North Carolina Agricultural & Technical State University

Graduate Student Handbook

Master of Science
Doctor of Philosophy

Department of Computer Science

508 McNair Hall
Greensboro, NC 27411

https://www.ncat.edu/coe/departments/cs/index.php

Phone: 336-334-7245 Fax: 336-334-7244
email: CompSci@ncat.edu

Revised July 2020

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1. Introduction

This handbook serves as both a source of information on the graduate program in the Computer Science Department for prospective students and as a manual on current policies, procedures, and guidelines for current students. This handbook should always be used in conjunction with other official publications of the University, of the Graduate College, and of the College of Engineering Graduate Office.

The current edition of the North Carolina Agricultural & Technical State University (NC A&T SU) Graduate Catalog contains the university procedures and requirements. Those procedures and requirements pertain to all graduate work undertaken at NC A&T SU. It is the responsibility of each graduate student to ensure that their graduate program conforms to these requirements. Additional information or clarification about the Graduate College requirements can be obtained from the Office of the Graduate Studies (120 Gibbs Hall), 336-285-2366 (http://www.ncat.edu/tgc/graduate-catalog/index.html)

Any changes in this catalog will be disseminated in writing. It is the student's obligation to obtain the most current information from their advisor before designing a course of study. The policies stipulated in this document are the only basis for designing a program of study for each MS and PhD student.

2. Master's and PhD Programs General Description

The Department of Computer Science offers an innovative graduate program combining computer science fundamentals with practical knowledge and technical excellence in the most advanced technologies. The Computer Science Department performs research funded by agencies including the National Science Foundation, the Department of Defense, the National Security Agency, the Department of Energy and national laboratories, and others.

The research interests of the faculty cover many areas of Computer Science including cyber security, cyber identify, artificial intelligence and data science, big data, visual analytics and virtual reality, software engineering and formal methods, distributed and web-based systems, multiagent systems, trustworthy cloud computing and high performance computing.

The Department offers a Master of Science in Computer Science (MSCS) degree and a Doctor of Philosophy in Computer Science (PhD in CS) degree. The MSCS degree provides an option of a "General Area" and three specialization areas that are "Software Engineering", "Cyber Security", and "Artificial Intelligence and Data Science". Students interested in these areas can choose one of these specialization areas, whereas students interested in other areas may select General Area, and design their curriculum in consultation with their advisor to satisfy all graduation requirements of an MS in CS. Detailed descriptions of the MS and PhD programs appear in Section 5 and Section 6 respectively.

3. Admission to Master of Science Program in Computer Science

It is assumed that all entering students have completed undergraduate courses in programming in an object oriented programming language (such as C++ or Java), data structures, operating system, and computer architecture. It is expected that students are mathematically mature, for example, they have taken Calculus I & II, and Discrete Mathematics. Students who have not had such courses or their equivalent may be required to take undergraduate courses to remedy deficiencies with no credit towards the degree. A 3.0 GPA and an undergraduate degree in Computer Science or a related discipline are required for unconditional admission.

Detailed information on admissions procedures, along with the appropriate forms, is available from the website of the Graduate College.

4. Admission to the Doctor of Philosophy Program in Computer Science

It is generally assumed that an entering student has completed graduate study with an MS in CS. A 3.25 GPA, GRE verbal score 150 and quantitative score 155 and a MS degree in Computer Science or a related discipline are required for admission. A highly qualified applicant with a B.S. in CS with GPA of at least 3.5, GRE verbal score of at least 153 and quantitative score of at least 159 can apply for the PhD program.

Detailed information on admission procedures, along with the appropriate forms, is available from the Graduate School and College of Engineering graduate office.

5. Master's Degree Requirements

The Master of Science in Computer Science at NC A&T SU can be earned through one of three options: Project, Thesis, or Course. The Thesis option requires thirty credit hours consisting of twenty-four credit hours of course work and six credit hours for the thesis. The Project option requires thirty credit hours consisting of twenty-seven credit hours of course work and three credit hours for the project. The course option requires thirty credit hours of course work. Graduate credit hours are earned only on courses numbered 600 and above, and at least half of the credit hours must be in courses numbered 700 and above.

As stated before, students may specialize in one of three Areas (Software Engineering, Cyber Security, and Artificial Intelligence and Data Science), or select the General Area and design their own program in consultation with their advisor such that all requirements for MS in CS at NC A&T SU are satisfied. Students choosing Software Engineering, Cyber Security, Secure Software Engineering or Artificial Intelligence and Data Science may benefit from the following description of the three areas:

SOFTWARE ENGINEERING (SE): Software engineering can be defined as the systematic approach to the development, operation, testing, maintenance, and deployment of software. Software includes the various documents needed for the development, installation, utilization, and maintenance of a system. Engineering refers to the application of a systems approach to the production of large software systems. The methods of software engineering seek to produce high-quality systems, on time, and at the lowest possible cost. Research projects include object-oriented methodologies, software production cost modeling, software reliability engineering, software reuse, and the social implications of computer technology.

Security vulnerabilities caused by software defects are costing business millions of dollars each year and threaten the security of individuals and the nation. There is a high demand for software professionals who can develop quality and secure software. Secure software engineering provides students with knowledge of requirements engineering for secure software, secure software architecture and design, secure coding and testing, and software security best practices, etc. Research topics include security requirements engineering, design for security, auditing software, implementation risks, application security, denial-of-service protection for concurrent software, and malicious code detection and analysis, etc.

CYBER SECURITY (CS): With wide spread use of the Internet, Cyber Security has become a dominant issue in the Information Technology (IT) industry. Cyber Security has significantly influenced priorities for IT education, research, and development. To defend our homeland and stay at the forefront of scientific discovery, federal and local governments recognize the need for a well-trained workforce in emerging and advanced tools of Cyber Security. The rapid growth of Cyber Security in the job market created a need for well-trained workers at all levels, including the master. Research topics include network security, Web security, mobile security, intrusion detection, information privacy and security, trustworthy cloud computing, software security, usable security and human aspects of security.

ARTIFICIAL INTELLIGENCE AND DATA SCIENCE (AI/DS)): Artificial intelligence (AI) attempts to perform with hardware and software complex and flexible tasks that are characteristic of human intelligence. AI has had notable success in fields such as natural language understanding and computer vision, and it is heavily used in driverless cars, robotics, and computer games. Traditional areas of AI include planning, knowledge representation, and reasoning and argumentation. Since the turn of the century, advances in computer power and the availability of large datasets have spurred research in machine learning, which is now the leading field in AI. Machine learning is also a critical component of what has become known as data science, which is a pragmatic discipline that extracts patterns from datasets for predictive uses. Data science uses statistics as well as machine learning, and it subsumes the field called data mining. Data science relies on database management as well as distributed and parallel systems, aspects that fall under the rubric "big data."

G**ENERAL AREA:** There are several other research areas in the Department of Computer Science. Students who wish to do project/thesis option can select a research topic from these areas. Students must consult their advisor to design their curriculum and project/thesis.

The MSCS program must be completed within six consecutive calendar years. The program is designed to be completed in three semesters of full-time study.

5.1. Course Requirements

The course-work requirements for MS in Computer Science at NC A&T SU must be satisfied by:

a) Nine credit hours courses in core area required of all students in the program,

COMP 710	Software Specification, Analysis, & Design
COMP 755	Advanced Operating Systems
COMP 775	Advanced Design and Analysis of Algorithms

b) Required courses specific to the student's area (Students selecting General Area design their curriculum in consultation with their advisor, and with approval of Graduate Coordinator),

The required courses for the four areas are listed below:

Software Engineering

COMP 620	3	Information Privacy and Security
COMP 725	3	Software Security Testing
COMP 727	3	Secure Software Engineering
COMP xxx	3	Software Engineering elective

Cyber Security

COMP 620	3	Information Privacy and Security
COMP 621	3	Web Security
COMP 726	3	Network Security
COMP xxx	3	Cyber Security elective

Artificial Intelligence and Data Science

COMP 651	3	Data Analytics Techniques
COMP 765	3	Data Mining
COMP 851	3	Big Data Analytics
COMP xxx	3	Artificial Intelligence and Data Science elective

General Area

COMP 620	3	Information Privacy and Security
COMP 651	3	Data Analytics Techniques

c) Approved elective courses in the student's area for students pursuing a specialty area in Software Engineering, Cyber Security, or Artificial Intelligence and Data Science,
d) Elective courses chosen with the prior written approval of the student's advisor, and
e) With permission of a student's advisor and the Graduate Coordinator, the student may take up to a maximum of two electives outside the Computer Science Department.

Note: A student can take COMP 685 a maximum of two times. A student can take COMP 790 Independent study at most one time.

5.2. Thesis, Project, and Course Option and Requirements

The Masters of Science in Computer Science at NC A&T SU can be earned through one of three options: Project, Thesis, or Course. The Thesis option requires thirty credit hours consisting of twenty-four credit hours of course work and six credit hours for the thesis. The Project option requires thirty credit hours consisting of twenty-seven credit hours of course work and three credit hours for the project. The course option requires thirty credit hours of course work. Graduate credit hours are earned only on courses numbered 600 and above, and at least half of the credit hours must be in courses numbered 700 and above.

Each student has the option of completing the final degree requirements with the completion of a Master's Thesis, a Master's Project, or by means of course work. The following tables summarize the requirements for each available option in the four areas.

SE Area	**Required Core**	**Specialty Required**	**Specialty Electives**	**Approved Electives**	**Project/Thesis**	**Total Credits**
SE Course Option	9 credits COMP 710 COMP 755 COMP 775	9 credits COMP 620 COMP 725 COMP 727	6 credits with approval (see list)	6 credits with approval (see list)	.	30
SE Project Option	9 credits COMP 710 COMP 755 COMP 775	9 credits COMP 620 COMP 725 COMP 727	6 credits with approval (see list)	3 credits with approval (see list)	COMP 796 MSCS Project: 3 credits.	30
SE Thesis Option	9 credits COMP 710 COMP 755 COMP 775	9 credits COMP 620 COMP 725 COMP 727	3 credits with approval (see list)	3 credits with approval (see list)	COMP 797 MS Thesis Research: 6 credits.	30

CS Area	**Required Core**	**Specialty Required**	**Specialty Electives**	**Approved Electives**	**Project/Thesis**	**Total Credits**
CS Course Option	9 credits COMP 710 COMP 755 COMP 775	9 credits COMP 620 COMP 621 COMP 726	6 credits with approval	6 credits with approval		30
CS Project Option	9 credits COMP 710 COMP 755 COMP 775	9 credits COMP 620 COMP 621 COMP 726	6 credits with approval	3 credits with approval	COMP 796 MSCS Project: 3 credits.	30
CS Thesis Option	9 credits COMP 710 COMP 755 COMP 775	9 credits COMP 620 COMP 621 COMP 726	3 credits with approval	3 credits with approval	COMP 797 MS Thesis Research: 6 credits.	30

AI/DS Area	**Required Core**	**Specialty Required**	**Specialty Electives**	**Approved Electives**	**Project/Thesis**	**Total Credits**
AI/DS Course Option	9 credits COMP 710 COMP 755 COMP 775	9 credits COMP 651 COMP 765 COMP 851	6 credits with approval (see list)	6 credits with approval (see list)		30
AI/DS Project Option	9 credits COMP 710 COMP 755 COMP 775	9 credits COMP 651 COMP 765 COMP 851	6 credits with approval (see list)	3 credits with approval (see list)	COMP 796 MSCS Project: 3 credits.	30
AI/DS Thesis Option	9 credits COMP 710 COMP 755 COMP 775	9 credits COMP 651 COMP 765 COMP 851	3 credits with approval (see list)	3 credits with approval (see list)	COMP 797 MS Thesis Research: 6 credits.	30

General Area	Required Core	Specialty Required	Specialty Electives	Approved Electives	Project/Thesis	Total Credits
General Course Option	9 credits COMP 710 COMP 755 COMP 775	6 credits COMP 620 COMP 651		15 credits with approval (see list)		30
General Project Option	9 credits COMP 710 COMP 755 COMP 775	6 credits COMP 620 COMP 651		12 credits with approval (see list)	COMP 796 MSCS Project: 3 credits.	30
General Thesis Option	9 credits COMP 710 COMP 755 COMP 775	6 credits COMP 620 COMP 651		9 credits with approval (see list)	COMP 797 MS Thesis Research: 6 credits.	30

5.3. Academic Advisor and MS Committee

Upon receipt of admission from the Dean of the Graduate College, a student will have the assignment of a temporary advisor. The advisor will assist the student in course selection until the student selects a permanent advisor by mutual agreement between the student and the graduate faculty member. All students must select a permanent advisor by the first month of their second semester of full time study.

Students who select the project or thesis option must form their thesis or project committee by the end of the first month of their second semester. The committee consists of a project/thesis advisor and two committee members. The project/thesis advisor serves as the chair of the committee. It is the responsibility of the student to meet all the deadlines.

5.4. Project/Thesis Requirements

- Project Requirements

The Project Option should be considered by students who seek to demonstrate that they have mastery of a computer science specialty by completing a substantial implementation project. This option provides an excellent opportunity for developing professional skills.

To select the Project Option, the student must find a member of the graduate faculty willing to serve as the Project Advisor. Acceptance to the MS program does NOT guarantee that the student will be able to find a graduate faculty member willing to serve as their Project Advisor. If no faculty member is willing to serve, the student will select either the Thesis Option or the Course Option.

With the project advisor, the student will select a committee of 3 to 5 faculty members as the MS Project Committee. This committee serves in the capacity of an impartial second source of professional review of the quality of the student's work and, in conjunction with the academic advisor, assists the student in the research work required for the Project. A majority of the members of this committee must be from within the Computer Science Department. Both the departmental Graduate Coordinator and the Department Chair are “ex-officio” members of every Project Committee, although they may also be selected as regular committee members.

With the project advisor, the student will select a topic for their project. The student will write a project proposal defining precisely what they will be doing for their project. The project proposal must be approved by all members of the students MS Project Committee, although an oral presentation of the project proposal is not required.

An oral defense of the Project is required and scheduled by the student. An affirmative vote by a majority of the committee after the oral examination is necessary for the student to pass. Note that COMP 797 MS Thesis credits cannot be counted towards the Project Option.

- Thesis Requirements

The Thesis Option requires twenty-four credit hours of course work and a written thesis acceptable to the student's thesis committee. This option provides depth in a research area. Students who may plan to pursue doctoral studies will especially benefit from the preparation provided by the Thesis Option.

To select the Thesis Option, the student must find a member of the graduate faculty willing to serve as the Thesis Advisor. Acceptance to the MS program does not guarantee that the student will be able to find a graduate faculty member willing to serve as their thesis advisor. If no faculty member is willing to serve, the student will select either the Project Option or the Course Option, as explained under the respective headings in this document.

With the thesis advisor, the student will select a committee of 3 to 5 faculty members as the MS thesis committee. This committee serves in the capacity of an impartial second source of professional review of the quality of the student's work and, in conjunction with the academic advisor, assists the student in the research work required for the Thesis. A majority of the members of this committee must be from within the Computer Science Department. The composition of the thesis committee must be approved by the departmental Graduate Coordinator. Both the departmental Graduate Coordinator and the Department Chair are "ex-officio" members of every Thesis Committee, although they may also be selected as regular committee members.

With the thesis advisor, the student will select a topic for their thesis. The student will write a thesis proposal defining precisely what they will be doing for their thesis. The student must make an oral presentation of their proposal to their MS thesis committee. The Committee may require changes in the proposal. The thesis proposal must be approved by all members of the students' MS thesis committee.

An oral defense of the thesis is required, whose scheduling is the student's responsibility. The student must complete the thesis and submit to the thesis committee for review at least one week before the oral defense. An affirmative vote by a majority of the committee after the oral defense is necessary for the student to pass. The committee may require changes to the thesis. The student will submit the final thesis to the Graduate College for approval.

5.5. One Year Course Option MSCS Program

The MS in CS program with course option can be obtained within one year if summer courses are taken. A sample curriculum guide is as follows (assuming a student starts the MSCS in the Fall semester, and completes the program in the Summer semester of the following year):

Fall semester:

COMP 775	Advanced Design and Analysis of Algorithms
COMP xxx	Specialty required course
COMP xxx	Specialty required course
COMP xxx	Specialty elective course

Spring semester:

COMP 710	Software Specification, Analysis, & Design
COMP 755	Advanced Operating Systems
COMP xxx	Specialty required course
COMP xxx	Specialty elective course

Summer semester:

6 credits of approved electives (COMP700-899 or courses from other departments with approval of advisor)

5.6. Critical Steps

The following are the critical steps in the progression to a Master's degree in Computer Science:

1) Apply for admission by completing the Graduate College application form on-line and send all required materials to the Graduate College. The Graduate College will forward the complete application package to the Graduate Coordinator of Computer Science Department.
2) Receive an admission status letter from the Graduate College.
3) Contact temporary advisor: see the temporary advisor that is assigned by the Department of Computer Science.

4) Prepare your study plan, fill out the graduate plan of study form, obtain advisor approval and the approval of the Graduate Coordinator or the Department Chair. The graduate plan of study form will be submitted to the Graduate College by the department.
5) Complete the courses required to remedy deficiency in background knowledge in CS.
6) Select permanent advisor before the first month of the second semester.
7) Consult with permanent advisor, possibly to update the plan of study.
8) Consult with permanent advisor to select thesis or project committee if Thesis or Project Option is selected. If Thesis Option is selected, fill out the Thesis Committee Composition form and submit to the Graduate College.
9) If Thesis Option is selected, schedule thesis proposal defense by the start of the second semester. The student must complete the thesis proposal and submit to the thesis committee at least one week before the thesis proposal defense.
10) Defend thesis proposal by the end of the second semester, and submit the Defense result form to the Graduate Coordinator.
11) If Project Option is selected, complete a project proposal and submit to the project committee to gain approval.
12) Complete course work.
13) Schedule and complete Project or Thesis defense if Project or Thesis Option is selected. Submit the defense result form to the Graduate Coordinator.
14) Submit Application for Graduation to the Graduate College. The Graduate Coordinator then submits your Final Graduate Clearance Checklist to the Graduate College.
15) Graduate!

6. Doctoral Degree Requirements

The Doctor of Philosophy in Computer Science at NC A&T SU can be earned by completing the required course work, research and a dissertation. Students must specialize in one of the research areas (Software Engineering, Cyber Security, Artificial Intelligence and Data Science, and others) and meet all requirements for PhD in CS.

6.1. Course Requirements

The PhD degree requires graded course work and non-graded course work. A student directly admitted into the program without an MS in computer science must complete 63 credit hours of course work that include 42 hours of graded courses and 21 hours of non-graded courses beyond the BS degree. A student with an MS in computer science must complete 45 credit hours of course work that includes 24 hours of graded courses and 21 hours of non-graded courses.

- Required Graded courses

A student must take core courses in the Department of Computer Science at NC A&T. A student must take at least 18 hours of 8xx level courses.

a) The required graded courses for post baccalaureate students are:

Core courses:

COMP 710	3	Software Specification, Analysis and Design
COMP 755	3	Advanced Operating Systems
COMP 775	3	Advanced Design & Analysis of Algorithms

Required course:

COMP 892	3	Doctoral Research Methods

COMP elective (24 credit hours): Take 24 credits of additional COMP 700-899 courses with approval of advisor

Elective (6 credit hours): Take 6 credit hours from COMP 700-899 courses or other departments with approval of advisor

b) The required graded courses for post baccalaureate students are:

Core courses*:

COMP 755	3	Advanced Operating Systems
COMP 775	3	Advanced Design & Analysis of Algorithms
COMP 892	3	Doctoral Research Methods

COMP elective (9 credit hours): Take 9 credits of additional COMP 700-899 courses with approval of advisor

Elective (6 credit hours): Take 6 credit hours from COMP 700-899 courses or other departments with approval of advisor

*If the student has already taken a core course then the student must substitute this course with an elective course with approval of the advisor.

- Required Non-graded courses

The required non-graded courses are described as follows:

COMP 991	0	Doctoral Qualifying Exam
COMP 994	3	Doctoral Research Exam
COMP 997	18	Doctoral Dissertation

6.1.1. Grades Required

Students must meet the minimum academic qualifications published by the Graduate College, which are as follows, where item 5 is a stricter version of what the Graduate College published:
1. To earn the degree, a student must have a cumulative average of "B" (3.0 on a 4.0 scale).
2. Students automatically go on probation when their GPA falls below 3.0.
3. Students may be dropped from the program if they have not been removed from probation after two consecutive terms as a full-time student.
4. Students may not repeat a required course in which a "C" or above was earned.
5. Earning an "F" in a required course results in termination of the student's graduate study.
6. All grades of "I" must be removed during the student's next term of enrollment.

6.1.2. Transfer Credit Accepted

A maximum of six transfer credit hours may be accepted for courses that are completed beyond the M.S. degree and that form part of a coherent plan of study. Decisions on transfer credits will be determined by the faculty with approval of the Graduate Coordinator.

6.2. Advisory Committee

A Ph.D. student must form an advisory committee consisting of at least three graduate faculty members from the Department of Computer Science, one being the student's faculty advisor, who serves as chair. Additional faculty members may be added at the discretion of the student and the student's advisor. At least one of the committee members must have already served on a Ph.D. committee; this member may be someone outside the department. This committee administers the Doctoral Research Examination and the final oral defense. To ensure timely progress, this committee annually evaluates the student's progress and communicates feedback to the student.

6.3. Sequence of Examinations

A student must pass a Doctoral Qualifying Examination on core topics; they are encouraged to take this within a year of acceptance. Next is the Doctoral Research Examination, in which the student's ability to perform independent research is demonstrated. A student will be considered a Ph.D. candidate after passing the proposal defense.

The Doctoral Qualifying Examination corresponds to COMP 991 and the Doctoral Research Examination corresponds to COMP 994. Before the final oral defense, the student must have registered for 18 credits of COMP 997, not necessarily all in the same semester.

6.3.1. Doctoral Qualifying Examination

A student must pass a qualifying examination based on core topics and the areas in which they claim competence. This examination is administered during the third week of each semester, and students must register for COMP 991. Students may take up to six component examinations and must pass at least four with a score of at least 80%. Students are encouraged to take this examination within one calendar year of acceptance into the Ph.D. program. Students passing fewer than four component examinations may retake those they failed at the next offering. A student's graduate study is terminated for failing to pass four component examinations in two attempts.

All Ph.D. students must take four component examinations, each covering the content of one of the courses listed below.
The Two core courses are:

- COMP 755: Advanced Operating Systems
- COMP 775: Advanced Design & Analysis of Algorithms.

The other two courses may be any two graduate level courses recently being offered in the CS department with the approval of their advisor.

6.3.2. Doctoral Research Examination

The Doctoral Research Examination allows the student to demonstrate the ability to perform independent research. The student will conduct a literature review in a problem area agreed upon by his or her committee. The student will then identify a research problem and produce some initial results relating to this problem. The student will be evaluated on his or her submitted written report and oral presentation. The report should clearly explain the background in a way that can be understood by a non-specialist. The COMP994 Doctoral Research Examination course must be taken the semester the student will be completing the exam. The student must complete the Doctoral Research Methods course (COMP 892) before taking this examination. This examination is determined by the student's advisory committee, which also evaluates the student's performance and determines the outcome.

A student failing the Doctoral Research Examination has a second chance at the discretion of their advisory committee. A student's graduate study will be terminated for failing to pass this examination after the second attempt.

6.3.3. Final Oral Defense

The final oral defense is a public defense of the student's research. Its outcome is determined by the advisory committee, with failure resulting in termination of the student's graduate study. The student must complete the dissertation and submit to the advisory committee for review at least one week before the final oral defense. The advisory committee may require changes to the dissertation. The student will submit the final dissertation to the Graduate College for review and approval.

6.4. Residency Requirement and Time Limit for Completion

Students must take twenty-four hours of credits on campus and must complete the requirements for the Ph.D. degree within seven years from the date of first enrollment in the program.

6.5. Critical Steps

The following are the critical steps in earning a Ph.D. in Computer Science.

1. Apply for admission by completing the graduate application form on-line and sending all required materials to the Graduate College, which will forward the complete application package to the Graduate Coordinator of Computer Science Department.
2. Receive an admission status letter from the Graduate College.
3. Contact the temporary advisor that is assigned by the Department of Computer Science.

4. Prepare study plan, fill out the graduate plan of study form, obtain the approval of the advisor and the Graduate Coordinator or Department Chair. The Department of Computer Science will submit it to the Graduate College.
5. Select a permanent advisor (with the approval of the Graduate Coordinator) no more than 9 credit hours into the program or by the end of the first semester (whichever comes first).
6. Possibly Revise the Plan of Graduate Study in consultation with your advisor and submit to the Graduate College.
7. Take the Qualifying Examination ideally within one calendar year of acceptance into the program, but in any case not later than the end of the fifth semester. This exam is given during the third week of each semester. You must register for COMP 991 to take the Qualifying Examination.
8. Form an advisory committee consisting of at least three graduate faculty members from the Department of Computer Science, one being your advisor, who serves as chair. Additional faculty members may be added at your and your advisor's discretion. At least one member must have already served on a PhD committee. This committee administers the Research Examination, proposal defense and the final oral defense. Fill out the Dissertation Committee Composition form and submit to the Graduate College.
9. Take the Research Examination. Completing the Research Method course (COMP 892) is a prerequisite for taking this exam. If you fail, you have a second chance at the discretion of your advisory committee.
10. When the student and their advisor have settled on a direction for the research, submit a dissertation title and research plan to the advisory committee.
11. Complete all course work.
12. Write the proposal and defend the proposed research. Schedule the proposal defense in consultation with the advisor and advisory committee. After their approval, post the time and place of the proposal defense. The student should submit the proprosal to the advisory committee at least one week before the scheduled propose defense. Failure to pass this defense, or failure to meet the specified conditions within the prescribed time, results in termination of the graduate study. The student will be considered a PhD candidate after passing the proposal defense.
13. No earlier than one semester (or four months) into the student's candidacy, schedule the Final Oral Defense. The student and their advisor must post the time and place of the defense no later than one week before the defense. The student should submit the draft of the dissertation to all committee members (including the representative of the Graduate College) for review no later than one week before the Final Oral Defense.
14. Final Oral Defense. This is a public defense of the dissertation research, and its outcome is determined by the advisory committee. Failure results in termination of the graduate study. The defense result form with signatures of all advisory committee members and the Graduate Coordinator/Department Chair is sent within 24 hours to the Graduate College by the student's advisor.
15. Submit Application for Graduation to the Graduate College. The Graduate Coordinator then submits the Final Graduate Clearance Checklist to the Graduate College.
16. Submit all required documentation to the Graduate College and to the Department of Computer Science.
17. Graduate.

7. Financial Support

The Computer Science Department is committed to financial support of worthy full-time students on a merit basis. A description of the policies that apply to all graduate assistantship is provided in the graduate catalog in the section titled: Types of Available Funds. The number of assistantships available varies from semester to semester that depends on the research grants and funding of the department and the Graduate College. All awards are made on competitive basis, and every applicant may not receive an offer. The award could be tuition or stipend. The student must indicate interest in these programs in the relevant section of the application package.

8. Computer Science Faculty Listing

Mohd Anwar, B.S., Winona State University; M.S. North Dakota State University; Ph.D. University of Saskatchewan; Associate Professor; Cybersecurity, Human-centered Computing, Health Informatics.

Kelvin S. Bryant, B.S., North Carolina State University; M.S., North Carolina State University; Ph.D., North Carolina State University; Associate Professor; Developing VR Applications to Model Hazardous Training Scenarios, Cyber Security, Computer Science Education.

Edward C. Carr, B.S., Wingate University; M.S., North Carolina A&T State University; M.S., Western Carolina University; Ph.D. North Carolina A&T State University; Teaching Assistant Professor and Undergraduate Coordinator; Graph Theory, Concurrency, AI.

Isaac Cho, B.S., Hallym University; Ph.D., University of North Carolina at Charlotte; Assistant Professor; Visualization, Visual Analytics, Immersive Visualization, Virtual Environments, 3D User Interfaces, Human Computer Interaction.

Albert C. Esterline, B.A., Lawrence University; M.Litt., Ph.D., University of St. Andrews; M.S., Ph.D., University of Minnesota; Associate Professor; Data Science, Network Science, Semantic Web, Formal Methods, Identity, Multiagent Systems.

Jung Hee Kim, B.S., Korea University; M.S., Ph.D., Illinois Institute of Technology; Associate Professor; Intelligent Tutorial Systems, Data Mining, Artificial Intelligence.

Sajad Khorsandroo, B.Eng., University of Applied Science and Technology; M.S., University of Malaya; Ph.D., University of Texas at San Antonio; Assistant Professor; Software Defined Networks (SDNs), Network Function Virtualization (NFV), Cloud Computing, Cyber Security.

Derrick Leflore, B.S., M.S., North Carolina A&T State University; Software Engineering, Algorithms, Operating Systems.

Letu Qingge, B.S., Inner Mongolia University; M.S., Beijing University of Chemical Technology; Ph.D., Montana State University; Assistant Professor; Algorithms, Data Science, Bioinformatics and Computational Biology, Theoretical Computer Science

Kaushik Roy, B.S., University of Rajshahi; M.S., Ph.D., Concordia University; Associte Professor; Artificial Intelligence, Cyber Identity, Biometrics, Big Data, and Computer Vision.

Jinsheng Xu, B.S., Nanjing University, M.S., Peking University, Ph.D., Michigan State University; Associate Professor; Cyber Security, Data Mining, Big Data, Machine Learning, Simulation, Parallel Computing.

Huiming Yu, B.S., Xiamen University; M.S., Hefei Polytechnic University; Ph.D., Stevens Institute of Technology; Professor and Graduate Coordinator; Visuzlization, Cyber Security, Web security and Trustworthy Cloud Computing.

Xiaohong Yuan, B.S., Hua Zhong University of Science and Technology; Ph.D., Institute of Automation, Chinese Academy of Sciences; Ph.D., Florida Atlantic University; Professor and Chair; Intrusion Detection, Machine Learning, Software Security, Cybersecurity Education.

9. Graduate Course Listing in Computer Science

Course	CS Graduate Courses (new)	SE Area		AI&DS Area		CS Area		General		Ph.D	
		Req	Elec	Req	Elec	Req	Elec	Req	Elec	Req	Elec
COMP 611	System Testing and Evaluation		√		√		√		√		√
COMP 620	Information, Privacy, and Security	√			√	√		√			√
COMP 621	Web Security		√		√	√			√		√
COMP 627	Wireless Network Security		√				√		√		√
COMP 645	Artificial Intelligence								√		√
COMP 651	Data Analytics Techniques		√	√			√	√	√		√
COMP 653	Computer Graphics		√		√		√		√		√
COMP 663	Compiler Construction		√		√				√		√
COMP 670	Advanced Computer Architecture		√		√		√		√		√
COMP 681	Formal Methods		√		√				√		√
COMP 685	Special topics in Computer Sci.		√		√		√		√		√
COMP 710	SW Spec., Analysis, & Design	√		√		√		√			√
COMP 711	SW System Design., Imptn., Veriftn., & Validtn.								√		√
COMP 712	Software Project Management				√		√		√		√
COMP 713	Social Impacts of Software Sys		√		√		√		√		√
COMP 716	OO Program and Software Reuse		√		√		√		√		√
COMP 717	Software Fault Tolerance		√				√		√		√
COMP 722	E-Commerce		√		√		√		√		√
COMP 723	Intrusion Detection		√				√		√		√
COMP 724	Security and Multiagent Systems		√		√		√		√		√
COMP 725	Software Security Testing	√	√		√		√		√		√
COMP726	Network Security		√			√			√		√
COMP 727	Secure Software Engineering	√	√		√		√		√		√
COMP 732	Advanced Software Tools		√				√		√		√
COMP 733	Parallel Computing Applications		√		√		√		√		√
COMP 740	Advanced Artificial Intelligence				√				√		√
COMP 741	Knowledge Repres. and Acquisitn		√		√		√		√		√
COMP 742	Automated Reasoning				√				√		√
COMP 743	Genetic and Evolutionary Gaming		√		√		√		√		√
COMP 744	Advanced Game Intelli. & Design		√		√		√		√		√
COMP 745	Computational Linguistics				√				√		√
COMP 747	Computer Vision Methodologies		√		√		√		√		√
COMP 749	Intelligent Robot				√				√		√
COMP 750	Distributed Systems		√		√		√		√		√
COMP 753	Performance Modeling and Eval		√		√		√		√		√
COMP 755	Advanced Operating Systems	√		√		√		√		√	
COMP 765	Data Mining		√	√			√		√		√
COMP 767	Computer Network Architecture		√		√		√		√		√
COMP 768	Advanced Data Mining		√		√		√		√		√
COMP 770	Comp Org. & Prog. for Sci. Comp		√		√		√		√		√
COMP 775	Advanced Analysis of Algorithms	√		√		√		√		√	
COMP 780	Semantics of Program Languages		√		√		√		√		√
COMP 786	Multiagent Systems		√		√		√		√		√
COMP 790	Independent Study		√		√				√		
COMP 793	Masters Supervised Teaching		√		√		√		√		
COMP 796	MSCS Project		√		√		√		√		

COMP 797	MS Thesis Research		√		√		√		√		
COMP 799	Continuation Research		√		√		√		√		
COMP 821	Cloud Computing & Security		√		√		√		√		√
COMP 823	Secure Social Computing		√		√		√		√		√
COMP 826	Security for Emerging Networks		√		√		√		√		√
COMP 829	Topics in Software Assurance		√		√		√		√		√
COMP 831	Biomedical Computing		√		√		√		√		√
COMP 832	Advanced Biometrics		√		√		√		√		√
COMP 833	Gentic & Evolutionary Biometrics		√		√		√		√		√
COMP 841	Computational Intelligence		√		√		√		√		√
COMP 851	Big Data Analytics		√	√			√		√		√
COMP 852	Web-based Visual Analytics		√		√		√		√		√
COMP 853	Data Fusion		√		√		√		√		√
COMP 863	Compiler Optimization		√		√		√		√		√
COMP 871	Advanced Network Science		√		√		√		√		√
COMP 872	Social Semantic Web		√		√		√		√		√
COMP 873	Web Science		√		√		√		√		√
COMP 874	Standards & Tech. for E-Com.		√		√		√		√		√
COMP 875	Security Enhanced OS		√		√		√		√		√
COMP 876	Secure Architecture		√		√		√		√		√
COMP 878	Usable Security		√		√		√		√		√
COMP 881	Advanced Multiagent Systems		√		√		√		√		√
COMP 883	Concurrency Formisms		√		√		√		√		√
COMP 885	Emergent Semantics		√		√		√		√		√
COMP 887	Formal Ontologies		√		√		√		√		√
COMP 892	Doctor Research Methods									√	
COMP 895	Special Topics										√
COMP 991	Doctor Qualifying Exam									√	
COMP 992	Doctor Seminar										√
COMP 993	Doctor Supervised Teaching										□√
COMP 994	Doctor Research Exam									√	
COMP 997	Doctor Dissertaton									√	
COMP 999	Continuation of Research										√

10. Course Descriptions

COMP 611. System Testing and Evaluation **Credit 3 (3-0)**

This course will focus on the methods, techniques, procedures for system testing and evaluation. The main topics include reliability measurement, testing small and large systems, black box software testing, white box software testing, testing of concurrent and real-time systems, client-server testing, test case design methods, and automated testing tools.

COMP 620. Information, Privacy and Security **Credit 3 (3-0)**

This course examines the security and privacy issues associated with information systems. There are cost/risk tradeoffs to be made. Topics discussed include technical, physical, and administrative methods of providing security, access control, identification, and authentication. Encryption is examined, including Data Encryption Standards (DES) and public key cryptosystems. Management considerations such as key protection and distribution, orange book requirements, and OSI data security standards are covered. Privacy legislation is covered, as is current cryptographic research.

COMP 621. Web Security **Credit 3 (3-0)**

This course focuses on the technologies that provide security services for the World Wide Web. It introduces a set of procedures, practices, and technologies for protecting web servers, web users, and their surrounding organizations.

We discuss, understand and use various security technologies for the World Wide Web (WWW). How to use these technologies to secure WWW applications will be addressed.

COMP 627. Wireless Network Security **Credit 3 (3-0)**
This course covers the security issues associated with wireless networks. Emerging wireless technologies, standards and protocols are explored. The course will define and demonstrate various threats to wireless security. Topics include security service, security protocol, and security architecture for wireless. Details of wireless encryption techniques are examined.

COMP 645. Artificial Intelligence **Credit 3 (3-0)**
This course presents the theory of artificial intelligence, and application of the principles of artificial intelligence to problems that cannot be solved, or cannot be solved efficiently, by standard algorithmic techniques. Knowledge representation, and Knowledge-based systems. Topics include search strategies, production systems, heuristic search, expert systems, inference rules, computational logic, natural language processing. Predicate calculus is discussed. An artificial intelligence language is presented as a vehicle for implementing concepts of artificial intelligence.

COMP 651 Data Analytics Techniques **Credit 3 (3-0)**
This course develops skills for data analytics including use of a high-level language widely used by the data-science community as well as libraries or packages in that language for numerical computing, statistics, plotting, data manipulation, and machine learning. Linear algebra and statistical reasoning using these packages will be covered.

COMP 653. Computer Graphics **Credit 3 (3-0)**
This is a course in fundamental principles and methods in the design, use, and understanding of computer graphic systems. Topics include coordinate representations, graphics functions, and software standards. Hardware and software components of computer graphics are discussed. The course presents graphics algorithms. It also introduces basic two-dimensional transformations, reflection, shear, windowing concepts, clipping algorithms, window-to-viewport transformations, segment concept, files, attributes and multiple workstation, and interactive picture-construction techniques.

COMP 663. Compiler Construction **Credit 3 (3-0)**
This course emphasizes the theoretical and practical aspects of constructing compilers for computer programming languages. The course covers principles, models, and techniques used in the design and implementation of compilers, interpreters, and assemblers. Topics include lexical analysis, parsing arithmetic expressions and simple statements, syntax specification, algorithms for syntax analysis, object code generation, and code optimization. Each student will develop and implement a compiler.

COMP 681. Formal Methods **Credit 3 (3-0)**
In this course formal methods that model the software development process will be studied. Fundamental and practical methodologies and theories, including set theory and the foundations of software engineering will be emphasized. Applications to formal specifications, object-oriented programming and data modeling will be examined. Topics include: set theory, relations and functions, induction and recursion, symbolic logic, complex models, and application case studies.

COMP 685. Special Topics in Computer Science **Credit 3 (3-0)**
This course introduces computer science topics of current interest to students. The subject matter will be identified before the beginning of the course.

COMP 710. Software Specification, Analysis and Design **Credit 3 (3-0)**
This course provides an introduction to Systems Analysis and Design. Topics include analyzing the business case, requirements modeling, data and process modeling, and development strategies, with an increased focus on object modeling and project management. Students also learn about output and user interface design, data design, systems architecture.

COMP 711. Software System Design, Implementation, Verification and Validation Credit 3(3-0)
This course proceeds from the evaluation of a completed system design for completeness, correctness, information engineering, and functionality. Accepted industry and academic standards for such reviews will be used, for example leveling of data flow diagrams, measures of module cohesion, control structures, and function point estimation. As part of the implementation process, verification and validation methodologies will be studied and practiced. An actual system will be implemented by the end of the semester. Prerequisite: COMP 710.

COMP 712. Software Project Management **Credit 3 (3-0)**
This course examines the nature of data processing projects, definitions of purpose, scope, objectives, deliverable dates, and quality standards. Interpersonal interaction and people-oriented management techniques are studied, along with team member measurement and assessment methods. Project management tools such as PERT (Project Evaluation and Review Technique), and CPM (Critical Path Method) are covered. Managerial styles in motivating,

innovating, and organizing will be examined, along with techniques for improving these skills. Equipment and software selection and installation guidelines, and the proper use of outside consulting services will be examined.

COMP 713. Social Impacts of Software Systems **Credit 3 (3-0)**

This course examines the increasing importance of computer technology in the functionality of our economy, our government, and our industry. Potential impacts upon personal privacy and autonomy are examined in relation to the public policy and social impacts of computer technology. The role and opportunity for historically under-represented technical professionals will be explored. Interdisciplinary readings, written and oral presentations, and in class debates are required. Outside speakers from related disciplines are invited to participate.

COMP 716. Object-Oriented Programming and Software Reuse **Credit 3 (3-0)**

Introduce software reuse principles and reuse driven software development. Reuse techniques will be addressed that include reuse readiness assessment, corporate reuse plan creation and organizing for reuse. Discuss application package selection, selecting reusable components and identifying candidate reusable components. Teach and use the object-oriented programming language Java, emphasize its object-oriented features and how to use Java to develop reusable components, subsystems and frameworks.

COMP 717. Software Fault Tolerance **Credit 3 (3-0)**

The principles, techniques and current practices in the area of fault tolerant computing with an emphasis on system structure and dependability are examined in this course. Major topics include system models, software/hardware interaction, failure and reliability, fault tolerance principles, redundancy, rollback and recovery strategies, and N-version programming. Redundancy in data structures and the validation of fault tolerant software are studied.

COMP 722. E-Commerce **Credit 3 (3-0)**

This course covers the computer science and technology that enable e-commerce and the business concepts needed to understand e-commerce. Topics reviewed include HTML and CSS as well as client-side scripting. Topics introduced include e-commerce features, business models, and marketing concepts. Topics emphasized include the HTTP protocol, server-side scripting, the XML family of specifications, web services, the Semantic Web, and security in an e-commerce context.

COMP 723. Intrusion Detection **Credit 3 (3-0)**

This course introduces the concepts, techniques, tools, and the state of the art in the area of network intrusion detection systems. Topics to be covered include: network and computer system security fundamentals, network security models and approaches, attack classification and analysis, intrusions detection techniques and tools (vulnerability scanners, network sniffer, system monitoring and logging, etc), firewall, as well as the tools and techniques for intrusion signature analysis. The course will be a seminar-like, research-oriented class. Students are required to actively participate in the class presentations and discussions. Besides the textbooks, we will read and discuss many recent technical papers from current research in intrusion detection.

COMP 724. Security and Multiagent Systems **Credit 3 (3-0)**

This course addresses agents that communicate and coordinate over the web. The focus is on DARPA Agent Markup Language (DAML) and similar contributions to the area known broadly as the Semantic Web. Necessary background in XML, RDF, and SOAP is covered. The course also considers specifications of security and trustworthiness properties for systems of such agents both using formal techniques (process algebras and modal logics) and considering social aspects of Web use (as in e-commerce).

COMP 725. Software Security Testing **Credit 3 (3-0)**

This course focuses on software security testing techniques and tools. It covers security testing techniques such as code reviews and static analysis, creating test plans based on risk analysis, black-box, white-box and gray-box security testing, fault injection etc. Security testing tools will be introduced.

COMP 726. Network Security **Credit 3 (3-0)**

The course covers various aspects of securing data during their transmission. It includes the following topics: vulnerabilities in software and hardware systems; cyber attack methods and their defense mechanisms; symmetric ciphers; public key ciphers; hash functions; message authentication and digital signature; public key infrastructure and web of trust; email security; web security; IPSec; firewall; intrusion detection system.

COMP 727. Secure Software Engineering **Credit 3 (3-0)**

This course discusses how to incorporate security throughout the software development lifecycle. The main topics include threats to the software, software vulnerabilities, risk management, security requirements, secure design principles and patterns, an overview of secure programming and security testing.

COMP 732. Advanced Software Tools **Credit 3 (3-0)**

The software tools utilized in the high performance and massively parallel computing environments are indispensable to the practicing computer scientist. Message passing, profiling, languages, compilers, porting, system library usage, cache optimization, and in-lining are the topics of this course.

COMP 733. Parallel Computing Applications **Credit 3 (3-0)**

Many problems in computing can be solved more efficiently on a parallel computer. The parallel computing paradigm is the main focus of this course. The applicability of Amdahl's law, PRAM models, matrix by vector transforms, matrix by matrix graphics and visualization computations will be discussed.

COMP 740. Advanced Artificial Intelligence **Credit 3 (3-0)**

This course is a further study of artificial intelligence principles, with a focus on knowledge based systems. The course examines planning, belief revision, control, and system evaluation and implementation. Advanced topics include automated theorem proving, learning and robotics, neural nets, and the adequacy of existing theoretical treatments.

COMP 741. Knowledge Representation and Acquisition **Credit 3 (3-0)**

The representation formalisms used in artificial intelligence are explained, along with representation selection and implementation in common Artificial Intelligence languages and shells. Formalisms include first order logic and its extensions, semantic nets, frames and scripts, and KL-ONE-like languages. Knowledge acquisition is introduced as eliciting knowledge, interpreting elicited data within a conceptual framework, and the formalizing of conceptualizations prior to software implementation. Knowledge acquisition techniques such as protocol analysis, repertory grids, and laddering are examined.

COMP 742. Automated Reasoning **Credit 3 (3-0)**

This course studies the computational aspects of logic via propositional and predicate calculi, as well as the theory underlying their automation through logic programming languages. Various forms of resolution and their soundness and completeness are examined along with unification and its properties. Proof procedures and their search characteristics, term rewriting, and techniques such as narrowing are researched as a means of theory resolution. The relationship of formal specification techniques such as cut elimination, efficiency, and implementation issues are addressed. Prerequisite: COMP 645.

COMP 743. Genetic and Evolutionary Gaming **Credit 3 (3-0)**

This course will provide an overview of the concept of genetic and evolutionary computation as it relates to game playing and game design.

COMP 744. Advanced Game Intelligence and Design **Credit 3 (3-0)**

This course will discuss current state-of-the-art concepts and techniques in game intelligence and design. Topics include machine learning, intelligent game agents, game engines, multiplayer online games, and other topics related to current game intelligence research.

COMP 745. Computational Linguistics **Credit 3 (3-0)**

A presentation of computational linguistics theory and practice. Advanced readings that emphasize theories of dialogue and research methodologies are examined. Technical writing for journals and conferences is stressed as a goal of research output. Prerequisite: COMP 645.

COMP 747. Computer Vision Methodologies **Credit 3 (3-0)**

This course researches techniques for image understanding, both low-level and high-level image processing, mathematical morphology, neighborhood operators, labeling and segmentation. Vision methods covered include perspective transformation, motion, the consistent-labeling problem, matching, object models, and knowledge-based vision. Prerequisite: COMP 653.

COMP 749. Intelligent Robots **Credit 3 (3-0)**

This course examines intelligent robot systems as inclusive of knowledge representations, path finders, inference systems of rules and logic, and image understanding and spatial reasoning systems. Problems of navigation, algorithm development, robot programming languages and multiple robot co-operation are explored.

COMP 750. Distributed Systems **Credit 3 (3-0)**

This course examines the operating system concepts necessary for the design and effective use of networked computer systems. Such concepts include communication models and standards, remote procedure calls, name resolution, distributed file systems, security, mutual exclusion, and distributed databases. Students are required to construct an advanced implementation of distributed operating system facilities or a simulation of same.

COMP 753. Performance Modeling and Evaluation **Credit 3 (3-0)**

Common techniques and current results in the performance evaluation of computer systems are studied in this course. Background material in probability theory, queuing theory, simulation, and discrete mathematics is reviewed so that a performance evaluation of resource management algorithms for operating systems and database management systems in parallel and distributed environments may be developed. Prerequisite: COMP 755.

COMP 755. Advanced Operating Systems **Credit 3 (3-0)**

This course centers on operating systems for multi-processing environments: concurrent processes, mutual exclusion, job scheduling, memory, storage hierarchy, file systems, security, and distributed processing. Also discussed are virtual resource management strategies. A design project involving the construction of operating facilities is produced.

COMP 765. Data Mining **Credit 3 (3-0)**

This course presents the modern computer application of data mining. The theory of data mining is presented as well as applications of its principles in the professional world. This class discusses the basics of techniques and applications such as cluster detection, market basket analysis, decision tree derivation, genetic algorithms, artificial neural networks, memory-based reasoning and data warehouses. Students learn a variety of algorithms for discovering meaningful patterns and rules in large quantities of data. The class includes a data mining project where students are responsible for manipulating raw data, applying an algorithm, and understanding and analyzing information.

COMP 767. Computer Network Architecture **Credit 3 (3-0)**

This is a course in the architecture of computer communication networks and the hardware and software required to implement the protocols that define the architecture. Basic communication theory, transmission technology, private and common carrier facilities, international standards, satellite communications, and local area networks are examined. Methods of performance analysis and communication network modeling are discussed.

COMP 768. Advanced Data Mining **Credit 3 (3-0)**

This class focuses on the application of data mining theory. Data mining techniques and algorithms are brought to bear on real-world projects obtained from industry or other outside organizations. Students work in teams and are expected to write publication-quality articles.

COMP 770. Computer Organization and Programming for Scientific Computing Credit 3 (3-0)

Computer programming in the High Performance Computing environment is unlike that of the common workstation or desktop computing platform. Programming parallel computers with regard to data transfer, data storage and process execution are the main focus of this course. The architecture and organization of various parallel computing platforms are examined.

COMP 775. Advanced Design and Analysis of Algorithms **Credit 3 (3-0)**

This course discusses the design and analysis of efficient algorithms and algorithmic paradigms. Applications include sorting, searching dynamic structures, graph algorithms, computationally hard problems, and NP completeness.

COMP 780. Semantics of Programming Languages **Credit 3 (3-0)**

This course examines the formal treatment of the specification, meaning, and correctness of programs. Required mathematical results are examined, in areas such as universal algebra and category theory. Major course topics include the lambda calculus, type systems for programming languages, polymorphism, algebraic specification, rewrite systems, and semantic domains. The denotational semantics of programming languages, program logics, and program verification are discussed.

COMP 786. Multiagent Systems **Credit 3 (3-0)**

This course primarily addresses multiagent systems, emphasizing collaboration and group attributes. Topics include planning for multiagent tasks and distributed planning, distributed problem solving, agent communication languages (involving speech acts), negotiation, ontologies and knowledge sharing, distributed rational decision making (involving techniques from economics), societal theories (from philosophy), and computational organization theory. Formalisms (including modal logics, process algebras, Petri nets, and Statecharts) are presented and applied to the specification and modeling of multiagent systems.

COMP 790. Independent Study **Credit 3 (3-0)**

This course can be used for study of advanced topics in computer science pertinent to the student's interest under supervision of a faculty member. Prerequisite: Permission of Instructor

COMP 793 Masters Supervised Teaching **Credit 3 (3-0)**

Students will gain teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment. Prerequisite: Graduate standing.

COMP 796. Masters Project **Credit 3 (3-0)**

The student will conduct advanced research of interest to the student and the instructor. A written proposal, which outlines the nature of the project and the deliverables, must be submitted for approval. This course is only available to project option students. Prerequisite: Permission of advisor.

COMP 797. Masters Thesis **Credit 3 (6-0)**

Master of science thesis research will be conducted under the supervision of the thesis committee chairperson leading to the completion of the master's thesis. This course is only available to thesis option students. Prerequisite: Permission of advisor.

COMP 799. Continuation of Research **Credit 1 (1-0)**

Continue incomplete thesis or project work.

COMP 821. Cloud Computing and Security **Credit 3 (3-0)**
This class covers the practices and applications of cloud computing and related security issues. The topics include architectures of cloud computing, models of cloud computing, Infrastructure-as-a-Service (IaaS), Software as a Service (SaaS), Platform-as-a-Service (PaaS), virtualization, parallelization, security/privacy/legal, and other issues in cloud computing.

COMP 823. Secure Social Computing **Credit 3 (3-0)**
Social Computing involves computational facilitation of social studies and human social dynamics as well as design and use of information and communication technologies that consider social context. Social computing is a central themes across a number of information and communication technology fields and attracts interest from researchers in computing and social sciences, software and online game vendors, web entrepreneurs, political analysts and digital government practitioners. This course focuses on the privacy, security, risk, and trust aspects of social computing.

COMP 826. Security for Emerging Networks **Credit 3 (3-0)**
This course discusses Software Defined Network (SDN)/Network Functions Virtulization (NFV), and other emerging network tecgnologies. It covers advanced attacks to SDN/NFV and other emerging networking paradigms and defense techniques in the current research. Prerequisite: COMP726 or permission of the instructor.

COMP 829. Topics in Software Assurance **Credit 3 (3-0)**
This course introduces topics in software assurance education and research. Software security across the development life cycle that address trustworthiness, predictable execution and conformance will be examined. Best practices and methodologies that promote integrity, security, reliability in software development, including processes and procedures that diminish the possibilities of vulnerabilities that could be introduced during development, will be discussed. Students will gain hands-on experience in various techniques and tools.

COMP 831. Biomedical Computing **Credit 3 (3-0)**
Biomedical Computing is the intersection of computer science and information technology with biology and medicine. Biomedical Computing entails the creation and advancement of databases, algorithms, computational and statistical techniques and theory to solve formal and practical problems arising from the management and analysis of biological and medical data. This course will introduce the major research topics within biomedical computing and then focus on the computational aspect of biomedical computing.

COMP 832. Advanced Biometrics **Credit 3 (3-0)**
This project course will explore advanced topics related to human recognition and authentication through various biometric modalities. Students will study iris, periocular, heartbeat, facial recognition, methods to combine the modalities (multi-biometrics) and other emerging modalities. Current research topics will be explored via research publications and students will be expected to produce and use tools in the biometrics lab.

COMP 833. Genetic & Evolutionary Biometrics **Credit 3 (3-0)**
This course introduces students to fields of Genetic & Evolutionary Computation and Biometrics. Students will study how Genetic & Evolutionary Computation can be applied to feature extraction and selection for a wide variety of biometric modalities.

COMP 841. Computational Intelligence **Credit 3 (3-0)**
This course provides students with hands on applications of Computational Intelligence in the form of Genetic, Evolutionary, and Neural Computing. Students will be introduced to methods (including but not limited to): Genetic Algorithms, Evolutionary Programming, Evolution Strategies, Swarm Intelligence, Differential Evolution, General Regression Neural Networks, Radial Basis Function Networks, Feed-Forward Neural Networks and Kohonen Learning.

COMP 851. Big Data Analytics **Credit 3 (3-0)**
This course provides a basic understanding of big data analytics and data science. The course also focuses on various advanced large-scale data analytic methods and tools required to handle vast amounts of unstructured data produced daily by users and systems in various fields. Prequisite COMP 651.

COMP 852. Web-based Visual Analytics **Credit 3 (3-0)**
The course introduces interactive web-based data visualization and analysis. Topic includes: visual representation, web-based visualization, front and back ends for visual analytics systems, and data analysis.

COMP 853. Data Fusion **Credit 3 (3-0)**
Data fusion uses data from multiple sources to support inferences. Low-level data-fusion techniques tend to be quite mathematical while high-level techniques are often drawn from artificial intelligence. This course introduces the student to appropriate programming technologies and software packages for linear algebra,

statistics, machine learning, and various classical techniques for data fusion. Data fusion models and architectures are also addressed.

COMP 863. Compiler Optimization **Credit 3 (3-0)**

This course examines how compilers can improve the performance of programs by effective code generation. Code generation for real and virtual architectures will be discussed. Automatic parallelization will be considered.

COMP 871. Advanced Network Science **Credit 3 (3-0)**

This course introduces rigorous definitions and applications of network properties, node and edge centrality measures, models of networks generated by random processes, and diffusion models. One area covered is social network analysis, including the application of game theory. Network analysis is extended into statistical methods and applications of linear algebra. A standard software package for network analysis is introduced along with the language providing the package and packages for allied tasks, including machine learning. Cloud resources are used, and public network libraries are used. Assignments have conceptual, formal, and especially programming components. This course requires a group project.

COMP 872. Social Semantic Web **Credit 3 (3-0)**

This course covers the use of concepts and techniques from the Semantic Web used to facilitate social computing and the establishment and maintenance of online social networks. It also addresses emerging standards and ontologies related to social networks.

COMP 873. Web Science **Credit 3 (3-0)**

In studying the Web (and networks in general), we consider both local structure and global behavior as well as how the former gives rise to the latter. Web science draws on the social sciences and computer science as well as techniques for analyzing complex systems. This course will address the fundamental concepts and techniques for analyzing the Web and networks in general. Students will use software packages for network analysis, will capture data from the Web, and will learn how to analyze the large datasets thus captured.

COMP 874. Standards and Technologies for E-commerce **Credit 3 (3-0)**

Appropriate E-commerce technology standards are the topic of this course. These technologies include those promoted by the W3C and OASIS (including the service-oriented-computing stack) as well as ones addressing social computing. Most important are XML-based standards, including XML Schema and simplified versions of it.

COMP 875. Security Enhanced Operating Systems **Credit 3 (3-0)**

This course examines operating systems that are designed explicitly to enhance security. The course will cover mandatory access control systems as well as computers intended for home use.

COMP 876. Secure Architectures **Credit 3 (3-0)**

Hardware and virtual machine enhancements to improve security are explored in this course. The course will cover mandatory access control systems as well as computers intended for home use.

COMP 878. Usable Security **Credit 3 (3-0)**

This course will delve into human factors and usability issues as they apply to security research and the design of secure systems. The purpose of this course is three-fold: a) Introduce students to a variety of usability and user interface problems related to security and privacy. b) Give students experience in designing studies aimed at helping to evaluate usability issues in security and privacy systems/solutions. c) Inspire students to explore novel security and privacy solutions that can achieve psychological acceptability of users.

COMP 881. Advanced Multiagent Systems **Credit 3 (3-0)**

This course addresses the key concepts behind multiagent systems, including logical foundations, topics from microeconomics (including game theory and negotiation), and topics from the social sciences more generally. It also addresses problem solving protocols and inter-agent communication and collaboration.

COMP 883. Concurrency Formalisms **Credit 3 (3-0)**

The course will include rigorous development of concurrency formalisms including modal, especially temporal, logics, process algebras, such as CCS, CSP, and the □-calculus, and various abstract machines, such as Petri nets and Büchi automata.

COMP 884.

COMP 885. Emergent Semantics **Credit 3 (3-0)**

This course covers the principles and techniques of analyzing the evolution of decentralized semantic structures in large scale distributed information systems. It also addresses collaborative and social tagging systems. The topics include classification, clustering, and association analysis on tagging systems and the applications of tagging systems on information retrieval.

COMP 887. Formal Ontologies **Credit 3 (3-0)**

This course focuses on logical foundations of ontologies which include description logics and various modal extensions. Applications for the Semantic Web and automated reasoning are addressed. Extra-logical formalisms (such as spatial and temporal representations) and their mathematical foundations are also considered.

COMP 892. Doctoral Research Methods **Credit 3 (3-0)**

Students are taught research techniques and the skills for writing publishable papers.

COMP 895. Special Topics **Credit 3 (3-0)**

This course introduces computer science topics of current interest.

COMP 991. Doctoral Qualifying Examination **Credit 0 (0-0)**

This is a supervised program for students who are preparing for the written qualifying examination and should be taken the semester before the student takes that examination.

COMP 992. Doctoral Seminar **Credit 3 (3-0)**

This course consists of colloquia, seminars and presentations by doctoral students on dissertation topics, works-in-progress and guests on important classical, contemporary, or research problems in computer science and related fields.

COMP 993. Doctoral Supervised Teaching **Credit 3 (3-0)**

This course will introduce the student to classroom teaching under the guidance of a faculty member. The student will gain experience in course planning, lecture preparation, classroom teaching, and student evaluation.

COMP 994. Doctoral Research Examination **Credit 3 (3-0)**

This is required for students who have completed the doctoral qualifying examination and who are taking the written in-depth examination during the semester. This is a supervised program to help prepare the student for that examination under the mentorship of the academic advisor. Upon passing without conditions or after fulfilling any conditions specified by the student's Ph.D. advisory committee, the doctoral student is admitted to candidacy. Prerequisites: COMP991 and COMP892

COMP 997. Doctoral Dissertation **Credit 3 (18-0)**

This supervised research leads to the dissertation of the doctoral student. Eighteen credits of dissertation are required for graduation. Prerequisites: COMP994

COMP 999. Continuation of Research **Credit 1 (1-0)**

Continue incomplete doctoral thesis work.

11. Approved MS Elective Courses from Other Departments

The following list indicates which courses from departments other than Computer Science can be taken as elective courses.

ELEN 602 Semiconductor theory and devices
ELEN 614 Integrated Circuit Fabrication Methods
ELEN 615 Silicon Device Fabrication laboratory
ELEN 616 Microprocessor Software Design
ELEN 617 Microprocessor Hardware Design
ELEN 627 Switching Theory
ELEN 629 VLSI Design
ELEN 633 Digital Electronics
ELEN 649 Modulation theory and Communication systems
ELEN 650 Digital Signal Processing I
ELEN 656 Probability and Random Processing
ELEN 668 Automatic Control Theory
ELEN 674 Network Synthesis
ELEN 705 Solid State Devices
ELEN 727 Switching and Finite Automata Theory
ELEN 729 Digital Systems
ELEN 748 Statistical Communication Theory
ELEN 756 Optical Electronics
ELEN 760 Theory of Linear Systems
ELEN 762 Network Matrices and Graphs
GEEN 601 Industrial Automation

GEEN 602 Advanced Manufacturing
INEN 600 Survey of Industrial Engineering Topics
INEN 615 Industrial Simulation
INEN 670 Principles of Ergonomics
INEN 675 Design and Analysis of Experiments
INEN 735 Human-Computer Interface
MATH 607 Theory of Numbers
MATH 620 Elements of Set Theory and Topology
MATH 623 Advanced Probability and Statistics
MATH 624 Methods of Applied Statistics
MATH 632 Games and Queue Theory
MATH 700 Theory of Functions of a Real Variable I
MATH 701 Theory of Functions of a Real Variable II
MATH 710 Theory of Functions of a Complex Variable I
MATH 711 Theory of Functions of a Complex Variable II
MATH 715 Projective Geometry
MFG 651 Principles of Robotics
MFG 674 Advanced Automation and Control
MFG 770 Managing a Total Quality System

12. Approved Ph.D Elective Courses from Other Departments

The following list indicates which courses from departments other than Computer Science can be taken as elective courses. No more than 6 credits from the following list may be counted among the 42 credit hours. But hours from approved 8XX-level electives from other departments count toward the required 18 8XX-level credit hours. All courses have a (3-0) profile unless otherwise stated.

ELEN 720 Theoretical Issues in Computer Engineering
ELEN 721 Fault-Tolerant Digital System Design
ELEN 723 System Design Using Programmable Logic Devices
ELEN 725 Pervasive Computing Systems
ELEN 727 Switching and Finite Automata Theory
ELEN 749 Digital Communications
ELEN 752 Wireless Information Networks
ELEN 762 Network Matrices and Graphs
ELEN 821 Advanced Computer Organization and Architecture
ELEN 822 Error-Correcting Codes
ELEN 823 Advanced VLSI Design
ELEN 847 Telecommunication Networks
ELEN 848 Information Theory
ELEN 849 Data Communications
ELEN 850 Digital Signal Processing II
ELEN 857 Pattern Recognition
ELEN 865 Theory of Linear Systems
ELEN 866 Discrete Time Systems
ELEN 867 Neural Networks Design
ELEN 868 Intelligent Methods for Control Systems
ELEN 869 Machine Vision for Intelligent-Robotics
ELEN 870 Fuzzy Logic with Applications
CSE 702 Computational Methods for Algebraic Systems
CSE 703 Program for Scalable Computing Systems
CSE 803 High Performance and Scalable Computing
CSE 804 Computational Modeling and Visualization
CSE 805 Machine Learning and Data Mining
CSE 815 Bioinformatics
CSE 817 Fundamentals of Big Data Analytics
INEN 735 Human-Computer Interface
INEN 742 Linear Optimization
INEN 812 Advanced Ergonomics
INEN 813 Cognitive Systems Engineering
INEN 814 Advanced Topics in Human-Machine Systems
INEN 832 Information Technology Management
INEN 841 Integer and Network Optimization
INEN 843 Queuing Theory
INEN 844 Reliability and Maintenance
MEEN 716 Finite Element Methods
MEEN 719 Advanced Computer Aided Design
MEEN 848 Digital Control of Machines and Processes
MEEN 849 Computer Control of Robot Manipulators
MATH 709 Discrete Mathematics
MATH 712 Numerical Linear Algebra
MATH 731 Advanced Numerical Methods
MATH 752 Calculus of Variations and Control Theory
MATH 765 Optimization Theory and Applications
MATH 781 Mathematical and Computational Modeling
MATH 782 Scientific Visualization
MATH 791 Interdisciplinary Computational Science Team Project I

MATH 792 Interdisciplinary Computational Science Team Project II
BIOL 700 Environmental Biology
BIOL 704 Cell and Molecular Biology
CHEM 731 Modern Analytical Chemistry
CHEM 732 Advanced Analytical Chemistry
CHEM 741 Principles of Physical Chemistry I
CHEM 742 Principles of Physical Chemistry II
PHYS 745 Computational Physics (2-3)
SOCI 701 Seminar in Cultural Factors in Communication
BUAD 740 Business Process Management & the Digital Firm
BUAD 746 E-Business and E-Commerce
AGEC 708 Econometrics
AGEC 710 Advanced Microeconomic Theory
AGED 709 Study and Application of Technological Advances and Best Practices to Agriculture
ANSC 771 Bioinformatics and Genome Analysis
AGEN 701 Soil and Water Engineering II
AGEN 714 Applied Hydrogeology

13. Forms

Important forms to ensure program requirements are available on the Computer Science Department's web site.
https://www.ncat.edu/coe/departments/comp/index.html

The Graduate College web site provides study plan forms, application forms and other materials.
https://www.ncat.edu/academics/colleges-departments/index.html#TGC