

## Program Overview

The Department of Computer Science offers an applied computer science Ph.D. program that incorporates leadership, innovation, and communication to prepare students to navigate multiple career environments. The program combines the application of computer science practice and theory. Students are encouraged, but not required to take electives in entrepreneurship and commercialization skills. The curriculum 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 has a programming requirement to ensure that students can implement a substantial piece of software.

Program focuses on key areas of applied computing of national priority: data science and machine learning, human-computer interaction, computer vision and multimedia, computer security and networking, high-performance computing, and software engineering and realtime systems

## 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 skills that prepare students to take on challenges in multiple career environments.

## 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 page (<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 and master's degree**
  - baccalaureate degree in computer science or related field from a regionally accredited university (Non-U.S. degrees must be equivalent to a four-year U.S. Bachelor's degree. In most cases, three-year degrees are not considered. Visit our International FAQs (<https://www.gradcollege.txst.edu/international/faqs.html>) for more information.)

- master's degree in computer science or related field from a regionally accredited university
- official transcripts from **each institution** where course credit was granted
- competitive GPA, which typically means an overall GPA of 3.3 or higher, in all completed graduate courses
- official GRE (general test only) with competitive scores in the verbal reasoning and quantitative reasoning sections
- resume/CV
- mentor recommendation letter from a current Texas State doctoral faculty member in the Computer Science program. Visit the faculty list (<https://cs.txstate.edu/accounts/faculty/>) for current faculty and their research interests and contact information. Your mentor must email their letter of support directly to The Graduate College at [gradcollege@txstate.edu](mailto:gradcollege@txstate.edu) ([gradcollege@txstate.edu](mailto:gradcollege@txstate.edu)). This letter must be on file before the program's deadline.
  - Since admission to this thesis-/dissertation-based program requires an intent to mentor letter (an agreement from one of our faculty members to supervise your research project) as part of the application process, we strongly recommend that applicants contact potential mentors by sending their CV and research interests and securing that agreement prior to submitting an admission application. The department cannot guarantee that a suitable mentor will always be available.
- 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
- interview (top-ranking applicants only.)
  - Applicants are independently reviewed and ranked by each member of the admissions committee based on a defined set of criteria. Those that are top-rated will be contacted for an interview via Skype or phone and asked a pre-determined set of questions. Based on the results of the interviews, the committee will rank the applicants again to determine the final list for admission.

## Approved English Proficiency Exam Scores

Applicants are required to submit an approved English proficiency exam score that meets the minimum program requirements below unless they have earned a bachelor's degree or higher from a regionally accredited U.S. institution or the equivalent from a country on our exempt countries list (<http://www.gradcollege.txstate.edu/international/language.html#wave>).

- 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
- official Duolingo scores required with a 115 overall
- official TOEFL Essentials scores required 9.5 overall
- 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 54 semester credit hours.

## Course Requirements

Code	Title	Hours
<b>Required Courses</b>		
CS 7300	Introduction to Research in Computer Science	3
<b>Breadth Requirement</b>		
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	
CS 7389E		
<b>Software Systems</b>		
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 7389B	Advanced Software Evolution	
CS 7389C		
CS 7389D		
<b>Technical Depth</b>		
Choose 9 hours from the following: <sup>1</sup>		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	
CS 7389C		
CS 7389D		
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.		
<b>Prescribed Electives</b>		
Choose a minimum of 6 hours from the following:		6
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		
CS 7389D		
CS 7389E		
ED 7359	Seminar in Quantitative Research	
MATH 7321	Graph Theory	
MATH 7325	Statistics 1	
MATH 7335	Statistics II: Linear Modeling	
MSEC 7301	Practical Skills in Commercialization and Entrepreneurship	
MSEC 7302	Leadership Skills in Commercialization and Entrepreneurship	
<b>Dissertation</b>		
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	
<b>Total Hours</b>		<b>54</b>

<sup>1</sup> Only courses which have not been completed in the breadth requirement may be completed in the depth requirement.

## 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 coursework 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 7315. Network Science.**

This course provides in-depth coverage of the fundamentals and research frontiers of network science. 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.**

**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 7334. 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.

**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 7352. Real-time Systems.**

This course covers 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.

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

**Grade Mode:** Standard Letter

**CS 7387. Research in Computer Science.**

This course covers current research topics in computer science under the direction of a supervising professor. 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 7389F. Secure Cyber-Physical Systems: Cryptography and Machine Learning.**

This course is designed to introduce students to the fundamentals of cryptography and machine learning and how they can be used to ensure security and privacy in cyber-physical systems (CPS). Topics will include an overview of cyber-physical systems, cryptographic techniques, machine learning algorithms, and security threats and attacks on CPS. The course will also cover privacy-preserving machine learning techniques and design principles for secure CPS. Students who successfully complete this course will be well-versed in cryptography and machine learning approaches for cybersecurity in CPS and be able to use these techniques to address practical real-world issues. Prerequisite: CS 3354 and CS 3358 both with a grade of "D" or better.

**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 7389G. Human-Centered Data Science.**

This course is to study the process of deriving insights from data in order to make optimal decisions. Human-Centered Data Science addresses various data science problems with attention to improve the quality of decisions by incorporating human experts in the learning process, e.g., interactive Machine Learning and eXplainable Artificial Intelligence. Prerequisite: CS 3358 with grade of "C" or better.

**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 7389H. Human-Centric Deep Learning.**

This course provides an in-depth exploration of deep learning, emphasizing multi-layer neural networks and their applications. Students will explore core topics like convolutional, recurrent, and graph neural networks, along with optimization algorithms and generative models. The curriculum uniquely integrates multimedia processing, Human-Computer Interaction (HCI), and "human in the loop" approaches, demonstrating how deep learning can be applied to image, video, and audio analysis, as well as to create user-centric and interactive systems. Practical aspects, including data preprocessing, model evaluation, and framework implementation, will also be covered, equipping students with the skills to apply deep learning techniques in a human-centered context.

**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 7389J. Advanced Natural Language Processing.**

This course is an interdisciplinary field that combines computational linguistics with statistical and machine learning techniques to enable the computer to understand, interpret, generate, and learn natural language. Natural Language Processing (NLP) introduces key concepts, tasks, and techniques, including recent advancements such as neural networks and large language models. It covers applications such as question answering, automatic speech recognition, and machine translation. Students will gain an understanding of fundamental concepts, advanced algorithms, and practical applications, and will also learn methods for acquiring and annotating text data, and representing linguistic structures. Familiarity with Linear Algebra and Python Programming is required.

**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 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

**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