
<td>4</td>
</tr>
<tr>
<td>WR 121</td>
<td>College Composition I</td>
<td>4</td>
</tr>
<tr>
<td>Second term of second-language sequence</td>
<td>5</td>
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<tr>
<td><strong>Credits</strong></td>
<td></td>
<td><strong>17</strong></td>
</tr>
<tr>
<td><strong>Spring</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIS 211</td>
<td>Computer Science II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 232</td>
<td>Elements of Discrete Mathematics II</td>
<td>4</td>
</tr>
<tr>
<td>WR 122</td>
<td>College Composition II</td>
<td>4</td>
</tr>
<tr>
<td>or WR 123</td>
<td>or College Composition III</td>
<td></td>
</tr>
<tr>
<td>Third term of second-language sequence</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Credits</strong></td>
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<td><strong>17</strong></td>
</tr>
<tr>
<td><strong>Total Credits</strong></td>
<td></td>
<td><strong>51</strong></td>
</tr>
</tbody>
</table>

### Four-Year Degree Plan

The degree plan shown is only a sample of how students may complete their degrees in four years. There are alternative ways. Students should consult their advisor to determine the best path for them. Additional information may be found at the department website (https://cs.uoregon.edu).
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
<th>Milestones</th>
</tr>
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<tbody>
<tr>
<td>MATH 253</td>
<td>Calculus III</td>
<td>4</td>
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</tr>
<tr>
<td>or</td>
<td>or Calculus with Theory III</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH 263</td>
<td>or Elementary Linear Algebra</td>
<td></td>
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<tr>
<td>or</td>
<td>or Statistical Models and Methods</td>
<td></td>
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</tr>
<tr>
<td>MATH 341</td>
<td>or Statistical Methods I</td>
<td></td>
<td></td>
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<tr>
<td>or</td>
<td>or MATH 425</td>
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<tr>
<td></td>
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<td>4</td>
<td></td>
</tr>
<tr>
<td>Credits</td>
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### Bachelor of Science in Computer and Information Science

<table>
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<tr>
<td>MATH 253</td>
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<tr>
<td>or</td>
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<td>or</td>
<td>or Statistical Models and Methods</td>
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<td>or Statistical Methods I</td>
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<td>or</td>
<td>or MATH 425</td>
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<td>General-education course in social science</td>
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<td>Credits</td>
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### Course Title Credits Milestones

#### First Year

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<tbody>
<tr>
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<td>Introduction to Programming and Problem Solving</td>
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<tr>
<td>MATH 112</td>
<td>Elementary Functions</td>
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#### Second Year

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<td>CIS 210</td>
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<td>MATH 231</td>
<td>Elements of Discrete Mathematics I</td>
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<td>WR 121</td>
<td>College Composition I</td>
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#### Third Year

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<tr>
<td>First course of additional science sequence</td>
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<td>General-education course in arts and letters</td>
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<td>Credits</td>
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<tr>
<td>Winter</td>
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<tr>
<td>CIS 422</td>
<td>Software Methodology I</td>
<td>4</td>
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<td>Upper-division elective course with CIS subject code</td>
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<tr>
<td>General-education course in social science that also meets multicultural requirement</td>
<td>4</td>
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<tr>
<td>Credits</td>
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<td>16</td>
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</tr>
<tr>
<td>Spring</td>
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<tr>
<td>CIS 425</td>
<td>Principles of Programming Languages</td>
<td>4</td>
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#### Fourth Year

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<tbody>
<tr>
<td>MATH 253</td>
<td>Calculus III</td>
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<tr>
<td>or</td>
<td>or Calculus with Theory III</td>
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<td></td>
</tr>
<tr>
<td>MATH 263</td>
<td>or Elementary Linear Algebra</td>
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<tr>
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<td></td>
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<td>or</td>
<td>or MATH 425</td>
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<td></td>
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<tr>
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<td>Upper-division elective course with CIS subject code</td>
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<tr>
<td>Elective course</td>
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<td>Winter</td>
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<tr>
<td>CIS 313</td>
<td>Intermediate Data Structures</td>
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<td>CIS 314</td>
<td>Computer Organization</td>
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</table>
Computer and Information Science

**MATH 252**
or **MATH 247**
or **MATH 262**
Calculus II or Calculus for the Biological Sciences II or Calculus with Theory II

General-education course in arts and letters that also satisfies multicultural requirement 4

| Credits | 16 |

**Spring**

<table>
<thead>
<tr>
<th>Course</th>
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</thead>
<tbody>
<tr>
<td>CIS 315</td>
<td>Intermediate Algorithms</td>
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<tr>
<td>CIS 330</td>
<td>C/C++ and Unix</td>
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</tr>
<tr>
<td>MATH 253</td>
<td>Calculus III</td>
<td>4</td>
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<tr>
<td>or</td>
<td>or Calculus with Theory III</td>
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</tr>
<tr>
<td>MATH 263</td>
<td>or Elementary Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>or</td>
<td>or Statistical Models and Methods</td>
<td></td>
</tr>
<tr>
<td>MATH 341</td>
<td>or Statistical Methods I</td>
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<tr>
<td>or</td>
<td>or MATH 425</td>
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</table>

General-education course in social science that also satisfies a multicultural requirement 4

| Credits | 16 |

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
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<td>Winter</td>
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<tr>
<td>Fall</td>
<td>CIS 415 Operating Systems</td>
<td>4</td>
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<td>Upper-division elective course with CIS subject code</td>
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<td>Elective course</td>
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| Credits | 16 |

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<th>Course</th>
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<tbody>
<tr>
<td>Spring</td>
<td>CIS 422 Software Methodology I</td>
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<tr>
<td>Upper-division elective course with CIS subject code</td>
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<tr>
<td>Second course of additional science sequence</td>
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<td>Elective course</td>
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| Credits | 16 |

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<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>Fourth Year</td>
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<tr>
<td>Fall</td>
<td>Upper-division elective course with CIS subject code</td>
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<tr>
<td>Upper-division mathematics elective</td>
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<tr>
<td>Elective course</td>
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</tbody>
</table>

| Credits | 12 |

**Graduate Studies**

The department offers programs leading to the master of science (MS) and doctor of philosophy (PhD).

**Master’s Degree Program**

**Admission**

Admission to the master’s degree program in computer and information science is competitive. It is based on prior academic performance, Graduate Record Examinations (GRE) scores, and computer science background. Minimum requirements for admission with graduate master’s status are as follows:

1. Documented knowledge of
   a. Principles of computer organization and operating systems
   b. Programming languages
   c. Program development and analysis
   d. Data structures and algorithm analysis
2. GRE scores on the general test. The computer science test is optional.
3. A score of at least 100 on the Internet-based option of the Test of English as a Foreign Language (TOEFL iBT) or a score of 7.0 on the International English Language Testing System (IELTS) for applicants who have no justification for a waiver. Applicants may be required to study one or more terms at the university’s American English Institute or elsewhere before taking any graduate work in the department. International applicants for teaching assistantships who score at least 26 on the speaking section of the TOEFL iBT will not have to take the Speaking Proficiency English Assessment Kit (SPEAK) test upon arrival at the university.
4. Three letters of recommendation, a statement of purpose, and unofficial transcripts (via online application). Note that official transcripts are sent to the UO Office of Admissions.

Grades from previous course work should indicate the ability to maintain at least a 3.00 grade point average in graduate-level courses.

Application materials should be submitted by February 1 for admission, via GradWeb (http://gradweb.uoregon.edu), for the following fall term.

Admission to the master’s degree program requires the substantive equivalent of an undergraduate degree in computer science. A second bachelor’s degree program can be used to gain the required level of computer science background. Students without this background may
be admitted conditionally and required to complete remedial course work before achieving unconditional standing in the program.

Master of Science Degree Requirements

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<thead>
<tr>
<th>Code</th>
<th>Title</th>
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<tr>
<td><strong>Breadth Requirement: 12 credits total</strong> 1</td>
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<tr>
<td>CIS 621</td>
<td>Algorithms and Complexity</td>
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<td>CIS 670</td>
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<td>And one of the following:</td>
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<tr>
<td>CIS 630</td>
<td>Distributed Systems 2</td>
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<tr>
<td>CIS 631</td>
<td>Parallel Processing 3</td>
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<td><strong>Depth Requirement: Choose one, 12 credits total</strong> 1</td>
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<tr>
<td>Each Depth requires three courses, at least one at 600-level</td>
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<td><strong>Foundations Depth</strong></td>
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<td>CIS 513</td>
<td>Advanced Data Structures</td>
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<td>CIS 520</td>
<td>Automata Theory</td>
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<td>CIS 527</td>
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<td>CIS 543</td>
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<tr>
<td>CIS 545</td>
<td>Modeling and Simulation</td>
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<tr>
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<td>Introduction to Compilers</td>
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<td>CIS 624</td>
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<td><strong>Data Science Depth</strong></td>
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<td>CIS 543</td>
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<td>CIS 551</td>
<td>Database Processing</td>
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<td>CIS 553</td>
<td>Data Mining</td>
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<tr>
<td>CIS 571</td>
<td>Introduction to Artificial Intelligence</td>
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<td>CIS 572</td>
<td>Machine Learning</td>
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<td>CIS 573</td>
<td>Probabilistic Methods for Artificial Intelligence</td>
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<td>CIS 600</td>
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<td><strong>Systems Depth</strong></td>
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<td>CIS 532</td>
<td>Introduction to Networks</td>
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<td>CIS 533</td>
<td>Computer and Network Security</td>
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<td>CIS 541</td>
<td>Introduction to Computer Graphics</td>
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<td>CIS 650</td>
<td>Software Engineering</td>
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<td>CIS 640</td>
<td>Writing in Computer Research</td>
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<td><strong>Elective Options: 28 credits total</strong> 4</td>
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<td>Up to twelve credits in courses outside department in area closely related to professional goals may be used 5</td>
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<tr>
<td><strong>Thesis Option</strong></td>
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<tr>
<td>CIS 503</td>
<td>Thesis (9-12 credits P/NP)</td>
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<td>CIS 5XX and CIS 6XX: Minimum of 8 graded credits, maximum of 10 P/NP credits</td>
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<td>CIS 609</td>
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</table>

1 A grade of B– or better is required
2 Cannot duplicate Depth course used
3 Cannot duplicate Breadth course used
4 A grade of C or better is required in graded elective credits
5 Courses must be approved by petition to the CIS GEC; options include courses in linguistics, mathematics, physics, and psychology.
6 Cannot include CIS 609 Final Project
7 CIS 609 Final Project requirements: 8-12 credits; graded or P/NP
8 No credit of CIS 503 (Thesis) or CIS 609 (Final Project) may count toward the elective credit requirements

Grade Requirements

The 24 credits in the breadth courses and the depth courses must be passed with grades of B– or better. Graded elective courses must be passed with grades of C or better. A 3.00 GPA must be maintained for courses taken in the program.

Master’s Thesis

The research option requires a written thesis and 9 to 12 credits in Thesis (CIS 503). Thesis research is supervised by a faculty advisor; this advisor and other faculty members constitute the thesis committee. The master’s thesis is expected to be scholarly and to demonstrate mastery of the practices of computer science. This option is recommended for students who plan subsequent PhD research.

Master’s Project

The project option requires a minimum of 9 credits, and as many as 12, in Final Project (CIS 609).

Under the supervision of a faculty member, the project may entail a group effort involving several master’s degree students.

Accelerated Master’s Degree Program

This program is open to students who earn a BS or BA degree in computer and information science at the University of Oregon and who want to enter the master’s degree program.

If a UO undergraduate takes one or two 400-level electives that also are offered as 500-level courses, the student can petition the department to have 4 or 8 credits deducted from the total number of elective credits required for the master’s degree. The student must earn an A– or better in the 400-level course and have an overall GPA of 3.50 in upper-division CIS courses to participate in this accelerated master’s program. Note that all admission procedures, as outlined in the Master’s Degree Program (p. 10) section, are also applicable. Applications are available in the department office.
Awards and Honor Societies

The Erwin and Gertrude Juilfs Scholarship in Computer and Information Science, in honor of Erwin and Gertrude Juilfs, is awarded to one or more students who show exceptional promise for achievement as evidenced by grade point average, originality of research, or other creative activities.

The J. Donald Hubbard Scholarship in Computer and Information Science, in honor of J. Donald Hubbard, recognizes an undergraduate or graduate student who shows outstanding promise in the fields of computer-human interaction, computer graphics, or multimedia.

The Gurdeep Pall Scholarship in Computer and Information Science, in honor of Gurdeep Pall, is awarded to a student based on the overall quality of their academic work, their commitment to learning, and their potential for further academic achievement.

Students with outstanding academic accomplishments may be invited to become members of Upsilon Pi Epsilon, the international honor society in computer science.

Doctoral Degree Program

The doctor of philosophy in computer and information science is, above all, a high-quality degree that is not conferred simply for the successful completion of a specified number of courses or years of study. It is a degree reserved for students who demonstrate a comprehensive understanding of computer science and an ability to do creative research. Each PhD student produces a significant piece of original research, presented in a written dissertation and defended in an oral examination.

The PhD program is structured to facilitate the process of learning how to do research. Students begin by taking required courses to build a foundation of knowledge that is essential for advanced research. Early in the program the student gains research experience by undertaking a directed research project under the close supervision of a faculty member and the scrutiny of a faculty committee. In the later stages of the program, students take fewer courses and spend most of their time exploring their dissertation area to learn how to identify and solve open problems. The final steps are to propose an independent research project, do the research, and write and defend a dissertation.

Admission

Application materials should be submitted by December 15 for the following fall term. Materials include everything required for admission to the master’s program as well as a discussion of the anticipated research area.

Students who enter the UO with a master’s degree may petition the Graduate Education Committee for credit toward the course requirements listed below, indicating how their prior graduate work corresponds to these courses. See the graduate coordinator for the petition.

PhD Course Requirements

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
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<tr>
<td></td>
<td><strong>Breadth Requirement: 12 credits total</strong></td>
<td>12</td>
</tr>
<tr>
<td>CIS 621</td>
<td>Algorithms and Complexity</td>
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<tr>
<td>CIS 670</td>
<td>Data Science</td>
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<tr>
<td>And one of the following:</td>
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<tr>
<td>CIS 630</td>
<td>Distributed Systems</td>
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<tr>
<td>CIS 631</td>
<td>Parallel Processing</td>
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<td><strong>Depth Requirement: Choose one, 12 credits total</strong></td>
<td>12</td>
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<td></td>
<td>Each Depth requires three courses, at least one at 600-level</td>
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<td></td>
<td><strong>Foundations Depth</strong></td>
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<tr>
<td>CIS 513</td>
<td>Advanced Data Structures</td>
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<td>CIS 520</td>
<td>Automata Theory</td>
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<td>CIS 527</td>
<td>Introduction to Logic</td>
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<td>CIS 543</td>
<td>User Interfaces</td>
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<td>CIS 545</td>
<td>Modeling and Simulation</td>
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<tr>
<td>CIS 561</td>
<td>Introduction to Compilers</td>
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<tr>
<td>CIS 624</td>
<td>Structure of Programming Languages</td>
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<td></td>
<td><strong>Data Science Depth</strong></td>
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<tr>
<td>CIS 543</td>
<td>User Interfaces</td>
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<td>CIS 553</td>
<td>Data Mining</td>
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<tr>
<td>CIS 571</td>
<td>Introduction to Artificial Intelligence</td>
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<td>CIS 572</td>
<td>Machine Learning</td>
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<td>CIS 573</td>
<td>Probabilistic Methods for Artificial Intelligence</td>
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<tr>
<td>CIS 6XX TBA</td>
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<td></td>
<td><strong>Systems Depth</strong></td>
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<tr>
<td>CIS 531</td>
<td>Introduction to Parallel Computing</td>
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<td>CIS 532</td>
<td>Introduction to Networks</td>
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<tr>
<td>CIS 533</td>
<td>Computer and Network Security</td>
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<td>CIS 541</td>
<td>Introduction to Computer Graphics</td>
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<td>CIS 561</td>
<td>Introduction to Compilers</td>
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<td>Distributed Systems</td>
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<td>CIS 631</td>
<td>Parallel Processing</td>
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<td>CIS 632</td>
<td>Computer Networks</td>
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<td>CIS 633</td>
<td>Advanced Network Security</td>
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<td><strong>Writing Requirement</strong></td>
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<tr>
<td>CIS 640</td>
<td>Writing in Computer Research</td>
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<td><strong>Elective Options: 24 credits total</strong></td>
<td>24</td>
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<td><strong>Total Credits</strong></td>
<td>50</td>
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1 A grade of B- or better is required
2 Cannot duplicate Breadth course used
3 Cannot duplicate Depth course used
4 A grade of C or better is required in graded elective credits

PhD Degree Requirements

PhD candidates who enter the program without a master’s degree in computer science must take 48 credits in graduate course work including the core and cluster courses required for the MS program. Doctoral students must earn a minimum grade of B- and an overall GPA of 3.50 in the six courses they use to satisfy the breadth and depth requirements.

Minimum Annual Enrollment

PhD students are expected to enroll in at least 6 credits of 600-level course work each year until their advancement to candidacy. Research: [Topic] (CIS 601), Dissertation (CIS 603), and Reading Conference: [Topic] (CIS 605) do not satisfy this requirement. After candidacy, PhD students are encouraged to continue participation in 600-level courses.
Directed Research Project
Complete a directed research project, which is supervised by a faculty member and evaluated by a faculty committee. The research project comprises the following:
1. The definition and expected results of the project in the form of a Directed Research Project Contract
2. Delivery of the materials constituting the results of the project and oral presentation of the results
3. A private oral examination by the committee members

Status Change
PhD candidates are admitted conditionally. Successful completion of the directed research project leads to a change in the student’s doctoral status from conditional to unconditional.

Dissertation Advisory Committee
After successfully completing the directed research project, PhD students form a Dissertation Advisory Committee chaired by their research advisor. The main role of the committee is to advise the student between completion of the research project and mounting the dissertation defense. The committee takes primary responsibility for evaluating student progress. In addition, it approves the plan for the area examination, which in turn is approved by the graduate education committee. See the graduate coordinator for further instructions.

Area Examination
The student chooses an area of research and works closely with an advisor to learn the area in depth by surveying the current research and learning research methods, significant achievements, and how to pose and solve problems. The student gradually assumes a more independent role and prepares for the area examination, which tests depth of knowledge in the research area. The examination contains the following:
1. A survey of the area in the form of a position paper and an annotated bibliography
2. A public presentation of the position paper
3. A private oral examination by committee members

Advancement to Candidacy
After the area examination, the committee decides whether the student is ready for independent research work; if so, the student is advanced to candidacy.

Dissertation and Defense
Identify a significant unsolved research problem and submit a written dissertation proposal to the dissertation committee. The dissertation committee, comprising three department members and one member from an outside department, is approved by the graduate education committee. In addition to these four, the dissertation committee often includes a fifth examiner. This outside examiner should be a leading researcher in the candidate’s field who is not at the University of Oregon. The outside member should be selected a year before the candidate’s dissertation defense, and no later than six months before.

The student submits a written dissertation proposal to the committee for approval, and the proposal is then submitted to the graduate education committee. The proposal presents the research problems to be tackled, related research, methodology, anticipated results, and work plan. The committee may request an oral presentation, similar to the area exam, which allows the student to explain and answer question about the proposed research. The student then carries out the research.

The final stage is writing a dissertation and defending it in a public forum by presenting the research and answering questions about the methods and results. The dissertation committee may accept the dissertation, request small changes, or require the student to make substantial changes and schedule another defense.

Graduate School Requirements
PhD students must meet the requirements set by the Graduate School as listed in that section of this catalog.

Research Areas
It is important that a PhD student be able to work effectively with at least one dissertation advisor. Hence the student should identify, at an early stage, one or more areas of research to pursue. The student should also find a faculty member with similar interests to supervise the dissertation.

Computer and Information Science Courses
CIS 102. Fundamentals of Computer and Information Security. 4 Credits.
This course introduces fundamental concepts, terminologies, principles, methods, and scenarios of computer and information security.

CIS 110. Fluency with Information Technology. 4 Credits.
Introduction to information technology (IT), the study of computer-based information systems. Basics of the Internet and World Wide Web. Students create websites using XHTML and CSS.

CIS 111. Introduction to Web Programming. 4 Credits.
Project-based approach to learning computer programming by building interactive web pages using JavaScript and XHTML. Programming concepts including structured and object-oriented program design. CIS 110 recommended preparation.
Prereq: MATH 101 or equivalent.

CIS 122. Introduction to Programming and Problem Solving. 4 Credits.
Computational problem solving, algorithm design, data structures, and programming using a multi-paradigm programming language. Introduces techniques for program design, testing, and debugging.
Prereq: MATH 101 or equivalent.

CIS 196. Field Studies: [Topic]. 1-2 Credits.
Repeatable.

CIS 198. Workshop: [Topic]. 1-2 Credits.
Repeatable.

CIS 199. Special Studies in Computer Science: [Topic]. 1-5 Credits.
Repeatable.

CIS 199L. Special Studies in Computer Science: [Topic]. 1-5 Credits.
Repeatable.

CIS 210. Computer Science I. 4 Credits.
Basic concepts and practices of computer science. Topics include algorithmic problem solving, levels of abstraction, object-oriented design and programming, software organization, analysis of algorithm and data structures. Sequence with CIS 211, CIS 212.
Prereq: MATH 112. Prior programming experience strongly encouraged.
CIS 211. Computer Science II. 4 Credits.
Basic concepts and practices of computer science. Topics include
algorithmic problem solving, levels of abstraction, object-oriented design
and programming, software organization, analysis of algorithm and data
structures. Sequence with CIS 210, CIS 212.
Prereq: CIS 210.

CIS 212. Computer Science III. 4 Credits.
Basic concepts and practices of computer science. Topics include
algorithmic problem solving, levels of abstraction, object-oriented design
and programming, software organization, analysis of algorithm and data
structures. Sequence with CIS 210, CIS 211.
Prereq: CIS 211.

CIS 313. Intermediate Data Structures. 4 Credits.
Design and analysis of data structures as means of engineering efficient
software; attention to data abstraction and encapsulation. Lists, trees,
heaps, stacks, queues, dictionaries, priority queues.
Prereq: CIS 210, CIS 212, MATH 231, MATH 232 with grades
of B- or better.

CIS 314. Computer Organization. 4 Credits.
Introduction to computer organization and instruction-set architecture—
digital logic design, binary arithmetic, design of central processing unit
and memory, machine-level programming.
Prereq: CIS 210, CIS 211, CIS 212, MATH 231 with grades of B- or
better.

CIS 315. Intermediate Algorithms. 4 Credits.
Algorithm design, worst-case and average-behavior analysis,
correctness, computational complexity.
Prereq: CIS 313.

CIS 322. Introduction to Software Engineering. 4 Credits.
A project-intensive introduction to software engineering intended to build
skills, knowledge, and habits of mind that prepare students for 400-level
computer science courses, internships, and other software.
Prereq: CIS 210, CIS 211, CIS 212 with grades of B- or better.

CIS 330. C/C++ and Unix. 4 Credits.
Practical software design and programming activities in a C/C++ and
Unix environment, with emphasis on the details of C/C++ and good
programming style and practices.
Prereq: CIS 314.

CIS 333. Applied Cryptography. 4 Credits.
This course provides a systematic study of cryptography and its
application. It covers cryptographic algorithms, including symmetric-key
cryptography, public-key cryptography, cryptanalysis, cryptographic hash
functions, and their usage toward message authentication codes, digital
signatures, key management and distribution, and user authentication
protocols.
Prereq: CIS 212.

CIS 372M. Machine Learning for Data Science. 4 Credits.
Introduction to Machine Learning, with an emphasis on topics relevant for
data science. Multilisted with DSCI 372M.
Prereq: CIS 212, DSCI 345M, MATH 342.

CIS 399. Special Studies: [Topic]. 1-5 Credits.
Repeatable when the topic changes.

CIS 400M. Temporary Multilisted Course. 1-5 Credits.
Repeatable.

CIS 401. Research: [Topic]. 1-21 Credits.
Repeatable.
Prereq: CIS 313.

CIS 403. Thesis. 1-12 Credits.
Repeatable.
Prereq: CIS 313.

CIS 404. Internship: [Topic]. 1-4 Credits.
Repeatable.
Prereq: CIS 313.

CIS 405. Reading and Conference: [Topic]. 1-12 Credits.
Repeatable up to five times.
Prereq: CIS 313.

CIS 406. Field Studies: [Topic]. 1-21 Credits.
Repeatable.
Prereq: CIS 313.

CIS 407. Seminar: [Topic]. 1-5 Credits.
Repeatable when the topic changes. Opportunity to study in greater
depth specific topics arising out of other courses.
Prereq: CIS 313.

CIS 408. Workshop: [Topic]. 1-21 Credits.
Repeatable.
Prereq: CIS 313.

CIS 409. Practicum: [Topic]. 1-2 Credits.
The student assists other students who are enrolled in introductory
programming classes. For each four hours of scheduled weekly
consulting, the student is awarded 1 credit. Repeatable for maximum of 4
credits.
Prereq: CIS 313.

CIS 410. Experimental Course: [Topic]. 1-5 Credits.
Repeatable when the topic changes.

CIS 413. Advanced Data Structures. 4 Credits.
Complex structures, storage management, sorting and searching,
hashing, storage of texts, and information compression.
Prereq: CIS 315.

CIS 415. Operating Systems. 4 Credits.
Principles of operating system design. Process and memory
management, concurrency, scheduling, input-output and file systems,
security.
Prereq: CIS 313, CIS 330.

CIS 420. Automata Theory. 4 Credits.
Provides a mathematical basis for computability and complexity.
Models of computation, formal languages, Turing machines, solvability.
Nondeterminism and complexity classes.
Prereq: CIS 315.

CIS 422. Software Methodology I. 4 Credits.
Technical and nontechnical aspects of software development, including
specification, planning, design, development, management and
maintenance of software projects. Student teams complete projects.
Prereq: CIS 313.

CIS 423. Software Methodology II. 4 Credits.
Application of concepts and methodologies covered in CIS 422/522.
Student teams complete a large system design and programming project.
Final system specification, test plan, user documentation, and system
walk throughs.
Prereq: CIS 422 with a B- or better.
CIS 425. Principles of Programming Languages. 4 Credits.
Prereq: CIS 315.

CIS 427. Introduction to Logic. 4 Credits.
Prereq: CIS 315; CIS 425 recommended pre or co-req.

CIS 429. Computer Architecture. 4 Credits.
RISC (reduced instruction-set computer) and CISC (complex instruction-set computer) design, storage hierarchies, high-performance processor design, pipelining, vector processing, networks, performance analysis.
Prereq: CIS 330.

CIS 431. Introduction to Parallel Computing. 4 Credits.
Parallel architecture, theory, algorithms, and programming with emphasis on parallel programming, focusing on models, languages, libraries, and runtime systems.
Prereq: CIS 330.

CIS 432. Introduction to Networks. 4 Credits.
Principles of computer network design. Link technologies, packet switching, routing, inter-networking, reliability. Internet protocols. Programming assignments focus on protocol design.
Prereq: CIS 330. CIS 415 recommended.

CIS 433. Computer and Network Security. 4 Credits.
Prereq: CIS 415.

CIS 434. Computer and Network Security II. 4 Credits.
This course covers security threats and solutions for distributed systems and networks, particularly the Internet, the Internet of Things, and distributed systems based on them.
Prereq: CIS 432, CIS 433.

CIS 436. Secure Software Development. 4 Credits.
This course establishes a foundation for applying security principles to the lifecycle of software development in order to minimize software vulnerabilities and counter cyber threats.
Prereq: CIS 330.

CIS 441. Introduction to Computer Graphics. 4 Credits.
Introduction to the hardware, geometrical transforms, interaction techniques, and shape representation schemes that are important in interactive computer graphics. Programming assignments using contemporary graphics hardware and software systems.
Prereq: CIS 330.

CIS 443. User Interfaces. 4 Credits.
Introduction to user interface software engineering. Emphasis on theory of interface design, understanding the behavior of the user, and implementing programs on advanced systems.
Prereq: CIS 313.

CIS 445. Modeling and Simulation. 4 Credits.
Theoretical foundations and practical problems for the modeling and computer simulation of discrete and continuous systems. Simulation languages, empirical validation, applications in computer science.
Prereq: CIS 315, 330.

CIS 451. Database Processing. 4 Credits.
Fundamental concepts of DBMS. Data modeling, relational models and normal forms. File organization and index structures. SQL, embedded SQL, and concurrency control.
Prereq: CIS 313, 314.

CIS 453. Data Mining. 4 Credits.
Databases, machine learning, artificial intelligence, statistics, and data visualization. Examines data warehouses, data preprocessing, association and classification rule mining, and cluster analysis.
Prereq: CIS 451/551.

CIS 461. Introduction to Artificial Intelligence. 4 Credits.
Basic themes, issues, and techniques of artificial intelligence, including agent architecture, knowledge representation and reasoning, problem solving and planning, game playing, and learning.
Prereq: CIS 315.

CIS 472. Machine Learning. 4 Credits.
A broad introduction to machine learning and its established algorithms. Topics include concept learning, decision trees, neural network.
Prereq: CIS 315.

CIS 473. Probabilistic Methods for Artificial Intelligence. 4 Credits.
Fundamental techniques for representing problems as probability distributions, performing inference, and learning from data. Topics include Bayesian and Markov networks, variable elimination, loopy belief propagation, and parameter.
Prereq: CIS 315.

CIS 474. Neural Networks. 4 Credits.
Introduces the basic concepts and applications of neural networks. Topics include artificial neural networks, learning algorithms, and applications.
Prereq: CIS 315.

CIS 475. Computer and Information Science. 4 Credits.
Computer and information science topics not covered in other courses.
Prereq: CIS 315.

CIS 500M. Temporary Multilisted Course. 1-5 Credits.
Repeatable.

CIS 503. Thesis. 1-16 Credits.
Repeatable.

CIS 507. Seminar: [Topic]. 1-5 Credits.
Repeatable. Opportunity to study in greater depth specific topics arising out of other courses.

CIS 508. Workshop: [Topic]. 1-21 Credits.
Repeatable.

CIS 510. Experimental Course: [Topic]. 1-5 Credits.
Repeatable.

CIS 513. Advanced Data Structures. 4 Credits.
Complex structures, storage management, sorting and searching, hashing, storage of texts, and information compression.

CIS 520. Automata Theory. 4 Credits.
Provides a mathematical basis for computability and complexity. Models of computation, formal languages, Turing machines, solvability, nondeterminism and complexity classes.

CIS 522. Software Methodology I. 4 Credits.
Technical and nontechnical aspects of software development, including specification, planning, design, development, management and maintenance of software projects. Student teams complete projects.

CIS 523. Software Methodology II. 4 Credits.
Student teams complete a large system design and programming project. Final system specifications, test plan, user documentation, and system walkthrough.
Prereq: CIS 522
CIS 527. Introduction to Logic. 4 Credits.

CIS 529. Computer Architecture. 4 Credits.
RISC (reduced instruction-set computer) and CISC (complex instruction-set computer) design, storage hierarchies, high-performance processor design, pipelining, vector processing, networks, performance analysis.

CIS 531. Introduction to Parallel Computing. 4 Credits.
Parallel architecture, theory, algorithms, and programming with emphasis on parallel programming, focusing on models, languages, libraries, and runtime systems.

CIS 532. Introduction to Networks. 4 Credits.
Principles of computer network design. Link technologies, packet switching, routing, inter-networking, reliability. Internet protocols. Programming assignments focus on protocol design.

CIS 533. Computer and Network Security. 4 Credits.

CIS 534. Computer and Network Security II. 4 Credits.
This course covers security threats and solutions for distributed systems and networks, particularly the Internet, the Internet of Things, and distributed systems based on them.

CIS 536. Secure Software Development. 4 Credits.
This course establishes a foundation for applying security principles to the lifecycle of software development in order to minimize software vulnerabilities and counter cyber threats.

CIS 541. Introduction to Computer Graphics. 4 Credits.
Introduction to the hardware, geometrical transforms, interaction techniques, and shape representation schemes that are important in interactive computer graphics. Programming assignments using contemporary graphics hardware and software systems.

CIS 543. User Interfaces. 4 Credits.
Introduction to user interface software engineering. Emphasis on theory of interface design, understanding the behavior of the user, and implementing programs on advanced systems.

CIS 545. Modeling and Simulation. 4 Credits.
Theoretical foundations and practical problems for the modeling and computer simulation of discrete and continuous systems. Simulation languages, empirical validation, applications in computer science.

CIS 551. Database Processing. 4 Credits.
Fundamental concepts of DBMS. Data modeling, relational models and normal forms. File organization and index structures. SQL, embedded SQL, and concurrency control.

CIS 553. Data Mining. 4 Credits.

CIS 561. Introduction to Compilers. 4 Credits.
Lexical analysis, parsing, attribution, code generation. Prereq: CIS 314 or equivalent, 624. CIS 420/520 strongly recommended.

CIS 571. Introduction to Artificial Intelligence. 4 Credits.
Basic themes, issues, and techniques of artificial intelligence, including agent architecture, knowledge representation and reasoning, problem solving and planning, game playing, and learning.

CIS 572. Machine Learning. 4 Credits.
A broad introduction to machine learning and its established algorithms. Topics include concept learning, decision trees, neural network.

CIS 573. Probabilistic Methods for Artificial Intelligence. 4 Credits.
Fundamental techniques for representing problems as probability distributions, performing inference, and learning from data. Topics include Bayesian and Markov networks, variable elimination, loopy belief propagation, and parameter.

CIS 601. Research: [Topic]. 1-16 Credits. Repeatable.

CIS 602. Supervised College Teaching. 1-5 Credits. Repeatable.

CIS 603. Dissertation. 1-16 Credits. Repeatable.

CIS 604. Internship: [Topic]. 1-4 Credits. Repeatable.

CIS 605. Reading and Conference: [Topic]. 1-16 Credits. Repeatable.

CIS 606. Field Studies: [Topic]. 1-16 Credits. Repeatable.

CIS 607. Seminar: [Topic]. 1-5 Credits. Repeatable. Research topics are presented.

CIS 608. Colloquium: [Topic]. 1 Credit. Repeatable.

CIS 609. Final Project. 1-16 Credits. Repeatable. Final project for master's degree without thesis.

CIS 610. Experimental Course: [Topic]. 1-5 Credits. Repeatable.

CIS 621. Algorithms and Complexity. 4 Credits.
Design and analysis of algorithms, strategies for efficient algorithms, introduction to complexity theory including NP-completeness. Prereq: CIS 420/520 strongly recommended.

CIS 624. Structure of Programming Languages. 4 Credits.
Introduction to axiomatic, operational, and denotational semantics. Environments, stores, and continuations. Type theory, subtypes, polymorphism, and inheritance. Functional and logic programming.

CIS 630. Distributed Systems. 4 Credits.
Principles of distributed computer systems: interprocess communication, distributed file systems, distributed timing and synchronization, distributed programming, transactions, process scheduling, distributed shared memory. Prereq: CIS 415 or equivalent, CIS 429/529.

CIS 631. Parallel Processing. 4 Credits.
Advanced topics in parallel processing including massively parallel computer architecture, supercomputers, parallelizing compiler technology, performance evaluation, parallel programming languages, parallel applications. Prereq: CIS 529, CIS 531.
**CIS 632. Computer Networks. 4 Credits.**
Advanced issues in computer networks, focusing on research to extend the services offered by the Internet.
Prereq: CIS 432/532.

**CIS 633. Advanced Network Security. 4 Credits.**
Classic and state-of-the-art research topics in network security; threats and attacks, defense algorithms and mechanisms, measurement and evaluation of both security problems and solutions. Offered alternate years.
Prereq: CIS 533.

**CIS 640. Writing in Computer Research. 2 Credits.**
Students learn to provide and accept constructive criticism of writing samples in a workshop format.

**CIS 670. Data Science. 4 Credits.**
Data science is the development of methods to study large and complex data sets. Methods that scale to very large data sets are of particular interest. This course introduces state-of-art data science methods focused on processing very large data sets of real-world data.
Prereq: CIS 551.

**Computer Information Technology Courses**

**CIT 281. Web Applications Development I. 4 Credits.**
Fundamentals of web application development using open-source software tools and technologies (Unix, Git), client-side frameworks, server-side programming (Node.js, PHP), model-view-controller pattern, data storage and APIs, cloud hosting.
Prereq: CIS 111 with a B- or higher.

**CIT 381. Database Systems. 4 Credits.**
Introduction to database systems, emphasis on database design and access. Database concepts, data modeling, SQL, connecting database to web.
Prereq: B- or better in CIT 281, and CIS 110 or 115.

**CIT 382. Web Applications Development II. 4 Credits.**
Server- and client-side technologies and their interaction for database-driven web applications; application frameworks, single-page applications, cloud platforms, and open-source software stacks—MEAN (MongoDB, ExpressJS, AngularJS, Node.js) versus LAMP (Linux, Apache, MySQL, PHP).
Prereq: CIT 381.

**CIT 383. Networking Fundamentals. 4 Credits.**
Prereq: CIT 382.

**CIT 405. Reading and Conference: [Topic]. 1-4 Credits.**
Repeatable.