

DOCTOR OF PHILOSOPHY (PH.D.) MAJOR IN COMPUTER SCIENCE (INFORMATION MANAGEMENT CONCENTRATION ENTERING WITH BACHELOR'S DEGREE)

Program Overview

The Department of Computer Science offers an applied computer science Ph.D. program that incorporates leadership, innovation, communication, and entrepreneurship to prepare students to navigate multiple career environments. The program is the first in Texas to combine the application of computer science practice and theory with entrepreneurial and commercialization skills. The curriculum integrates entrepreneurship and commercialization and is centered on two technical tracks that align with faculty research interests: Information Management and Software Systems. The Information Management track encompasses research topics in data analytics and management, human computer interaction, and informatics. The Software Systems track covers topics in computer security and networking, high-performance computing, and software engineering. In addition, the program requires students to participate in entrepreneurship boot camps, defend a business plan, design and implement a substantial piece of software, and complete business and commercialization courses.

Educational Goal

Based on the curricular areas and expectations described above, the main educational objectives of the Texas State program are to equip program graduates with:

1. technical knowledge in complementary areas of applied computing,
2. skills for conducting cutting-edge research that advances the current state-of-the-art in applied computing, and
3. leadership, innovation, communication, and entrepreneurial skills that prepare students to take on challenges in multiple career environments, including their own startup companies.

Application Requirements

The items listed below are required for admission consideration for applicable semesters of entry during the current academic year. Submission instructions, additional details, and changes to admission requirements for semesters other than the current academic year can be found on The Graduate College's website (<http://www.gradcollege.txstate.edu>). International students should review the International Admission Documents webpage (<http://mycatalog.txstate.edu/graduate/admission-documents/international/>) for additional requirements.

- completed online application
- \$55 nonrefundable application fee

or

- \$90 nonrefundable application fee for applications with international credentials
- **Transcripts & GPA for applicants with a bachelor's degree only**
 - baccalaureate degree in computer science or related field from a regionally accredited university
 - official transcripts from **each institution** where course credit was granted
 - minimum 3.0 GPA in the last 60 hours of undergraduate courses (plus any completed graduate courses)
- official GRE (general test only) with competitive scores in the verbal reasoning and quantitative reasoning sections
- interview (top-ranking applicants only)
- resume/CV
- three letters of recommendation submitted directly from professionals who are qualified to assess the student's academic abilities
- written statement of research interests and goals

TOEFL, PTE, or IELTS Scores

Non-native English speakers who do not qualify for an English proficiency waiver:

- official TOEFL iBT scores required with a 85 overall
- official PTE scores required with a 57 overall
- official IELTS (academic) scores required with a 6.5 overall and minimum individual module scores of 6.0

This program does **not** offer admission if the scores above are not met.

Degree Requirements

The Doctor of Philosophy (Ph.D.) degree with a major in Computer Science concentration in Information Management requires 78 semester credit hours for students entering with a bachelor's degree, up to 24 hours of which can be from 5000 level master's Computer Science courses (the selection of courses in this category should be made in consultation with the student's Ph.D. advisor and the program director). Two boot camps are required. The boot camps will provide academic preparation in non-technical skills such as the development of business plans, project management, negotiation, grant writing, intellectual property, leadership, entrepreneurship, and communication.

Course Requirements

Code	Title	Hours
Required Courses		
CS 7300	Introduction to Research in Computer Science	3
MSEC 7301	Practical Skills in Commercialization and Entrepreneurship	3
MSEC 7302	Leadership Skills in Commercialization and Entrepreneurship	3
Breadth Requirement		
Information Management		
Choose 6 hours from the following:		6
CS 7311	Data-Driven Computational Methods and Infrastructure	
CS 7312	Advanced Data Mining	
CS 7313	Advanced Machine Learning and Pattern Recognition	

CS 7314	Bioinformatics
CS 7321	Human Computer Interaction: Concepts, Models, and Methodologies
CS 7322	Human Factors and Ergonomics
CS 7323	Image Processing and Computer Vision
CS 7324	HCI Paradigms for Animation, Visualization, and Virtual/Augmented Reality
CS 7389A	Service Computing

Software Systems

Choose 6 hours from the following:	6
CS 7331	High-Performance Computing
CS 7332	Advanced Parallel Computing
CS 7333	Advanced Green Computing
CS 7341	Cyberspace Security
CS 7342	Advanced Computer Networking
CS 7343	Mobile Networks and Computing
CS 7351	Advanced Software Engineering
CS 7389C	Real-time Systems
CS 7389D	Scalable Systems for Supercomputing

Technical Depth

Choose 9 hours from the following: ¹	9
CS 7100	Graduate Computer Science Internship
CS 7311	Data-Driven Computational Methods and Infrastructure
CS 7312	Advanced Data Mining
CS 7313	Advanced Machine Learning and Pattern Recognition
CS 7314	Bioinformatics
CS 7321	Human Computer Interaction: Concepts, Models, and Methodologies
CS 7322	Human Factors and Ergonomics
CS 7323	Image Processing and Computer Vision
CS 7324	HCI Paradigms for Animation, Visualization, and Virtual/Augmented Reality
CS 7387	Research in Computer Science
CS 7389A	Service Computing

Up to two graduate-level courses outside of the Computer Science department can be taken if the dissertation project requires multidisciplinary knowledge as determined by the dissertation advisor. The dissertation advisor must approve the courses.

Prescribed Electives

Choose 24 hours from the following 7000 and 5000 level courses: ²	24
CS 7100	Graduate Computer Science Internship
CS 7311	Data-Driven Computational Methods and Infrastructure
CS 7312	Advanced Data Mining
CS 7313	Advanced Machine Learning and Pattern Recognition
CS 7314	Bioinformatics
CS 7321	Human Computer Interaction: Concepts, Models, and Methodologies
CS 7322	Human Factors and Ergonomics
CS 7323	Image Processing and Computer Vision

CS 7324	HCI Paradigms for Animation, Visualization, and Virtual/Augmented Reality
CS 7331	High-Performance Computing
CS 7332	Advanced Parallel Computing
CS 7333	Advanced Green Computing
CS 7341	Cyberspace Security
CS 7342	Advanced Computer Networking
CS 7343	Mobile Networks and Computing
CS 7351	Advanced Software Engineering
CS 7387	Research in Computer Science
CS 7389A	Service Computing
CS 7389B	Advanced Software Evolution
CS 7389C	Real-time Systems
CS 7389D	Scalable Systems for Supercomputing
CS 7389E	Network Analysis
CS 5306	Advanced Operating Systems
CS 5310	Network and Communication Systems
CS 5318	Design of Programming Languages
CS 5326	Advanced Studies in Human Factors of Computer Science
CS 5329	Algorithm Design and Analysis
CS 5332	Data Base Theory and Design
CS 5334	Advanced Internet Information Processing
CS 5338	Formal Languages
CS 5341	Advanced Network Programming
CS 5343	Wireless Communications and Networks
CS 5346	Advanced Artificial Intelligence
CS 5351	Parallel Processing
CS 5352	Distributed Computing
CS 5391	Survey of Software Engineering
CS 5392	Formal Methods in Software Engineering
CS 5393	Software Quality
CS 5394	Advanced Software Engineering Project
CS 5395	Independent Study in Advanced Computer Science
CS 5396	Advanced Software Engineering Processes and Methods

Dissertation

Choose a minimum of 24 hours from the following:	24
CS 7199	Dissertation
CS 7299	Dissertation
CS 7399	Dissertation
CS 7599	Dissertation
CS 7699	Dissertation
CS 7999	Dissertation

Total Hours **78**

¹

Only courses which have not been completed in the breadth requirement may be completed in the depth requirement.

²

Courses that are already used to satisfy the breadth and technical depth cannot be used for other elective requirements.

Procedures for Prior Learning Assessment Course Credit:

Students in the Ph.D. program in Computer Science can apply up to a maximum of 12 hours of course work through a prior learning assessment (PLA) evaluation process when they demonstrate mastery of applicable skills and learning outcomes. PLA course credit can be satisfied through experiential learning students gained through work, non-course-based advanced studies, internships, or externships prior to beginning the Computer Science Ph.D. Program. Note that the total number of credits earned through PLA and course transfer must not exceed 12 semester credit hours (for criteria and processes for earning transfer credit, see the relevant section in the catalog). Students who apply for PLA credit must meet the following conditions:

- Full-time students must make the request for PLA credit in their first year in the program. Part-time students must make the request before completing a total of 18 credits.
- The PLA experiences on which the student is basing the request for PLA credits must have occurred within five years of when the request is made.

The process of applying for PLA credit includes the following:

- A portfolio of written work is used to evaluate a student's work and experience for course credit.
- The student provides a summary document that includes the course description for each course for which they are requesting PLA credit, the student learning outcomes for the course (SLOs), and a numbered and detailed explanation of how their experience demonstrates expertise in the subject matter.
- The explanation should include the SLOs for each course under consideration and explicitly map them to parts of the student's supported materials that demonstrate mastery of the SLO. There should be no "double dipping" of a single aspect of a student's supporting materials, i.e., materials cannot be mapped to more than one course SLO. In addition, if credit for several courses is requested, a single aspect of a student's supporting materials cannot be used for more than one course.
- In addition to the summary document, the student will include supporting materials in the form of appendices, which contain reports, peer-reviewed publications, contracts, grant proposals, certificates, official transcripts, etc.

The portfolio is evaluated by a PLA evaluation committee, constituted and chaired by the director of the doctoral program. In addition to the director of the doctoral program, the committee will include two core doctoral faculty (appointed by the department chair) and one faculty member in the student's subfield, also with appropriate doctoral faculty status. If one or more of the courses for which the student is requesting PLA credit are not Computer Science courses (e.g., an MSEC course), an external faculty responsible for the non-CS course will be invited to serve on the committee in place of the member representing the student's subfield. Approval of the portfolio is required by the doctoral program director and a majority of the evaluation committee. Once approval is recommended by the department, the Ph.D. program director submits a written petition to the Dean of The Graduate College to grant course credit for prior learning assessment. The petition must include the courses for which credit is requested. The petition also includes the decision of the evaluating committee and the summary document created by the student. The appendices are made available on request.

Application for Advancement to Candidacy

When all requirements for admission to candidacy have been met (completion of boot camps, completion of required coursework, passing of the qualifying and comprehensive exams, completion of the programming requirement, and submission of an approved dissertation proposal) the Ph.D. program director forwards the Application for Advancement to Candidacy to the dean of The Graduate College for review and approval. This application form is available on The Graduate College website.

Grade-Point Requirements for Advancement to Candidacy

A minimum GPA of 3.0 on all coursework undertaken in the doctoral program is required for admission to candidacy. Grades below a B on any graduate coursework cannot be applied toward the Ph.D. degree. Incomplete grades must have been cleared before approval for advancement to candidacy can be granted. No more than six semester credit hours of dissertation research can be taken before advancing to candidacy.

Advancement to Candidacy Time Limit

No credit will be applied toward a student's doctoral degree for coursework completed more than five years before the date on which the student is admitted to candidacy. This time limit applies to course credit earned at Texas State as well as course credit transferred to Texas State from other institutions.

Dissertation Proposal

The proposal must outline the substance and scope of the planned dissertation research and explain its merits. It has to include at least an introduction, methodology to be used, a survey of the relevant literature, and preliminary results that demonstrate the feasibility. The goal of the proposal is to establish that the student has a sufficient grasp of the fundamentals of the chosen dissertation topic to execute the research.

Comprehensive Examination

The comprehensive examination consists of a written and an oral component. The qualifying exam serves as the written component. The oral component is administered by the dissertation committee, typically right after the dissertation proposal. Completion of both the business plan and a grant proposal are required for advancing to candidacy and is part of the comprehensive examination.

Dissertation Enrollment Requirements

After being admitted to candidacy, students must be continuously enrolled for dissertation hours each fall and spring semester until the defense of their dissertation. At least 18 semester credit hours of dissertation research must be taken after having advanced to candidacy. If a student is receiving supervision on the dissertation during the summer or if the student is graduating in the summer, the student must be enrolled in dissertation hours for the summer. All candidates for graduation must be enrolled in dissertation hours (e.g., CS 7199) during the semester in which the degree is to be conferred, even if they have already satisfied the minimum dissertation hours.

Dissertation Time Limit

Each Ph.D. student must prepare a written dissertation proposal and defend it orally. This should be done by the time the student has completed 36 semester credit hours and after identifying the dissertation committee, passing the qualifying exam, fulfilling the programming requirement, and completing all required courses and boot camps. Any

student who does not defend his/her dissertation proposal by the time 45 semester credit hours have been accrued will be dismissed from the program. After advancing to candidacy a student should complete their dissertation within five years, keeping in mind the ten year total time limit.

If the proposal defense is not passed, the student will have the option of taking a second and final defense in the following long semester. Students will be dismissed from the program if they do not pass the proposal defense the second time.

Dissertation Committee

The student, in consultation with his/her dissertation advisor, must establish a dissertation committee that consists of the dissertation advisor, two other doctoral faculty members from the Department, and one faculty member with at least adjunct doctoral faculty status either from another department within the university or from another institution who would be selected based on the relevancy of their research to the student's dissertation. The dissertation advisor serves as the chair of the committee.

Committee Changes

Any change to the dissertation committee must be submitted using the Dissertation Advisor/Committee Member Change Request Form for approval by the Dean of The Graduate College. Changes must be submitted no later than sixty days before the dissertation defense. The "Dissertation Advisor/Committee Member Change Request form" may be downloaded from The Graduate College's website.

Dissertation Proposal

The proposal must outline the substance and scope of the planned dissertation research and explain its merits. It has to include at least an introduction, methodology to be used, a survey of the relevant literature, and preliminary results that demonstrate the feasibility. The goal of the proposal is to establish that the student has a sufficient grasp of the fundamentals of the chosen dissertation topic to execute the research.

Dissertation Research and Writing

All doctoral students must complete a dissertation that consists of original research and demonstrates mature scholarship and critical judgment in addition to familiarity with tools and methods in the chosen area. The dissertation project must adhere to the dissertation proposal and cover the topic approved by the student's dissertation committee.

Dissertation Defense

Once the dissertation has been completed, a final exam (referred to as the dissertation defense) on the dissertation must be conducted. The dissertation defense cannot be scheduled until all other academic and program requirements have been fulfilled. A complete draft of the dissertation must be given to the members of the dissertation committee at least one month before the defense. However, students are highly encouraged to provide drafts earlier so that the committee members can provide feedback, which the student, in consultation with the dissertation advisor, will address in later drafts to ensure that the dissertation is defensible and each committee member is satisfied before the dissertation defense takes place.

The dissertation defense consists of two parts. The first part is a public presentation of the dissertation research. The second part of the defense immediately follows the public presentation. It is restricted to participation of the student's dissertation committee and entails an oral examination of the dissertation research. Approval of the dissertation requires positive votes from the student's dissertation advisor and from the majority of the remaining members of the dissertation committee.

Notice of the defense presentation will be publicly posted at least two weeks in advance.

If the dissertation defense is not approved, the student will have the option of taking a second and final dissertation defense in the following long semester. Students who do not pass the dissertation defense the second time will be dismissed from the program.

The results of the dissertation defense must be recorded in the Dissertation Defense Report Form and submitted to The Graduate College before the Dean of The Graduate College can give final approval of the dissertation. This form can be downloaded from The Graduate College's website. The student must submit his/her dissertation to The Graduate College for final approval. The guidelines for submission and approval of the dissertation can be obtained from The Graduate College.

Students must pass the dissertation defense by the time 90 semester credit hours have been accrued. The Ph.D. program director will review each student annually to ascertain his/her progress towards the degree and will consult the student's dissertation advisor and dissertation committee on this matter as needed. Any student who does not pass the dissertation defense by the time 90 semester credit hours have been accrued will be dismissed from the program.

Approval and Submission of the Dissertation

A final copy of the dissertation proposal, accompanied by the signed approval forms, must be turned in to the Ph.D. program director, who will forward them to the Dean of The Graduate College for review and final approval.

Doctorate level courses in Computer Science: CS

Courses Offered

Computer Science (CS)

CS 7100. Graduate Computer Science Internship.

This course provides advanced training supervised by computer scientists in internship programs approved by the department.

1 Credit Hour. 0 Lecture Contact Hours. 1 Lab Contact Hour.

Course Attribute(s): Exclude from 3-peat Processing

Grade Mode: Credit/No Credit

CS 7199. Dissertation.

Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Graded on a credit (CR), progress (PR), no-credit (F) basis. Repeatable for credit. Prerequisite: Instructor approval.

1 Credit Hour. 1 Lecture Contact Hour. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing

Grade Mode: Credit/No Credit

CS 7299. Dissertation.

Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Graded on a credit (CR), progress (PR), no-credit (F) basis. Repeatable for credit. Prerequisite: Instructor approval.

2 Credit Hours. 2 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing

Grade Mode: Credit/No Credit

CS 7300. Introduction to Research in Computer Science.

This credit/no credit course is designed to develop research and communication skills for Ph.D. students. Topics covered include research processes, research methods, ethics, conducting literature review, critiquing papers, preparing research proposals, faculty research presentations, and the software tools and platforms available for conducting applied computing research.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Credit/No Credit

CS 7308. Computer Science Studies.

This course provides foundations in computer science for students entering the doctoral program who may need certain background or leveling coursework. The course does not earn graduate degree credit. It is repeatable with a different emphasis.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing|Exclude from Graduate GPA|Leveling

Grade Mode: Leveling/Assistantships

CS 7309. Professional Development of Doctoral Assistants.

This course is designed to equip the doctoral students with skills and an understanding of the proper procedures to be effective doctoral instructional and teaching assistants. This course does not earn graduate degree credit.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Graduate Assistantship|Exclude from Graduate GPA

Grade Mode: Leveling/Assistantships

CS 7311. Data-Driven Computational Methods and Infrastructure.

This course covers computational and statistical methods for using large-scale data sets ('big data') to answer scientific and business questions. It focuses on framing research questions, understanding how data can answer them, and using modern software tools for scalable data storage, processing, and analysis.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7312. Advanced Data Mining.

This course provides in-depth coverage of advanced data mining and information retrieval principles and techniques. It also offers extensive training and practice opportunities in frontier research directions. Prerequisite: CS 5316 with a grade of "B" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7313. Advanced Machine Learning and Pattern Recognition.

This course provides students advanced theoretical and practical skills to learn, design, implement, and apply machine learning and pattern recognition approaches. The students will gain analytical and problem-solving skills by studying machine learning and pattern recognition techniques and applying them to solve real problems.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7314. Bioinformatics.

This course introduces advanced algorithms for data-intensive computational analysis targeting biological applications such as drug response prediction, gene network analysis, and protein/RNA structure prediction. Main techniques include greedy search, linear regression, clustering, network analysis, expectation maximization, and Hidden Markov models, which are widely applicable beyond biological data.

Prerequisite: CS 5329 or CS 5369L either with a grade of "B" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7321. Human Computer Interaction: Concepts, Models, and Methodologies.

This course provides an introduction to Human Computer Interaction (HCI) research, methods, and topics, including fundamentals of user interface and experimental design, usability, evaluation methods, software toolkits for interactive applications, graphics, visualization, mobile design, collaborative and social computing, biological factors, and human computation.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7322. Human Factors and Ergonomics.

This course combines knowledge in the fields of intelligent user interfaces, human factors, ergonomics, and environmental psychology. Topics include HCI principles, human information processing, anthropometry, principles of eye tracking and their effects on human factors research, as well as operations of biometrics systems and human factors influencing those systems.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7323. Image Processing and Computer Vision.

Image Processing and Computer Vision are research areas with a variety of modern applications ranging from the analysis of images and videos to real-time processing of image streams coming from self-driving vehicles and robotic agents. This course will prepare students with advanced state of the art knowledge in those fields. Prerequisite: CS 5329 with a grade of "B" or better.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7324. HCI Paradigms for Animation, Visualization, and Virtual/Augmented Reality.

This course introduces advanced methods for enhancing user experience and presents effective HCI models via computer graphics, imaging, animation, simulation, visualization, augmented reality, and immersive virtual reality. Additionally, the course presents related science and engineering foundations as well as graphic design, cognitive science, and perceptual psychology theories and models. Prerequisite: CS 5329 with a grade of "B" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7331. High-Performance Computing.

This course covers the advanced design, analysis, and optimization of high-performance applications. Topics include high-performance computer architectures, including accelerators and systems-on-chip, performance modeling and benchmarking, data and control dependence analysis, data locality estimation, memory hierarchy management, techniques for exposing parallelism, and code transformations. Different workloads are studied. Prerequisite: CS 5329 with a grade of "B" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7332. Advanced Parallel Computing.

This course covers advanced design of parallel algorithms, performance modeling, parallel hardware, language support for parallel programming, and programming models for shared- and distributed-memory systems ranging from handheld multicore devices to large-scale clusters and accelerators. The students will gain applied knowledge and skills by developing parallel software for multiple platforms. Prerequisite: CS 5351 with a grade of "B" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7333. Advanced Green Computing.

This course covers hardware and software techniques to improve the energy-efficiency of computing systems. Topics include best practices in building energy-efficient data centers and mobile devices, current trends in reducing the energy consumption of processors and storage components, energy-aware resource management, software optimizations, and hands-on experience on power-measurable systems. Prerequisite: CS 5351 and CS 5369Y both with grades of "B" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7341. Cyberspace Security.

This course presents recent advances in methodologies, models, systems and applications of cyberspace security research. Topics include in-depth coverage of the state-of-the-art security technologies and research issues on information security, software security, network security, secure system design, secure programming, applied cryptography, vulnerability, and threats. Prerequisite: CS 5378 with a grade of "B" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7342. Advanced Computer Networking.

This course covers recent research ideas, methodologies and approaches in networking research. The course focuses on the development of protocols and the analysis of related algorithms. Topics include new network architectures, cloud computing, software defined networking, wireless systems, social networks, and security and privacy. Prerequisite: CS 5310 or CS 5343 either with a grade of "B" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7343. Mobile Networks and Computing.

This course provides an in-depth study of wireless mobile communication networks, wireless network measurements and modeling, channel assignments and coverage, wireless network protocols, mobile data management, wireless security, and various wireless network applications including ad hoc, sensor networks, delay-tolerant networks, and mobile social networks. Prerequisite: CS 5310 or CS 5343 either with a grade of "B" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7351. Advanced Software Engineering.

Software engineering is the application of scientific methods to software development and maintenance. This course provides an in-depth study of advanced concepts and techniques of automatic software generation and analysis. Topics include software process programming, symbolic execution, model checking, property generation and checking, and runtime verification of complex software systems. Prerequisite: Instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Grade Mode: Standard Letter

CS 7387. Research in Computer Science.

This course covers up-to-date research topics in computer science under the direction of a supervising professor. The course can be taken up to four times, each time with a different emphasis. Prerequisite: Instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing

Grade Mode: Credit/No Credit

CS 7389A. Service Computing.

This course introduces concepts and principles for enabling the development of software as a service based on Service-Oriented Architecture (SOA), methodology of SOA systems development, the main technologies used in achieving SOA, and state of the art techniques and advances in emerging cloud and edge (Internet of Things) services. Prerequisite: CS 5329 with a grade of "B" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing|Topics

Grade Mode: Standard Letter

CS 7389B. Advanced Software Evolution.

This topics course provides an in-depth study of state-of-the-art software evolution techniques and tools based on the current research literature. Software evolution has become increasingly important in software development. Software systems often evolve to fix defects, to improve performance, or to adapt to various other requirements. Prerequisite: Instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing|Topics

Grade Mode: Standard Letter

CS 7389C. Real-time Systems.

This course is to study issues related to the design and analysis of systems with real-time constraints. The problem of ensuring such constraints is ultimately a scheduling problem, so much attention is devoted to such problems. This course aims to provide a solid foundation for conducting research in real-time systems or related areas. Prerequisite: Instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing|Topics

Grade Mode: Standard Letter

CS 7389D. Scalable Systems for Supercomputing.

This course will teach basic aspects of building a scalable high performance computing (HPC) system. Specifically, it will focus on the design principles for scaling parallel communication and I/O operations for accessing HPC storage using a message-passing programming model. The course will use two large-scale systems—checkpointing for resilience and a parallel file system for storage as use cases to demonstrate how these principles are used in practice. Students will develop components of a scalable system and use software tools to measure and analyze their performance. Prerequisite: CS 4328 and CS 4310 both with grades of "D" or better or instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing|Topics

Grade Mode: Standard Letter

CS 7389E. Network Analysis.

This course provides in-depth coverage of the fundamentals and research frontiers of network analysis. The main topics include mathematical models and computational algorithms for analyzing the structure of complex networks and predicting dynamic processes on networks. Other topics include machine learning and data mining on graphs.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing|Topics

Grade Mode: Standard Letter

CS 7399. Dissertation.

Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Graded on a credit (CR), progress (PR), no-credit (F) basis. Repeatable for credit. Prerequisite: Instructor approval.

3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing

Grade Mode: Credit/No Credit

CS 7599. Dissertation.

Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Graded on a credit (CR), progress (PR), no-credit (F) basis. Repeatable for credit. Prerequisite: Instructor approval.

5 Credit Hours. 5 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing

Grade Mode: Credit/No Credit

CS 7699. Dissertation.

Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Graded on a credit (CR), progress (PR), no-credit (F) basis. Repeatable for credit. Prerequisite: Instructor approval.

6 Credit Hours. 6 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing

Grade Mode: Credit/No Credit

CS 7999. Dissertation.

Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Graded on a credit (CR), progress (PR), no-credit (F) basis. Repeatable for credit. Prerequisite: Instructor approval.

9 Credit Hours. 9 Lecture Contact Hours. 0 Lab Contact Hours.

Course Attribute(s): Exclude from 3-peat Processing

Grade Mode: Credit/No Credit