COMPUTER AND INFORMATION SCIENCE

Admission

Applicants for the MS in Computer and Information Science are required to meet the following requirements:

1. A bachelor's degree from an accredited institution with a grade point average of B or better. Applicants with lower GPAs may be granted conditional admission. Preference will be given to students with a background in Computer and Information Science, engineering, math and science.
2. Satisfactory completion of the following:
   a. Calculus I & II
   b. One course in probability and statistics or linear algebra)
   c. Programming Language (Preferably C/C++ I & II)
   d. One course in data structures with algorithm analysis
   e. One course in computer architecture
   f. One course in operating systems

Note: Students may be admitted conditionally to make up the deficiencies in item 2. In this case, the applicant will be required to complete appropriate courses within two years from the date of entrance. These courses may not be used to satisfy degree requirements.

1. Two letters of recommendation, with at least one from a person familiar with the candidate's academic performance, are required. Copies of the applicant's undergraduate transcripts and degree must be submitted.

Degree Requirements

To satisfy the requirements for the MS degree in CIS, all students admitted to the program are expected to complete 30 semester hours of graduate coursework, with a cumulative grade point average of *B* or better. The program of study consists of core courses, electives and the coursework/project/thesis option.

Minimum Grade Requirement in addition to maintaining a minimum cumulative GPA of 3.0 or higher every semester.

- Courses in which grades of C- or below are earned cannot be used to fulfill degree requirements.
- A minimum of a 3.0 cumulative GPA or higher is required at the time of graduation.

Accelerated Master's Options for Undergraduate Students (4+1 Program)

Accelerated master's (4+1) programs in the Computer and Information Science (CIS) department allow qualified undergraduate students to seamlessly transition into the department's graduate programs. These programs will enable students to earn both a bachelor's and a master's degree in a reduced timeframe, enhancing their academic experience and providing a cost-effective pathway to advanced degrees.

Students enrolled in this option can take eligible 500-level courses during their junior and senior years, with up to 9 credit hours of such coursework being double-counted toward both degrees. Additionally, another 6 credit hours earned but not applied to the bachelor degree can later be counted toward the master's degree. Depending on the number of graduate courses taken while working toward the bachelor program, students will need to complete 15-21 credit hours to finish the master's program after earning their undergraduate degree.

BS in Computer and Information Science (CIS) or Software Engineering (SWE) can advance to M.S. in CIS, Data Science (DATA), Artificial Intelligence (AI), Software Engineering (SWE) or Cybersecurity and Information Assurance (CIA).

A maximum of 9 credits from combined undergraduate and graduate courses can be double-counted toward both the undergraduate and graduate degrees. This will streamline the process and reduce the total credit load required to complete both degrees. Any 500-level course that is part of the respective master's program can be selected for double-counting, as shown in the following table. If there is a mismatch in credit hours between the combined course pair, only the smaller number of credits will be counted.
In addition, students may apply up to 6 additional credits of 500-level courses toward their master's degree, taken during their undergraduate study, though these credits cannot be double-counted. This allows students to make substantial progress toward their graduate degree while still completing their undergraduate requirements. However, the courses of these six additional credits should be listed in the corresponding graduate program.

To ensure that students entering the 4+1 programs are well-prepared for the academic rigor of graduate-level coursework, the following admission criteria will apply:

- A minimum cumulative GPA of 3.2 at the University of Michigan-Dearborn after completing at least 60 credits.
- Letters of recommendation are waived.
- A regular admission review will be streamlined for students with a cumulative GPA of 3.4 or higher at the University of Michigan-Dearborn after completing at least 85 credits.
- Students must have completed CIS 310, CIS350/3501, CIS 375, and CIS 427 with a grade of B or better.

The following undergraduate programs are approved for the MS-CIS 4+1 program:

1. BS in Computer and Information Science
2. BS in Software Engineering

Advanced Standing

Up to six graduate credit hours (grade of *B* or better) may be transferred from another accredited institution .

Master's Thesis Committee

A Master's Thesis committee consists of three full-time CIS faculty members, one of whom is the thesis advisor, and requires the approval of the CIS graduate committee. When deemed appropriate, the chair of the graduate committee may request, in the committee, the presence of an additional member from outside the department.

Course Requirements

The 30 semester hours of required graduate work are as follows:

Coursework Option

Code	Title	Credit Hours
Core Courses		9
Two Specialization Areas		12
Cognate Courses		6
CIS Elective Course		3
Total Credit Hours		**30**

Project Option

Code	Title	Credit Hours
Core Courses		9
Two Specialization Areas		12
Cognate Courses		6
Project		3
Total Credit Hours		**30**

Thesis Option

Code	Title	Credit Hours
Core Courses		9
One Specialization Area		6
Cognate Courses		6
CIS Elective		3
Thesis		6
Total Credit Hours		**30**

Core

All students are required to take one course from each of the following three categories:

Code	Title	Credit Hours
Category 1		
CIS 505	Algorithm Analysis and Design [2]	3
CIS 566	Software Architecture and Design Patterns [2]	3
Category 2		
CIS 527	Computer Networks	3
CIS 544	Computer and Network Security [2]	3
Category 3		
CIS 574	Compiler Design [2]	3
CIS 578	Advanced Operating Systems	3

Specializations

Each student is required to take at least four courses from two of the following specialization areas:

Code	Title	Credit Hours
Artificial Intelligence		
CIS 511	Introduction to Natural Language Processing [2]	3
CIS 536	Text Mining and Information Retrieval [2]	3
CIS 568	Data Mining	3
CIS 5700	Advanced Data Mining	3
CIS 579	Artificial Intelligence [2]	3
CIS 581	Computational Learning [2]	3
CIS 582	Trustworthy Artificial Intelligence [2]	3
CIS 583	Deep Learning [2]	3
CIS 585	Advanced Artificial Intelligence	3
CIS 685	Research Advances in Artificial Intelligence	3
Computer Graphics, Geometric Modeling, and Game Design		
CIS 505	Algorithm Analysis and Design [1, 2]	3
CIS 515	Computer Graphics and Visual Computing [2]	3
CIS 551	Advanced Computer Graphics	3
CIS 552	Information Visualization with Parallel Computing [2]	3
CIS 5570	Introduction to Big Data	3
CIS 587	Computer Game Design and Implementation [2]	3
CIS 588	Computer Game Design II [2]	3
CIS 652	Advanced Information Visualization and Virtualization	3
Computer Networks and Security		
CIS 527	Computer Networks [1]	3
CIS 537	Advanced Networking and Distributed Systems [2]	3
CIS 540	Foundation of Information Security	3
CIS 544	Computer and Network Security [1,2]	3
CIS 545	Data Security and Privacy [2]	3
CIS 546	Security and Privacy in Wireless Networks [2]	3
CIS 548	Security and Privacy in Cloud Computing	3
CIS 549	Software Security [2]	3
CIS 5570	Introduction to Big Data	3
CIS 559	Principles of Social Network Science	3
CIS 569	Internet of Things and Smart Cities	3
CIS 571	Web Services	3
CIS 584	Advanced Computer and Network Security	3
CIS 624	Research Advances in Computer and Network Security	3
CIS 647	Research Advances in Networking and Distributed Systems	3
Data Management and Analytics		
CIS 511	Introduction to Natural Language Processing [2]	3
CIS 534	Semantic Web	3
CIS 536	Text Mining and Information Retrieval [2]	3
CIS 545	Data Security and Privacy [2]	3
CIS 548	Security and Privacy in Cloud Computing	3
CIS 556	Database Systems [2]	3
CIS 5570	Introduction to Big Data	3
CIS 559	Principles of Social Network Science	3
CIS 579	Artificial Intelligence [2]	3
CIS 562	Web Information Management	3
CIS 568	Data Mining	3
CIS 5700	Advanced Data Mining	3
CIS 571	Web Services	3
CIS 581	Computational Learning [2]	3
CIS 582	Trustworthy Artificial Intelligence [2]	3
CIS 583	Deep Learning [2]	3
CIS 584	Advanced Computer and Network Security	3

CIS 585	Advanced Artificial Intelligence	3
CIS 586	Advanced Data Management	3
CIS 658	Research Advances in Data Management	3
CIS 679	Research Advances in Computational Game Theory and Economics	3
Information Systems		
CIS 511	Introduction to Natural Language Processing [2]	3
CIS 536	Text Mining and Information Retrieval [2]	3
CIS 540	Foundation of Information Security	3
CIS 556	Database Systems [2]	3
CIS 559	Principles of Social Network Science	3
CIS 564	Enterprise Information Systems	3
CIS 571	Web Services	3
CIS 572	Object Oriented Systems Design	3
CIS 579	Artificial Intelligence [2]	3
CIS 585	Advanced Artificial Intelligence	3
CIS 586	Advanced Data Management	3
Software Engineering		
CIS 525	Web Technology [2]	3
CIS 535	Wireless Technologies and Pervasive Computing [1]	3
CIS 549	Software Security [2]	3
CIS 553	Software Engineering	3
CIS 565	Software Quality Assurance	3
CIS 566	Software Architecture and Design Patterns [2]	3
CIS 575	Software Engineering Mgmt	3
CIS 577	S/W User Interface Dsgn&Analys	3
CIS 580	Data Analytics in Software Engineering	3
CIS 587	Computer Game Design and Implementation [2]	3
CIS 588	Computer Game Design II [2]	3
CIS 678	Research Advances in Software Engineering	3
System Software		
CIS 505	Algorithm Analysis and Design [1, 2]	3
CIS 512	Introduction to Quantum Computing [2]	3
CIS 527	Computer Networks [1]	3
CIS 535	Wireless Technologies and Pervasive Computing [1]	3
CIS 544	Computer and Network Security [1, 2]	3
CIS 548	Security and Privacy in Cloud Computing	3
CIS 5570	Introduction to Big Data	3
CIS 569	Internet of Things and Smart Cities	3
CIS 571	Web Services	3
CIS 574	Compiler Design [1, 2]	3
CIS 578	Advanced Operating Systems [1]	3
CIS 579	Artificial Intelligence [2]	3
CIS 584	Advanced Computer and Network Security	3
CIS 589	Edge Computing [2]	3
ECE 554	Embedded Systems	3
Web/Cloud Computing		
CIS 511	Introduction to Natural Language Processing [2]	3
CIS 525	Web Technology [2]	3
CIS 534	Semantic Web	3
CIS 535	Wireless Technologies and Pervasive Computing [1]	3
CIS 536	Text Mining and Information Retrieval [2]	3
CIS 540	Foundation of Information Security	3
CIS 544	Computer and Network Security [1,2]	3
CIS 548	Security and Privacy in Cloud Computing	3
CIS 549	Software Security [2]	3
CIS 559	Principles of Social Network Science	3
CIS 562	Web Information Management	3
CIS 571	Web Services	3
CIS 579	Artificial Intelligence [2]	3
CIS 584	Advanced Computer and Network Security	3
CIS 585	Advanced Artificial Intelligence	3
CIS 589	Edge Computing [2]	3
CIS 624	Research Advances in Computer and Network Security	3

[1] May not be used as concentration course if counted as core course.
[2] Simultaneous credit toward eligible undergraduate majors and MS CIS for students admitted to the 4+1 option. Please see the College's website for admission requirements and program details.

Cognate

Students can take any graduate-level courses approved by the student's advisor, as described in the requirements for graduation (excluding ENGR 500 and ENGR 501).

Coursework Option

Students must take a CIS elective course for 3 credit hours.

- Core courses - 9 credit hours
- Two specialization areas - 12 credit hours
- Cognate courses - 6 credit hours
- CIS elective course - 3 credit hours

Project Option

Students must take CIS 695, Master's Project for 3 credit hours.

- Core courses - 9 credit hours
- Two specialization areas - 12 credit hours
- Cognate courses - 6 credit hours
- Project - 3 credit hours

Thesis Option

Students must take a CIS elective course for 3 credit hours and CIS 699, Master's Thesis for 6 credit hours.

- Core courses - 9 credit hours
- One specialization area - 6 credit hours
- Cognate courses - 6 credit hours
- CIS elective course - 3 credit hours
- Thesis - 6 credit hours

The Ph.D. CIS program will follow the guidelines of the Rackham Graduate School and consists of at least 36 credits of coursework beyond the bachelor's degree and at least 24 dissertation credits.

There are three types of students who will be admitted to the Ph.D. CIS program:

- Students with just a B.S. in computer and information science or closely related area
  - Complete at least 36 credit hours of coursework, including 30 credit hours toward the completion of the MS degree, and at least 24 dissertation credits, and can earn an M.S. CIS, M.S. DS, M.S. SWE, M.S. CIA, or M.S. AI along the way to their Ph.D. CIS.
- Students with a relevant Rackham or a UM-Dearborn master's degree
  - Complete at least 6 credits of coursework and at least 24 dissertation credits.
- Students with a relevant non-Rackham and non-UM-Dearborn master's degree
  - Complete at least 18 credits of coursework and at least 24 credits of thesis research.

Each student is guided by a research advisor and a dissertation committee and has to pass the following major milestones:

- Identifying the faculty advisor and research topic
- Completion of required coursework
- Passing the qualifying examination consisting of two parts:
  - Curriculum exam
  - Research proficiency exam
- Advancement to candidacy
- Forming the dissertation committee
- Passing the dissertation proposal examination
- Completion of required research credit hours
- Preparation of a written dissertation and its oral defense

The target typical time of degree completion is five (5) years.

Step 1: Qualification

In addition to fulfilling the following coursework requirements, a Ph.D. student must have:

- a 3.5/4.0 GPA overall and a 3.5/4.0 GPA for all CIS courses to sign up for these exams
- A working relationship with a CIS faculty member as a research advisor

Breadth Requirement

The breadth requirement is satisfied by taking three courses (9 credit hours), one from each of three of the four concentration areas below. All Ph.D. breadth courses must be completed with a grade of B+ or better within 3 full terms (1.5 years) for a full-time student with a relevant Master's degree or 4 full terms (2 years) for all other full-time students.

Depth Requirement

The depth requirement is satisfied by taking four courses (12 credit hours). At least one and at most two of these courses can be CIS 791—Advanced Guided Study for Doctoral Students (Directed Study course below). The remainder of these courses must be in the same concentration area, below, and must be different from the courses taken for the breadth requirement. Each of these Ph.D. depth courses must be completed with a grade of A- or better and may not be completed via equivalency. At least one of these courses must be 600-level.

Mathematics Requirements

The student must take CIS 505 (Algorithm Design and Analysis) and at least one other advanced mathematics course. CIS 505 must be taken within the first two semesters after enrollment in the Ph.D. CIS program. These latter mathematics courses can be used to meet the cognate course requirement. The other required mathematics course must be selected from the list provided below.

- MATH 504: Dynamical Systems
- MATH 512: Introduction to Modern Algebra
- MATH 520: Stochastic Processes
- MATH 523 Applied Linear Algebra
- MATH 525: Statistical Inference
- MATH 551: Advanced Calculus
- MATH 554: Fourier Series and Boundary Value Problems
- MATH 555: Functions of a Complex Variable with Applications
- MATH 562: Mathematical Modeling
- MATH 572: Intro to Computational Mathematics
- MATH 592: Introduction to Topology
- STAT 530: Applied Regression Analysis
- STAT 535: Data Analysis and Modeling
- STAT 560: Time Series
- STAT 590: Topics in Applied Statistics

These latter mathematics courses can be used to meet the cognate course requirement.

Elective Requirement

The remaining CIS coursework must be chosen from the concentration area courses, below (*indicates a course in the planning stages). 0:9 credits of concentration area courses are required depending on the student's individual background. Students should consult with their advisor.

Code	Title	Credit Hours
1. Data Management		
CIS 534	Semantic Web	3
CIS 536	Text Mining and Information Retrieval	3
CIS 556	Database Systems	3
CIS 5570	Introduction to Big Data	3
CIS 562	Web Information Management	3
CIS 569	Internet of Things and Smart Cities	3
CIS 586	Advanced Data Management	3
CIS 658	Research Advances in Data Management	3
2. Data Science		
CIS 511	Introduction to Natural Language Processing	3
CIS 5570	Introduction to Big Data	3
CIS 559	Principles of Social Network Science	3
CIS 568	Data Mining	3
CIS 5700	Advanced Data Mining	3
CIS 579	Artificial Intelligence	3
CIS 581	Computational Learning	3
CIS 582	Trustworthy Artificial Intelligence	3
CIS 583	Deep Learning	3
CIS 585	Advanced Artificial Intelligence	3
CIS 679	Research Advances in Computational Game Theory and Economics	3

CIS 685	Research Advances in Artificial Intelligence	3
STAT 530	Applied Regression Analysis	3
3. Systems and Security		
CIS 512	Introduction to Quantum Computing	3
CIS 527	Computer Networks	3
CIS 535	Wireless Technologies and Pervasive Computing	3
CIS 537	Advanced Networking and Distributed Systems	3
CIS 540	Foundation of Information Security	3
CIS 544	Computer and Network Security	3
CIS 545	Data Security and Privacy	3
CIS 546	Security and Privacy in Wireless Networks	3
CIS 548	Security and Privacy in Cloud Computing	3
CIS 549	Software Security	3
CIS 552	Information Visualization with Parallel Computing	3
CIS 571	Web Services	3
CIS 574	Compiler Design	3
CIS 578	Advanced Operating Systems	3
CIS 582	Trustworthy Artificial Intelligence	3
CIS 584	Advanced Computer and Network Security	3
CIS 589	Edge Computing	3
CIS 624	Research Advances in Computer and Network Security	3
CIS 647	Research Advances in Networking and Distributed Systems	3
4. Software Engineering		
CIS 553	Software Engineering	3
CIS 565	Software Quality Assurance	3
CIS 566	Software Architecture and Design Patterns	3
CIS 575	Software Engineering Mgmt	3
CIS 577	S/W User Interface Dsgn&Analys	3
CIS 580	Data Analytics in Software Engineering	3
CIS 587	Computer Game Design and Implementation	3
CIS 588	Computer Game Design II	3
CIS 678	Research Advances in Software Engineering	3

Directed Study

A commitment from an approved CIS faculty member to act as one's research advisor is a requirement of the qualification stage. All students who aspire to receive a Ph.D. must demonstrate a potential for conducting original research. This is accomplished by completing either 3 or 6 credit hours of a research-oriented directed study (CIS 791—Advanced Guided Study for Doctoral Students) prior to the Research Proficiency Exam. These must be taken while in residence on the UM-Dearborn campus.

Ph.D. students must complete 3 credits of CIS 791 within their first two semesters (Fall and Winter Semesters) of the Ph.D. CIS program.

Ph.D. Research Seminar

This seminar will be offered in the fall and winter semesters.

Continuous attendance will be required of all program students, including those at the pre-candidacy level. The focus will be on reports by students on the status of their research projects. Occasional presentations by guest speakers will also be included. This seminar will have no credit hours. Passing the course will be based on participation and attendance.

Ph.D. Research Methodology Seminar (ENGR 700)

This seminar course must be completed within the first two semesters after enrolling into the program. Students must register for two semesters of the course (one Fall semester and one Winter semester). Besides the fundamental training for conducting high-level scholarly research, the seminars will also include the Responsible Conduct of Research and Scholarship training workshops. The seminars will carry no credit hours. Passing is based on participation and attendance.

Cognate Credits

At least 4 credit hours of coursework must be outside the computer and information science area (excluding ENGR 500 and ENGR 501). The second mathematics class (see above) can be used to satisfy all or part of this requirement. Other ways of satisfying this requirement are:

- Completion of at least four credit hours of approved cognate credits, which must be from outside the CIS department. The minimum acceptable grade for a cognate course is a B.
- Completion of a University of Michigan Master's degree, which includes a cognate component. This coursework must have been completed no more than 5 years before admission to the CIS Ph.D. Program.
- Completion of a relevant Master's degree from another university which had coursework that meets the expectation of the program cognate requirement, without transferring the credit to the transcript. This coursework must have been completed no more than 5 years before admission to the CIS Ph.D. Program. These courses do not apply toward the minimum 18 (or 36) credit hours required for the degree and do not appear on the University transcript.

Qualifying Exam

There are two qualification exams, and they should be taken in sequence: the Curriculum Exam and the Research Exam. To take these exams, a student must have an overall and CIS GPA of at least 3.5 and will be given two attempts to pass each exam.

Once all the requirements for Qualification have been met, a decision whether the student is qualified to continue in the Ph.D. Program is made by vote of the CIS Faculty in attendance.

Curriculum Exam:

The goal of this examination will be to ensure that students have a good understanding of the fundamentals of Computer and Information Science in the broad area of their research. The examination committee will be selected from the Graduate Faculty by the Ph.D. Program Committee. The examination will include the following steps:

1. The student selects three (3) CIS graduate courses during the first semester of the program. One course should be in the area of the student's research. The two other courses should be in separate areas.
2. These three (3) courses should be approved by the Ph.D. CIS program committee to ensure that the student has proper fundamental knowledge in CIS for his/her study in the program.
3. For each of the three courses, if the student receives at least an A- in this course, the written exam is waived. However, if the student receives a grade lower than A- in this course, a 1-hour-long

written exam on the course material, together with the underlying undergraduate material, is taken by the student.

4. For students who do not pass this exam in the first time, an additional oral exam is conducted.

Research Proficiency Exam:

The student's ability to conduct independent research is evaluated through a written report of a project done in CIS 791, followed by a 90-minute oral exam by three faculty members. The student's research advisor cannot be among the three faculty. The Ph.D. CIS committee selects the three faculty members based on the student's research area. The student should prepare a 45-minute presentation, followed by up to 45 minutes of questions. Examiners will be given the written report on the Directed Study at least one week before the examination, and each examiner will submit a written report on the examination. The student must submit four copies of the written report to the Ph.D. CIS program committee director at least one week before the research proficiency exam.

Step 2: Candidacy

The decision to admit a student to Candidacy is based on the following,

- The CIS Qualification process has been completed successfully
- Completion of at least a 4-credit cognate course with a grade of at least B

A student must apply for candidacy by submitting the appropriate forms to the CIS Ph.D. Program Director before the term in which the student plans to become a candidate. Candidacy is *not* awarded automatically; it must be applied for. The achievement of candidacy is considered an important milestone in a Ph.D. student's progress. A full-time student with a relevant Master's degree is making satisfactory progress if candidacy is achieved after 3 full terms (1.5 years) and must be achieved after 4 full terms (2 years). Other full-time students are making satisfactory progress if candidacy is achieved after 5 full terms (2.5) years and must be achieved within 6 full terms (3 years). Part-time students are making satisfactory progress if candidacy is achieved after 7 full terms (3.5) years and must be achieved within 8 full terms (4 years).

Step 3: Dissertation and Defense

Dissertation and Defense for the CIS Ph.D. requires the following:

- Identify a research advisor and agree on an appropriate topic
- Identify a doctoral committee
- Submit and defend a proposal for the doctoral research content
  - Dissertation Proposal Examination
- Do the research and write the dissertation
- Submit and defend the dissertation

The Dissertation Committee

The composition of a dissertation committee must adhere to the Rackham guidelines (see the Rackham dissertation handbook).

- Dissertation committees must have at least four members, including at least three tenure or tenure-track members (appointment as Professor, Associate Professor, or Assistant Professor) of the instructional faculty affiliated with a Rackham doctoral program.
- The chair, or one of the co-chairs in the case of co-advising, must be a member of the graduate faculty in the Computer and Information Science (CIS) Department.
- At least two of the four committee members must hold at least 50% appointment as tenured or tenure-track faculty in the CIS Department, with at least one being a member of the graduate faculty.
- Committees must have a cognate member from outside the department: a faculty member with at least 50% appointment from a Rackham Doctoral program other than Ph.D CIS. The cognate member may not serve as chair or co-chair.
- A committee may have a sole chair or two co-chairs. By special arrangement, retired faculty members who were affiliated with a Rackham doctoral program or research professors may serve as sole chairs. Persons who may serve as co-chair, but not sole chair, include:
  - tenure or tenure-track members of the university's instructional faculty who are not affiliated with a Rackham doctoral program;
  - research faculty;
  - instructors and lecturers;
  - similarly qualified university faculty or staff, or a person from outside the university; and
  - former university faculty members who have moved to a faculty position at another university
- Committees may include a person holding a regular clinical, research professor, visiting, adjunct, instructor, or lecturer appointment. Subject to review on a case-by-case basis, a committee may include other qualified university faculty and staff, or a person from outside the university who can provide expertise in the candidate's research area.
- Persons who do not have an earned doctorate, whether affiliated with a Rackham doctoral program or not, must be approved for committee service on a case-by-case basis.

For more information on the composition of the committee and roles of the members, see Guidelines for Dissertation Committee Service (https://rackham.umich.edu/downloads/oard-dissertation-committee-guidelines.pdf). The committee chair, graduate program personnel, or the graduate student may call a meeting of the dissertation committee, as needed.

Dissertation Proposal Examination

The next important step of the Dissertation and Dissertation Defense stage will be the Dissertation Proposal Examination. The main objective is to ensure that the proposed research topic, as well as the student's background and relevant knowledge, are of sufficient strength.

The examination will consist of a written Dissertation Proposal and a presentation open to the public by the student. The examination will be conducted by the Dissertation Committee formed by the Ph.D. Program Committee. As a rule, the Dissertation Committee will continue overseeing the student's work to the stage of final dissertation defense.

Dissertation Defense

After the initial requirements are met, the student may proceed with the dissertation research and the writing of the dissertation. The dissertation should document the original contributions made by the candidate as a result of independent research. This research work should be of archival quality. In advance of graduation, the dissertation must be approved by all the members of the student's dissertation committee. To obtain this approval a student must submit a written copy of the dissertation to the dissertation committee and defend the research work at a final oral examination open to other faculty, students, and the interested public.

The dissertation must strictly follow the Rackham Graduate School Dissertation guidelines as described in the Dissertation Handbook Guidelines for copyrighting, publishing and distributing, dissertation embargo and distribution limitations.

Students are expected to complete the degree within two years of passing the dissertation proposal exam, but no more than seven years from the date of the first enrollment in the Ph.D. CIS program. The Ph.D. CIS committee conducts annual reviews to evaluate progress toward degree completion. Students defending the dissertation must be registered in the 990 Dissertation Research course.

Copies of the dissertation, approved by the student's research advisor, must be provided to the committee at least two weeks before the oral defense. Copies of the dissertation given to the committee should be in final form and must meet campus dissertation guidelines (https://umdearborn.edu/office-graduate-studies/doctoral-dissertation-policies-and-procedures/).

Dissertation committee members are required to submit written evaluations of the student's dissertation prior to the oral defense. The dissertation committee members must be present at the dissertation defense. Since the defense examination includes the formal public presentation of the dissertation research, it will be publicized throughout the college and the university. The time between passing the Dissertation Proposal Examination and the dissertation oral defense should be at least 14 weeks.

Publication of Research

The Ph.D. CIS program is designed to give a student a comprehensive and in-depth knowledge of the computer and information science field, as well as training in research methods. Therefore, based on the student's dissertation research, the student is required to have published at least 1 paper in a top-quality, peer-reviewed, professional conference or journal in the field, prior to scheduling the final oral examination. The department will provide a list of acceptable top-quality conferences and journals in all CIS research areas.

Time Limit for Completing the Degree

The CIS Ph.D program has a time limit of 7 years. Full-time students are expected to complete the degree within five years of achieving candidacy, but no more than seven years from the date of the first enrollment in the CIS Ph.D program. Students who have not completed their degree within the seven-year limit may petition the CIS Ph.D Program Committee for an extension of time to degree with a plan for completion. A student who does not complete the degree after two years of extension may be returned to pre-candidacy status and required to meet candidacy requirements again.

Learning Goals

1. Students will be able to identify, explain, and apply knowledge of mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices.
2. Students will be able to analyze a CIS problem and identify and define the computing requirements appropriate to its solution.
3. Students will be able to design, implement and evaluate a computer-based system, process, component, or program to meet desired needs.
4. Students will be able to apply design and development principles in the construction of computer-based systems of varying complexity.
5. Students will be able to compare various research contributions and communicate effectively as researchers and/or practitioners.

CIS 505 Algorithm Analysis and Design 3 Credit Hours
This course investigates how to design efficient algorithms. Topics covered include: asymptotic analysis, average-case and worst-case analysis, recurrence analysis, amortized analysis, classical algorithms, computational complexity analysis, NP-completeness, and approximation algorithms. In addition, the course investigates approaches to algorithm design including: greedy algorithms, divide and conquer, dynamic programming, randomization, and branch and bound.
Prerequisite(s): CIS 350 or CIS 3501 or IMSE 350 or (ECE 370 and MATH 276) or (ECE 370 and ECE 276)
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or or Doctorate
Can enroll if College is Engineering and Computer Science

CIS 510 Computer Interfacing 3 Credit Hours
This course covers fundamentals of computer interfacing to the external world through the following: parallel and serial interfaces, timers, interrupts, Uart, and Duart. Programming aspects will be emphasized. Knowledge of an assembly language required. (YR).
Prerequisite(s): CIS 310

CIS 511 Introduction to Natural Language Processing 3 Credit Hours
This course provides an introduction to the theory and practice of natural language processing (NLP), as well as the approaches that allow understanding, generating, and analyzing natural language. The course will introduce both knowledge-based and statistical approaches to NLP, illustrate the use of NLP techniques and tools in a variety of application areas, and provide insight into many open research problems.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Software Engineering, Data Science, , Computer & Information Science

CIS 512 Introduction to Quantum Computing 3 Credit Hours
This course provides an introduction to the theory and practice of quantum computing. It covers the basic background of quantum physics principles, mathematical modeling of quantum states and quantum operations, and some important quantum algorithms such as Shor's factoring algorithm, Grover's search algorithm, and Quantum Teleportation. Participation in a term project is a requirement in this course. Students cannot receive credit for both CIS 412 and CIS 512.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Computer Engineering, Data Science, Robotics Engineering, Computer & Information Science

CIS 515 Computer Graphics and Visual Computing 3 Credit Hours
This course introduces basic techniques for computer gaming, information visualization, multimedia, scientific and engineering visualization, web-based graphics, visual perception, and computer vision. It covers the basic graphical concepts such as color systems, images, graphics output primitives, two-dimensional transformations, windowing, clipping and viewing, three-dimensional transformations, windowing, clipping and viewing, visible line/surface detection methods, shading, texture mapping, interactive graphical user interface, virtual reality, visual understanding, and web-based visualization.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Rackham or Doctorate
Can enroll if Degree is Master of Sci in Engineering, Doctorate in Science, Master of Science
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Computer & Information Science, Software Engineering, Data Science, , Computer Engineering

CIS 525 Web Technology 3 Credit Hours
This course deals with the study of the technologies used to design and implement multimedia web sites. Topics include web servers, HTML, CGI, scripting languages, Java applets, back-end database connectivity, web security, multimedia, XML, web services, .NET, semantic web.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Software Engineering, Data Science, Info Systems and Technology, , Computer & Information Science

CIS 527 Computer Networks 3 Credit Hours
To study the technical and management aspects of computer networks and distributed systems. Topics include: communication hardware, communication protocols, network architectures, local area networks, distributed database systems. Case studies and research project will be assigned for additional insight.
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Software Engineering, Computer Engineering, Info Systems and Technology, , Computer & Information Science

CIS 534 Semantic Web 3 Credit Hours
The aim of this course is to investigate the fundamental concepts, techniques, and technologies for enabling the envisioned semantic Web. The topics to be covered include ontologies, domain modeling, logic, reasoning and inference techniques, semantic Web services, and ontology interoperation/mappings. We will review major semantic web research projects, as well as current technologies for enabling the semantic web.
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Software Engineering, Data Science, Info Systems and Technology, , Computer & Information Science

CIS 535 Wireless Technologies and Pervasive Computing 3 Credit Hours
This course covers contemporary technologies for programmable mobile and wireless intelligent hand-held devices. Students will get an overview of mobile operating system concepts/techniques and will learn how to develop software for mobile/smart devices, with particular emphasis on the constraints intrinsic to such devices. Topics in location-based services and pervasive computing will also be covered. Participation in a project is a requirement in this course. This class requires knowledge in computer programming.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Software Engineering, Computer & Information Science, Computer Engineering,

CIS 536 Text Mining and Information Retrieval 3 Credit Hours
This course covers techniques for retrieving ranked relevant documents from a text repository based on user queries, using various techniques for extracting and representing latent knowledge from these documents. Topics also include language models, summarization, topic modeling, entity extraction, sentiment analysis, and embeddings. A significant aspect of this course is participation in a medium to large-scale project.
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Software Engineering, Computer & Information Science, Data Science,

CIS 537 Advanced Networking and Distributed Systems 3 Credit Hours
This course focuses on the design, implementation, analysis, and evaluation of large-scale networked systems. Specific networking topics include congestion/flow control, traffic analysis, routing, internetworking, multicast, mobile and wireless networks, quality of service, and security. Fundamental distributed systems topics include domain name service, global routing protocols, content delivery networks, and peer-to-peer systems.
Prerequisite(s): CIS 527
Restriction(s):
Can enroll if Level is Graduate or Rackham or Doctorate
Can enroll if College is Engineering and Computer Science

CIS 540 Foundation of Information Security 3 Credit Hours
This course provides the foundation for understanding the key issues associated with protecting information assets, determining the levels of protection and response to security incidents, and designing a consistent, reasonable information security system, with appropriate intrusion detection and reporting features. The purpose of the course is to provide the student with an overview of the field of information security and assurance. Students will be exposed to the spectrum of security activities, methods, methodologies, and procedures. Coverage will include inspection and protection of information assets, detection of and reaction to threats to information assets, and examination of pre-and post-incident procedures, technical and managerial responses, and an overview of the information security planning and staffing functions.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Data Science, Info Systems and Technology, Computer & Information Science

CIS 541 Immersive Computing and Digital Twins 3 Credit Hours
This course introduces the core concepts and applications of Immersive Computing and Digital Twins, focusing on key technologies such as VR/AR/MR, AIoT, visible light communication (VLC), data visualization, and human-centric sensing, positioning and computing. Students will explore fundamental architecture and technologies, learn how immersive visualizations, AI-driven insights, VLC, and advanced sensing enhance digital twin systems, and develop hands-on prototypes using tools/platform like Unity, Arduino, Unreal Engine, Blender, light sensors, mobile phone, and the UM Great Lake computing platform. The course also covers future trends, including the metaverse and brain-computer interfaces, preparing students to design and implement innovative immersive and digital twin solutions. (W).

CIS 542 Software Engineering for AI Systems 3 Credit Hours
This course is designed to foster collaboration between software engineers and data/ML/AI engineers, who contribute to the development of AI/ML-enabled systems while bringing diverse expertise and perspectives. It is aimed at software engineers seeking to build robust and responsible products with AI/ML components, covering topics such as requirement analysis, software architecture for AI/ML-enabled systems, data workflow management (e.g., Airflow), quality assurance (e.g., MLflow), operations (MLOps), and responsible AI/ML engineering. The course is particularly suitable for students pursuing careers as AI/ML software engineer, focusing on the entire process of transforming a model into a reliable and responsible production system. (F).
Restriction(s):
Can enroll if Class is Graduate

CIS 543 GPU Computing 3 Credit Hours
In today's data-driven world, mastering GPU architecture and programming is essential to harness the full potential of high-performance computing and drive innovation across industries. This course is dedicated to exploring the fundamentals and advanced topics in GPU architecture and programming. It covers the hardware designs, memory hierarchies, and the parallel processing capabilities that make GPUs a critical component in high-performance computing. Students will learn to program GPUs using CUDA and other related frameworks while gaining hands-on experience through practical programming assignments. Topics include GPU pipeline design, thread organization (SIMT), memory coalescing, synchronization, and performance optimization techniques. (F).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Computer & Information Science, Computer Engineering, Software Engineering, Electrical Engineering, Robotics Engineering, Data Science

CIS 544 Computer and Network Security 3 Credit Hours
The course will provide a broad spectrum introduction of the fundamental principles of computer and network security. Topics will include security policies, models and mechanism for confidentiality, integrity and availability, access control, authorization, cryptography and applications, threats and vulnerabilities in computer networks, key management, firewalls and security services in computer networks.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Computer Engineering, Info Systems and Technology, Computer & Information Science

CIS 545 Data Security and Privacy 3 Credit Hours
With the continuing proliferation of ways to collect and use information about people, there is a great concern whether such use of information about people affects privacy adversely. This course covers basics of data security and privacy techniques which can facilitate the use of data in a secure and privacy-sensitive way. Topics include security and privacy challenges due to big data collection and analytics, technologies and strategies for data security and privacy (access control mechanism, integrity policy, cryptography and encryption, notice and consent, anonymization or de-identification, deletion and non-retention).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Software Engineering, Computer & Information Science, Data Science,

CIS 546 Security and Privacy in Wireless Networks 3 Credit Hours
This course focuses on security issues in wireless networks, such as cellular networks, wireless LANs, mobile ad-hoc networks, vehicular networks, sensor networks, and RFID. The course will first present an overview of wireless networks, then focus on attacks and discuss proposed solutions and their limitations.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Computer Engineering, Data Science, Info Systems and Technology, Computer & Information Science

CIS 548 Security and Privacy in Cloud Computing 3 Credit Hours
This course covers the major security and privacy topics in cloud computing. The goals of this course are to familiarize students with the major security and privacy issues and challenges associated with cloud computing, and to show them how to address them. Topics include outsourced storage security and privacy, outsourced computation security and privacy, secure virtualization and cloud platform security, trusted cloud computing technology, key management in the cloud, cloud forensics, cloud-related regulatory and compliance issues, and business and security risk models.
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is , Software Engineering, Computer Engineering, Data Science, Info Systems and Technology, Computer & Information Science

CIS 549 Software Security 3 Credit Hours
This course provides a broad-spectrum introduction to the fundamental principles of software security, as well as the approaches that allow understanding common software security practices, analyzing programs for vulnerabilities, and methods for developing secure software systems. The course will cover three major areas: software attacks and defenses, program analysis, and software verification. Various forms of software will be considered in this class including high level applications and system software. The course will also provide insight into many open research problems in this area.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Software Engineering, Computer & Information Science,

CIS 551 Advanced Computer Graphics 3 Credit Hours
Introduction to curves, surfaces, and solids. Bezier and B-spline curves, spline surfaces, intersections of curves and surfaces, blending methods. Illumination models and surface rendering. Solid modeling-wireframe, constructive solid geometry.
Prerequisite(s): CIS 515
Restriction(s):
Can enroll if Level is Graduate or Rackham or Doctorate

CIS 552 Information Visualization with Parallel Computing 3 Credit Hours
This course introduces basic techniques for visualization, quantitative analysis, intelligent visual understanding, virtualization, digital animation, computer and video games, and web multimedia. Topics include data visualization, computer vision, visual analysis, the process of creating animated video clips, and computer virtualization; several key techniques include graphic design, video editing, motion generation, motion capture, multimedia, real-time rendering, visualization tools, and parallel computing. (W).
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Software Engineering, Computer Engineering, Data Science, , Computer & Information Science

CIS 553 Software Engineering 3 Credit Hours
Program design methodologies; control flow and data flow in programs; program measurement. Software life cycle; large program design, development, testing, and maintenance. Software reliability and fault tolerance. Evolution dynamics of software.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Software Engineering, Computer & Information Science, Info Systems and Technology,

CIS 5550 Reinforcement Learning 3 Credit Hours
This course will focus on the basic and advanced concepts, algorithms, and challenges of Reinforcement Learning (RL). It will introduce the basic learning framework and the core concepts and algorithms of RL. Next, the course will focus on Deep Reinforcement Learning and the extensions of these basic core algorithms to Deep Learning to handle higher dimensional domains like simulated robotics. It will discuss the various kinds of advanced learning techniques within Deep RL like learning from offline data/demonstrations, preference-based learning (currently popular as Learning from Human Feedback (RLHF)) etc. to enable learning in complex domains like Robotics control, navigation tasks, etc. (F).
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Data Science, Info Systems and Technology, Computer & Information Science

CIS 556 Database Systems 3 Credit Hours
Introduction to database system concepts and techniques. Topics covered include: database environment, ER model, relational data model, object-oriented databases, object-relational databases, database design theory and methodology, database languages, query processing and optimization, concurrency control, database recovery, and database security. No credit given to both CIS 421 and CIS 556.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Software Engineering, Data Science, Info Systems and Technology, , Computer & Information Science

CIS 5570 Introduction to Big Data 3 Credit Hours
This course provides an overview of what big data is and explores its characteristics. It introduces the fundamental technologies, platforms, and methods that enable Big Data analysis, and covers how to acquire, store, and analyze very large amounts of information to complete Big Data analysis tasks. Students will gain hands-on experience in real-world applications of Big Data such as in cyber-physical systems and health informatics. Most of the work in this course will be team-based and task-oriented.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Data Science, Info Systems and Technology, Computer & Information Science

CIS 559 Principles of Social Network Science 3 Credit Hours
This course presents an in-depth study of various types of information networks, which range from the structure and behavior of the world-wide web, to the structure and behavior of various collaboration networks, such as bibliographic citations, viral marketing, and online social networks. Using concepts from graph theory and game theory, topics include small-world networks, scale-free networks, the structure of the web, link analysis and web search, and influence networks.
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Software Engineering, Data Science, Info Systems and Technology, , Computer & Information Science

CIS 562 Web Information Management 3 Credit Hours
This course provides an in-depth examination of advances in web information management, retrieval and applications. Topics covered include: web interfaces to databases, XML standards, web database design, web database architectures, web query languages, web data restructuring, web information integration, semantic web and ontologies, and web mining.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Data Science, Info Systems and Technology, Computer & Information Science

CIS 564 Enterprise Information Systems 3 Credit Hours
The purpose of this course is to provide a foundation for the analysis, design and implementation of enterprise information systems. Topics include systems and organization theories, and information systems planning and evaluation. Students will be also introduced to various systems development life cycle phases of an enterprise information system. Students will acquire an understanding of the flow of information (forecasts, financial, accounting and operational data) within an enterprise and the factors that should be considered in designing an integrated enterprise information system. This includes all systems in the business cycle from revenue forecasts, production planning, inventory management, logistics, manufacturing, accounts payable, sales, accounts receivable, payroll, general ledger and report generation. Specifications for some of these systems will be developed utilizing ERP software such as SAP R/3 application development software suite. (F, W).
Restriction(s):
Cannot enroll if Class is

CIS 565 Software Quality Assurance 3 Credit Hours
The processes, methods, and techniques for developing quality software, for assessing software quality, and for maintaining the quality of software. Software testing at the unit, module, subsystem and system levels, automatic and manual techniques for generating and validating test data, the testing process, static vs. dynamic analysis, functional testing, inspections, and reliability assessment. Tradeoffs between software cost, schedule, time and quality, integration of quality into the software development process, as well as the principles of test planning and test execution.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Software Engineering, Computer & Information Science, Info Systems and Technology,

CIS 566 Software Architecture and Design Patterns 3 Credit Hours
Architectural and software design patterns in theory and in practice, with various applications. The course will end with a case study and design exercise demonstrating identification and utilization of architectural design patterns in a real world application. Students will test their understanding by completing projects utilizing popular design patterns and a term project utilizing a multitude of patterns. Class presentation of published advanced patterns may be required.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Software Engineering, Computer & Information Science,

CIS 568 Data Mining 3 Credit Hours
Advances in computer information systems, machine learning, statistics, and intelligent systems and methodologies for the automatic discovery of knowledge from large high- dimensional databases. This course also uses engineering development tools such as neural networks, fuzzy logic, and genetic algorithms.
Prerequisite(s): ECE 479 or CIS 479
Restriction(s):
Can enroll if College is Engineering and Computer Science

CIS 569 Internet of Things and Smart Cities 3 Credit Hours
This course provides students with an overview of the Internet of Things (IoT) and the issues related to the design and implementation of smart city applications. It introduces students to the state-of-the-art in IoT and smart cities, focusing on the integration of wireless sensor networks within urban environments. The course helps them solve problems in designing and deploying resource-limited IoT systems for real-world smart city applications. During this course, students are required to work in teams to design and implement some fundamental smart city sensing applications.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Software Engineering, Computer Engineering, , Computer & Information Science

CIS 5700 Advanced Data Mining 3 Credit Hours
This course provides an in-depth study of advanced data mining, data analysis and pattern recognition concepts and algorithms. Course content builds upon a first data mining course and explores advanced machine learning algorithms, high-dimensional data, graph and temporal data, and advanced methods and applications to deal with dynamic stream data. Various applications will be considered, including social networks and health informatics. Students will be able to understand the research methods applied in the field and conduct an end-to-end data mining project and document and present the results.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Computer Engineering, Data Science, Info Systems and Technology, Computer & Information Science

CIS 571 Web Services 3 Credit Hours
In this course, we study the major concepts and techniques for enabling service based interactions on the Web. The objective is to familiarize the students with the recent trends in industry and academia to address service computing research and implementation issues. The course will address various aspects of service computing including SOAP Services, WSDL, REST services, service composition and mashup, security, privacy, service management as well as recent trends in service computing such as cloud, Internet of Things (IoT), social media, crowdsourcing, and big data.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Software Engineering, Data Science, Info Systems and Technology, , Computer & Information Science

CIS 572 Object Oriented Systems Design 3 Credit Hours
Students will be introduced to fundamental concepts and methods of object design and development. Topics that will be covered include object database concepts, data models, schema design (conceptual schema and physical schemas), query languages, physical storage of objects and indexes on objects, version management, schema evolution and systems issues such as concurrent control and recovery from failure. For application programming, a programming language such as C++ will be used for database design and query language. (YR).
Restriction(s):
Can enroll if Class is Post-baccalaureate Cert only or Post-baccalaureate NCFD or Graduate

CIS 574 Compiler Design 3 Credit Hours
Principles of language compilation. Introduction to formal languages, lexical analysis, top-down and bottom-up parsing, code generation and optimization. Error handling and symbol table management, run-time storage management, programming language design. Introduction to compiler-writing tools such as LEX and YACC.
Prerequisite(s): CIS 350 or CIS 3501 or IMSE 350 or (ECE 370 and MATH 276)
Restriction(s):
Can enroll if Class is Graduate
Can enroll if College is Engineering and Computer Science

CIS 575 Software Engineering Mgmt 3 Credit Hours
Quantitative models of the software lifecycle; cost-effectiveness; uncertainty and risk analysis; planning and modeling a software project; software cost estimation (COCOMO, Function points); software engineering metrics; software project documentation. Special emphasis on emerging software process standards such as the Capability Maturity Model of the Software Engineering Institute, and other international ones.
Prerequisite(s): CIS 553
Restriction(s):
Can enroll if College is Engineering and Computer Science

CIS 577 S/W User Interface Dsgn&Analys 3 Credit Hours
This course introduces current theory and design techniques concerning how user interface (UI) and user experience (UX) should be designed and assessed to be easy to learn and use. Course includes flowing general modules: introduction of HCI & UX; Interface/Interaction design strategy; Advanced Issues in HCI; and Evaluation methods.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science

CIS 578 Advanced Operating Systems 3 Credit Hours
Advanced techniques and uses in operating system design. Distributed operating systems. Message-based operating systems. Operating systems for parallel architectures. Layered techniques in operating systems. Formal models of operating systems. Current trends in operating system design.
Prerequisite(s): ECE 478 or CIS 450 or IMSE 450

CIS 579 Artificial Intelligence 3 Credit Hours
This course introduces students to the essential concepts, methods, and techniques of artificial intelligence (AI) from a computer science perspective. The general topics of the course will include a variety of knowledge representations and algorithms for interference, decision-making, planning, and learning. Modern intelligent systems, including those that can handle uncertainty, will serve to motivate the course material. The course will cover topics at a depth appropriate for an introductory AI course at the graduate level. A student project may be required.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Computer Engineering, Data Science, Computer & Information Science

CIS 580 Data Analytics in Software Engineering 3 Credit Hours
Full Course Title: Data Analytics in Software Engineering-This course focuses on state-of-the-art methods, tools, and techniques for evolving software. Topics such as reverse engineering, design recovery, program analysis, program transformation, refactoring, and traceability will be covered. There will be a project in which student teams participate.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is Software Engineering, Data Science, , Computer & Information Science

CIS 581 Computational Learning 3 Credit Hours
This graduate-level course covers computational aspects of learning from experience to making inferences and providing improved decisions. The main focus is an in-depth examination of the computational learning landscape from the viewpoint of a computer scientist. We will focus on such computer science concerns as basic runtimes, time/space complexity analysis, programming aspects, and empirical evaluations, including the appropriateness of various techniques for particular problems. Topics include learning frameworks and problem formulations, standard models, methods, computational tools, algorithms and modern techniques, and methodologies to evaluate learning ability to automatically select optimal models. Applications to areas such as visual analysis, natural language processing, and multimodal interaction will also motivate the course material. (W).
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Software Engineering, Computer & Information Science, Data Science,

CIS 582 Trustworthy Artificial Intelligence 3 Credit Hours
This course introduces the broad and evolving notion of trustworthy artificial intelligence (AI). It covers three broad areas of trustworthiness in AI: robustness, transparency, and accountability. For robustness, the course introduces the AI threat landscape focusing on training data poisoning, model evasion, privacy-sensitive data inference, model stealing/extraction, and threats to safe deployment of AI. For transparency, the course covers frameworks used to interpret/explain AI model's decisions. For accountability, the course discusses methods and tools for reducing bias and ethical pitfalls when AI models are deployed in high-stakes application domains. The course also discusses the dynamics among the three broad AI trustworthiness desirables. The course adopts a predominantly project-based setting to enhance hands-on experience. Students will also work on a term project. No credit given to both CIS 482 and CIS 582.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Computer & Information Science, Software Engineering, Data Science, Industrial & Systems Engin, Info Systems and Technology, Mechanical Engineering, Robotics Engineering, Computer Engineering

CIS 583 Deep Learning 3 Credit Hours
This course is an introduction to deep learning, a branch of machine learning concerned with the development and application of modern deep neural networks. Students will learn to build up deep learning models and review the state-of-the-art deep learning literature to solve real-world computational problems. Students will delve into selected deep learning topics, discussing a range of model architectures such as CNN (convolutional neural network), RNN (recurrent neural network), LSTM (long short-term memory network), GAN (generative adversarial network), etc., and commonly used model optimizers. Students will participate in a research-oriented project in the course.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Data Science, Info Systems and Technology, Computer & Information Science

CIS 584 Advanced Computer and Network Security 3 Credit Hours
This course consists of an in-depth examination of current technological advancements in computer and network security. Topics will include secure group communication (key generation, distribution, and management), secure routing and multicasting, identity-based encryption, digital signatures, broadcast authentication, device pairing, and malware/intrusion detection and mitigation.
Prerequisite(s): CIS 544
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science

CIS 585 Advanced Artificial Intelligence 3 Credit Hours
This course will cover the most recent advances in the theory and practice of artificial intelligence, from a computer-science perspective. Topics covered will include the state-of-the-art in knowledge representation, uncertainty, learning, CSPs, graphical models, multi-agent systems, algorithms and heuristics, and propagation-based techniques. Various application areas will be taken from security, game theory, economics, finance, biology, sociology, and big data.
Prerequisite(s): CIS 579
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or

CIS 586 Advanced Data Management 3 Credit Hours
This course provides an in-depth examination of some advanced database technologies. Topics are selected from: object-relational databases, active databases, distributed databases, parallel databases, deductive databases, fuzzy databases, data warehousing and data mining, spatial and temporal databases, multimedia databases, advanced transaction processing, information retrieval and database security.
Prerequisite(s): CIS 556
Restriction(s):
Can enroll if Level is Graduate or Rackham or Doctorate
Can enroll if College is Engineering and Computer Science

CIS 587 Computer Game Design and Implementation 3 Credit Hours
This course deals with the study of the technology, science, and art involved in the creation of computer games. The focus of the course will be hands-on development of computer games. Students will study a variety of software technologies relevant to computer game design, including: programming languages, scripting languages, operating systems, file systems, networks, simulation engines, and multi-media design systems. Lecture and discussion topics will be taken from several areas of computer science: simulation and modeling, computer graphics, artificial intelligence, real-time processing, game theory, software engineering, human computer interaction, graphic design, and game aesthetics.
Prerequisite(s): CIS 553*
Restriction(s):
Can enroll if Class is Post-baccalaureate NCFD or Graduate
Can enroll if College is Engineering and Computer Science

CIS 588 Computer Game Design II 3 Credit Hours
This course is a continuation of the material studied in CIS 587. Focus on hands-on development of computer games and computer game development tools, such as game engines. A variety of software technologies relevant to computer game design, including data-driven game design, multiplayer game programming, game AI, game theory, game content development, and game aesthetics.
Prerequisite(s): CIS 587
Restriction(s):
Can enroll if Class is Graduate
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Software Engineering, Computer & Information Science

CIS 589 Edge Computing 3 Credit Hours
This course introduces state-of-the-art edge computing technologies and their applications in data-intensive distributed systems like smart homes, Internet of Things, and connected vehicles. Topics include edge computing applications and platforms, edge-based sensor data collection and processing, computation offloading and QoS-optimal task scheduling, and security/privacy. This course will also explore the current challenges facing edge computing. Participation in a project is a requirement in this course.
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if Major is , Software Engineering, Computer Engineering, Data Science, Computer & Information Science

CIS 590 Selected Topics 1 to 3 Credit Hours
In-depth study of a CIS topic of contemporary interest. Topic varies from semester to semester.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science

CIS 591 Directed Research Project 1 to 3 Credit Hours
Special projects for laboratory or library investigation with the intent of developing initiative and resourcefulness. The student will submit a report of the project and give an oral presentation to a panel of faculty members at the close of the term.
Restriction(s):
Can enroll if Class is Graduate

CIS 624 Research Advances in Computer and Network Security 3 Credit Hours
An in-depth study of the current state-of-the-art in computer and network security. Selected topics will be from areas such as social network security, sensor network security, information and network provenance, cyber-physical system security, pervasive and mobile computing security, smart-grid security, and healthcare system security and privacy.
Prerequisite(s): CIS 584
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or

CIS 647 Research Advances in Networking and Distributed Systems 3 Credit Hours
In-depth investigation of one or more advanced areas in networking and distributed systems. Examples of possible areas are Internet analysis, approaches for network performance enhancements, multimedia applications, network coding, routing techniques, congestion control, wireless networking, vehicular networks, distributed algorithms, and concurrency control and synchronization.
Prerequisite(s): CIS 527
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or

CIS 652 Advanced Information Visualization and Virtualization 3 Credit Hours
This course introduces algorithms for virtual reality, three-dimensional imaging, geometric modeling, geometric processing, information visualization, computer animation, and computer virtualization. Particular research topics include data visualization, cognitive science, perception, volume graphics, point-based graphics, surface reconstruction, wavelet and subdivision methods, level of details, and virtual machines. Students will study state-of-the-art papers in the above areas and be involved in a course project.
Prerequisite(s): CIS 552
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or

CIS 658 Research Advances in Data Management 3 Credit Hours
An in-depth study of special topics of current interest in database systems. Selected topics will be from areas such as query optimization for emerging database systems, indexing for non-traditional data, data provenance for scientific databases, databases on modern hardware, self-managing databases, information integration and retrieval, bioinformatics, or other emerging database areas/applications.
Prerequisite(s): CIS 556
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or

CIS 676 Soft Arch Des & Analysis 3 Credit Hours
This course provides in-depth coverage of the concepts needed to effectively design and analyze software architectures. It introduces major architectural styles and design patterns and illustrates their application in designing and analyzing modern software architectures such as wireless, service-oriented, and security-based systems. The course also studies software architecture documentation practices that meet the needs of the entire architecture stakeholder community.
Prerequisite(s): CIS 553
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or

CIS 678 Research Advances in Software Engineering 3 Credit Hours
An in-depth study of the current state-of-the-art in software engineering. Selected topics will be from areas such as software maintenance, software testing, model-driven engineering, human factors in software engineering, software specifications, software management, emerging technology and applications, applying optimization techniques in software engineering, and empirical software engineering.
Prerequisite(s): CIS 553
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or

CIS 679 Research Advances in Computational Game Theory and Economics 3 Credit Hours
This course will introduce students to fundamental concepts and results in the area of computational game theory and economics, and expose them to the state-of-the-art and applications, providing them with the ability to make significant contributions to this quickly developing research area. This emerging area is at the interface of computer science and economics and seeks to build on classical results in game theory to provide practical models and effective algorithms better suited to study and solve problems in large complex systems in modern society. Of major interest are compact models and efficient algorithms to understand and predict the complex global behavior that emerges from local interactions. Auctions, the Internet, social networks, computational biology, and interdependent security are some example application domains. (F).
Prerequisite(s): CIS 579
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or

CIS 685 Research Advances in Artificial Intelligence 3 Credit Hours
Full Course Title: Research Advances in Artificial Intelligence. An in-depth study of the current state-of-the-art in artificial intelligence. Selected topics will be from areas such as analytics, advanced neural nets and deep learning, multi-agent systems, auctions, cooperation, competition, genetic algorithms and evolutionary computing, swarm intelligence, game-theoretic approaches to decision and policy making, advanced techniques for natural language processing, and advanced techniques in knowledge discovery.
Prerequisite(s): CIS 579
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science

CIS 691 Advanced Directed Study 1 to 3 Credit Hours
Advanced Directed Studies: Special topic in computer and information science. A project report and a seminar are required.
Restriction(s):
Can enroll if Level is Rackham or or Graduate or Doctorate
Can enroll if College is Engineering and Computer Science

CIS 695 Master's Project 3 Credit Hours
Application of the methodologies, tools and theory of software engineering to produce a specific validated software product. Projects can be faculty-generated, self-generated, and/or work related. All projects must be undertaken with one or more students under the supervision of the instructor. Prior to enrollment, a project proposal must be prepared and approved by the instructor. Standard software engineering documents must be prepared and approved at each phase of the project, and an oral presentation of the project is required. Course includes lectures and case studies. Permission of instructor required.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Rackham or Graduate
Can enroll if College is Engineering and Computer Science
Cannot enroll if Program is

CIS 699 Master's Thesis 1 to 6 Credit Hours
Graduate students electing this course, while working under the general supervision of a member of the department faculty, are expected to plan and carry out the work themselves and submit a thesis for review and approval, and also present an oral defense of the thesis.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Rackham or Graduate
Can enroll if College is Engineering and Computer Science

CIS 791 Advanced Guided Study for Doctoral Students 2 to 6 Credit Hours
This is a guided study course for doctoral students on an advanced topic of research. A report and an oral presentation are required.
Restriction(s):
Can enroll if Level is Doctorate or
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Computer & Information Science

CIS 798 Doctoral Seminar 0 Credit Hours
After attaining candidacy, every Ph.D. student is required to attend and actively participate in seminars each semester until graduation. In addition, each Ph.D. student is required to present a one-hour seminar about his/her research on a pre-assigned research topic, as wel as lead a follow-up discussion on the future trends in his/her field.
Restriction(s):
Can enroll if Level is Rackham or or Doctorate
Can enroll if Major is Computer & Information Science

CIS 980 Pre-Candidate Dissertation Research 1 to 9 Credit Hours
Dissertation work by a pre-candidate student in Computer and Information Sciences program conducted under guidance of the faculty advisor.
Restriction(s):
Can enroll if Level is or Doctorate
Can enroll if Major is Computer & Information Science

CIS 990 Doctoral Dissertation 1 to 9 Credit Hours
Dissertation work by a student of the Ph.D. in Computer and Information Science program, conducted under guidance of the faculty advisor. The student must be a Ph.D. candidate.
Restriction(s):
Can enroll if Level is Doctorate or
Can enroll if Major is Computer & Information Science

*An asterisk denotes that a course may be taken concurrently.

Frequency of Offering

The following abbreviations are used to denote the frequency of offering: (F) fall term; (W) winter term; (S) summer term; (F, W) fall and winter terms; (YR) once a year; (AY) alternating years; (OC) offered occasionally