North Carolina Agricultural & Technical State University

Graduate Student Handbook

Master of Science
Doctor of Philosophy

Department of Computer Science

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Greensboro, NC 27411

http://www.ncat.edu/academics/schools-colleges1/coe/comp/index.html

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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 School of Graduate Studies, 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 School of Graduate Studies requirements can be obtained from the Office of Graduate Studies (120 Gibbs Hall), 336-285-2366 (http://www.ncat.edu/academics/schools-colleges1/grad/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 Ph.D student.

2. Masters and Ph.D 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 Aeronautics and Space Administration, the U.S. Air Force, the National Security Agency, the Naval Oceanographic Office, National Science Foundation and among others.

The research interests of the faculty cover many areas of Computer Science including software engineering, Cyber security, secure software engineering, artificial intelligence, computational science, distributed systems, multiagent systems, computer security, visualization, 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 (PhDCS) degree. The MSCS degree provides option of a "General Track", and four specialization tracks "Software Engineering", "Cyber Security ", "Secure Software Engineering" and "Artificial Intelligence". Students interested in these tracks can choose one of these specialization tracks, whereas students interested in other areas may select General Track, and design their curriculum in consultation with their advisor to satisfy all graduation requirements of an MS in CS. Detailed description of the program appear in Section 5 on Degree requirements. The PhDCS degree in section 6.

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), in data structures, in operating system, and in computer architecture, as well as mathematical maturity (for example Calculus I & II, and Discrete Mathematics or Switching Theory). 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, are available from the website of the School of Graduate Studies (http://www.ncat.edu/academics/schools-colleges1/grad/index.html).

4. Admission to Docter of Philosophy Program in Computer Science

It is assumed that all entering students have completed graduate study with an M.S. in CS. A 3.25 GPA, GRE verbal score 450 (150 new scale) and quantitative score 700 (155 new scale) and a MS degree in Computer Science or a related discipline are required for unconditional admission. An applicant may be granted provisional admission and requireed to take courses to remedy deficiencies, with no credit towards the degree. A highly qualified applicant with

a B.S. in CS with GPA 3.5, GRE verbal score of 500 (153 new scale) and quantitative score of 750 (159 new scale) can apply for the Ph.D program.

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

5. Master Degree 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-three credit hours consisting of thirty credit hours of course work and three credit hours for the project. The course option requires thirty-three 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 four tracks (Software Engineering, Secure Software Engineerig, Cyber Security , and Artificial Intelligence), or select the General Track and design their own program in consultation of their advisor such that all requirements for MS in CS at NC A&T SU are satisfied. Students choosing Software Engineering, Secure Software Engineering, Cyber Security, or Artificial Intelligence may benefit from the following description of the four areas:

SOFTWARE ENGINEERING (SE): Software engineering can be defined as the systematic approach to the development, operation, maintenance, and retirement of software. Software is not only program code, but 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. Methodologies for analysis and design are evolving, and being automated through the use of CASE (computer aided software engineering) tools. The methods of software engineering seek to produce high quality systems, on time, 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. In accordance with our historical mission, the program also provides students with knowledge of organizational theory, management practices, information economics, and societal and policy frameworks.

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's. Research topics include network security, Web security, wireless security, intrusion detection, information privacy and security, trustworth cloud computing, and software development security.

SECURE SOFTWARE ENGINEERING (SSE): Security vulnerabilities caused by software defects are costing business millions of dollars each year and threaten the security of individuals and the nation. To improve the current situation in industry and government, there is the pressing demand for well-trained software professionals who can develop quality and secure software. The program 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.

ARTIFICIAL INTELLIGENCE (AI): Artificial intelligence uses symbolic computation and complex interrelations of variables to produce "intelligent" responses to problem situations. The responses are intelligent in the sense that unforeseen situations are accommodated. Problems of interest are frequently ill-structured: that is, they cannot be stated in the forms required by commonly used deterministic and sequential algorithms. Artificial intelligence often involves search and inference, and frequently supports human decision making. It is thus natural to view artificial intelligence software as tackling problems as humans would tackle them. Research topics include mobile robots motion planning, computer vision, automated reasoning, the acquisition and representation of knowledge, and the analysis of decision making in realistic business settings. Artificial intelligence uses a multitude of paradigms, willingly collaborates with other areas of computer science, and pursues real-world applications.

GENERAL TRACK: There are several other research areas in the Department of Computer Science. Students can select a research topic from these areas as the project/thesis. 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 Requrements

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

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

COMP 755	Advanced Operating Systems
COMP 785	Advanced Design and Analysis of Algorithms

b) Required courses specific to the student's track (Students selecting General Track design their curriculum in consultation with their advisor, and with approval of Director of Graduate Studies),

The required course for the four tracks are listed below:

Software Engineering

COMP 710	3	Software Specification, Analysis, & Design
COMP 711	3	Software System Design, Implementation, Verification, & Validation
COMP 712	3	Software Project Management
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

Secure Software Engineering

COMP 710	3	Software Specification, Analysis, & Design
COMP 725	3	Software Security Testing
COMP 727	3	Secure Software Engineering
COMP xxx	3	Secure Software Engineering elective

Artificial Intelligence

COMP 645	3	Artificial Intelligence
COMP 740	3	Advanced Artificial Intelligence
COMP xxx	6	AI Electives

General Track

COMP 681	3	Formal Methods
COMP 710	3	Software Specification, Analysis, & Design

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

Note: A student can take COMP 790 a maximum of two times. A student can take COMP 700 Independent study 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-three credit hours consisting of thirty credit hours of course work and three credit hours for the project. The course option requires thirty-three 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 courses work. The following tables summarize the requirements for each available option in the four tracks.

SE Track	**Required Core**	**Specialty Required**	**Specialty Electives**	**Approved Electives**	**Project/Thesis**	**Total Credits**
SE Course Option	6 credits COMP 755 COMP 785	9 credits COMP 710 COMP 711 COMP 712	3 credits with approval (see list)	15 credits with approval (see list)	.	33
SE Project Option	6 credits COMP 755 COMP 785	9 credits COMP 710 COMP 711 COMP 712	3 credits with approval (see list)	12 credits with approval (see list)	COMP 796 MSCS Project: 3 credits.	33
SE Thesis Option	6 credits COMP 755 COMP 785	9 credits COMP 710 COMP 711 COMP 712	3 credits with approval (see list)	6 credits with approval (see list)	COMP 797 MS Thesis Research: 6 credits.	30

CS Track	**Required Core**	**Specialty Required**	**Interdisciplinary Electives**	**Approved Electives**	**Project/Thesis**	**Total Credits**
CS Course Option	6 credits COMP 755 COMP 785	9 credits COMP 620 COMP 621 COMP 726	6 credits with approval	12 credits with approval		33
CS Project Option	6 credits COMP 755 COMP 785	9 credits COMP 620 COMP 621 COMP 726	6 credits with approval	9 credits with approval	COMP 796 MSCS Project: 3 credits.	33
CS Thesis Option	6 credits COMP 755 COMP 785	9 credits COMP 620 COMP 621 COMP 726	6 credits with approval	3 credits with approval	COMP 797 MS Thesis Research: 6 credits.	30

SSE Track	Required Core	Specialty Required	Interdisciplinary Electives	Approved Electives	Project/Thesis	Total Credits
SSE Course Option	6 credits COMP 755 COMP 785	9 credits COMP 710 COMP 725 COMP 727	6 credits with approval	12 credits with approval		33
SSE Project Option	6 credits COMP 755 COMP 785	9 credits COMP 710 COMP 725 COMP 727	6 credits with approval	9 credits with approval	COMP 796 MSCS Project: 3 credits.	33
SSE Thesis Option	6 credits COMP 755 COMP 785	9 credits COMP 710 COMP 725 COMP 727	6 credits with approval	3 credits with approval	COMP 797 MS Thesis Research: 6 credits.	30

AI Track	Required Core	Specialty Required	Specialty Electives	Approved Electives	Project/Thesis	Total Credits
AI Course Option	6 credits COMP 755 COMP 785	6 credits COMP 645 COMP 740	6 credits with approval (see list)	15 credits with approval (see list)		33
AI Project Option	6 credits COMP 755 COMP 785	6 credits COMP 645 COMP 740	6 credits with approval (see list)	12 credits with approval (see list)	COMP 796 MSCS Project: 3 credits.	33
AI Thesis Option	6 credits COMP 755 COMP 785	6 credits COMP 645 COMP 740	6 credits with approval (see list)	6 credits with approval (see list)	COMP 797 MS Thesis Research: 6 credits.	30

General Track	Required Core	Specialty Required	Specialty Electives	Approved Electives	Project/Thesis	Total Credits
General Course Option	6 credits COMP 755 COMP 785	6 credits COMP 681 COMP 710		21 credits with approval (see list)		33
General Project Option	6 credits COMP 755 COMP 785	6 credits COMP 681 COMP 710		18 credits with approval (see list)	COMP 796 MSCS Project: 3 credits.	33
General Thesis Option	6 credits COMP 755 COMP 785	6 credits COMP 681 COMP 710		15 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 School of Graduate Studies, the student will have the assignment of a temporary advisor. The advisor will assist the student in registration 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.

Thesis and project students 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 deadlines.

5.4. Project/Thesis Requirements

- Project Requirement

The Project Option should be considered by students who seek to demonstrate that they have mastery of a computer science specialty that can be demonstrated by the completion of a substantial implementation project. This option provides excellent preparation for development of the professional skills of the students already working as a computer professional, as well as those students who seek substantive work experiences after graduation, or who may plan to pursue doctoral studies.

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 Director of Graduate Studies 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, 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 Requirement

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 the greatest theoretical depth in a research area. This is the most challenging route to the MS degree, and is suggested for those students who show self motivated and are capable of independent work.

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 Advisor aid, 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 Director of Graduate Studies. Both the departmental Director of Graduate Studies 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, and its scheduling is the student's responsibility. An affirmative vote by a majority of the committee after the oral examination is necessary for the student to pass.

5.5. Critical Steps

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

1) Apply for admission: complete the School of Graduate Studies application form on-line and send all required materials to the School of Graduate Studies. The School of Graduate Studies will forward the complete application package to the Graduate Director of Computer Science.
2) Receive the admission letter: receive an admission status letter from the School of Graduate Studies.
3) Contact temporary advisor: see the temporary advisor that is assigned by the Department of Computer Science.
4) Plan of study: Prepare course schedule for first term, obtain advisor approval, submit to departmental Director of Graduate Studies. [File The School of Graduate Sudies Master and Doctoral Plan of Graduate Work Form]
5) Complete any and all course deficiencies.
6) Select permanent advisor before the first month of the second semester. Obtain approval of departmental Director of Graduate Studies.
7) Consult with permanent advisor to complete degree plan.
8) Consult with permanent advisor to select thesis or project committee if applicable.
9) Have degree plan approved by all concerned, handed in the study plan to the School of Graduate Studies and placed on file with the departmental Director of Graduate Studies.
10) Write the thesis/project proposal and distribute it to the theis/project committee.
11) Schedule thesis/project proposal defense.
12) Present thesis/project proposal, pass, and place on file with the departmental Director of Graduate Studies. [File Acceptance of Proposal for Thesis/Project Form]
13) Complete course work.
14) Schedule and complete as applicable the Course Option, Project, or Thesis defense. [File Defense Results Form]
15) Obtain written approvals for completion of all work.
16) Transmit completion information as necessary with the departmental Director of Graduate Studies and the Graduate School. [File Graduation Request Form]
17) Graduate!

6. Doctor Degree Requirements

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

6.1. Course Requirements

The Ph.D degree requires course work and non-course work. A student must complete 72 credit hours of course work that include 42 hours graded courses and 30 hours non-graded courses beyond the BS degree.

- Required Graded courses

The required 42 graded courses hours include 9 hours core courses and courses from the security group and the Artificial Intelligence and Web-Based Software group. A student must take at least two classes (6 hours) from one group and one class (3 hours) from the other group. A student must take at least 21 hours of 8xx level courses.

Core courses are:

COMP 755	3	Advanced Operating Systems
COMP 785	3	Advanced Design & Analysis of Algorithms
COMP 892	3	Doctoral Research Methods

Security courses are:

COMP 821	3	Cloud Computing & Security
COMP 823	3	Secure Social Computing

Artificial Intelligence and Web-Based Software courses are:

COMP 832	3	Advanced Biometrics
COMP 841	3	Computational Intelligence
COMP 872	3	Social Semantic Web
COMP 881	3	Advanced Multiagent Systems

- Required Non-graded courses

The required non-graded courses are described as follows and they must be taken in the order listed.

COMP 991	3	Doctoral Qualifying Exam
COMP 994	3	Doctoral Research Exam
COMP 995	3	Doctoral Preliminary Exam
COMP 997	18	Doctoral Dissertation

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6.1.1. Grades Required

Students must meet the minimum academic qualifications published by the School of Graduate Studies, which are as follow, where item 5 is a stricter version of what the school 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 successive 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 18 credit hours at the M.S. level may be counted toward the class credits required for the Ph.D. 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

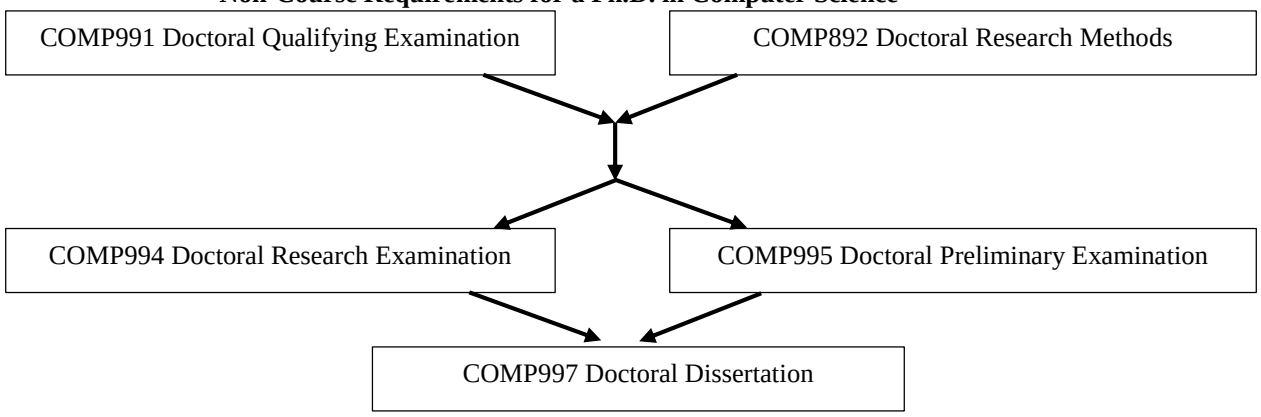
A Ph.D. student must form an advisory committee consisting of at least three graduate faculty members from the Department of Computer Science, one being the student's faculty advisor, who serves as chair. Additional faculty members may be added at the discretion of the student and the student's graduate 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 as well as the Doctoral Preliminary 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 sequence of examinations, including a final defense, detailed below and illustrated with the following figure, as part of earning the required 72 credit hours. A student must pass a Doctoral Qualifying Examination on core topics; they are encouraged to take this within a year of unconditional acceptance. Next is the Doctoral Research Examination, in which the student's ability to perform independent research is demonstrated. An oral Doctoral Preliminary Examination allows the student and the advisory committee to agree on a reasonable dissertation topic and should be taken at least one semester before the final oral defense of the dissertation. A student will be considered a Ph.D. candidate after passing the proposal defense.

Each of these examinations is associated with a 9XX-level course intended to provide credits while the student prepares for the examination. Passing the course is contingent on passing the corresponding examination, and a condition for taking the examination is enrollment in the corresponding course. Thus, prerequisite relations among the courses enforce sequencing among, and passing of, the examinations. The Doctoral Qualifying Examination corresponds to COMP 991, the Doctoral Research Examination corresponds to COMP 994, and the Doctoral Preliminary Examination corresponds to COMP 995. Before the final oral defense, the student must have registered for 18 credits of COMP 997, not necessarily all in the same semester.

Non-Course Requirements for a Ph.D. in Computer Science



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. The content of these topics and areas are defined by the 7XX-level courses listed below. This examination is administered during the first week of each semester, and students must notify the graduate coordinator of their intent to take it. 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 unconditional 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 course listed below. Two of these courses are:

- COMP 755: Advanced Operating Systems
- COMP 785: Advanced Design & Analysis of Algorithms.

The other two courses may be any of the following, here organized under themes:

- Software Engineering
  COMP 710: Software Specification, Analysis, and Design,
  COMP 711: Software System Design, Implementation, Verification & Validation
  COMP 681: Formal Methods
- Security
  COMP 725: Software Security Testing
  COMP 727: Secure Software Engineering
  COMP 620: Information, Privacy, and Security
  COMP 621: Web Security
  COMP 726: Network Security
  COMP 767: Computer Network Architecture
- Artificial Intelligence and Web-based Systems
  COMP 625: Artificial Intelligence
  COMP 740: Advanced Artificial Intelligence
  COMP 786: Multiagent Systems

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. Its make-up 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.

6.3.3. Doctoral Preliminary Examination

The Doctoral Preliminary Examination (DPE) allows the student and their advisory committee to confirm the dissertation topic. The COMP993 Doctoral Preliminary Examination course must be taken the semester the student will be completing the exam.The exam is given at least one semester before the final oral defense and consists of a public presentation of the proposed research topic along with the estimated time to complete the dissertation. The outcome—pass, conditional pass, or fail—is determined by the student's advisory committee; specified conditions must be met within a given period of time. Failure to pass the DPE, or failure to meet the specified conditions within the prescribed time, results in termination of the student's graduate study.

6.3.4. Final Oral Defense

The final oral defense (held no earlier than one semester after the Doctoral Preliminary Examination) 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.

6.4. Residency Requirement and Time Limit for Completion

Students must take 44 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. There are no language requirements and no research requirements other than those listed above.

6.5. Curriculum Guide

The following is a curriculum guide for the program that assumes that the student has completed a master's degree in computer science and has transferred 18 credit hours from the M.S.

Fall 1		**Spring 1**	
Area required course	3	COMP 991 Qualifying Examination	3
non-area required course	3	area required course	3
800 level elective	3	800 level elective	3

Fall 2		**Spring 2**	
COMP 892 Research Methods	3	COMP 994 Research Examination	3
COMP 993 Supervised Teaching	3	800 level elective	3
800 level elective	3	800 level elective	3

Fall 3		**Spring 3**	
COMP 995 Doctoral Prelim. Exam	3	COMP 997 Doctoral Dissertation	9

Fall 4		**Spring 4**	
COMP 997 Doctoral Dissertation	9		

6.6. 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 School of Graduate Studies, which will forward the complete application package to the Graduate Coordinator of Computer Science.
2. Receive an admission status letter from the School of Graduate Studies.
3. Submit the enrollment intention card to the School of Graduate Studies.
4. Meet with the Graduate Coordinator to obtain information about the program and to be assigned a temporary advisor.
5. Prepare a course schedule for the first term, obtain advisor approval, and submit the schedule to the Graduate Coordinator.
6. Complete all course deficiencies (if any).
7. 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).
8. Complete the Plan of Graduate Study in consultation with your advisor. It must be approved by the Graduate Coordinator by the end of your second semester. A revised Plan must include the word "REVISED". The School of Graduate Studies requires a copy of the Plan and any revised versions.
9. Take the Qualifying Examination within one calendar year of unconditional acceptance into the program. This exam is given during the first week of each semester. You must tell the Graduate Coordinator that you intend to take the exam no later than the end of the previous semester.
10. 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 Ph.D. committee; this member may be someone outside the department. This committee administers the Research Examination as well as the Doctoral Preliminary Examination and the final oral defense.
11. Take the Research Examination. Completing the Doctoral Supervised Research 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.

12. When you and your advisor have settled on a direction for your research, submit a dissertation title and research plan to your Advisory Committee.
13. Complete all course work.
14. After passing the Qualifying Examination, and when your proposed research is mature and it is clear that what is proposed is doable, original, and significant, schedule your Doctoral Preliminary Examination in consultation with your advisor and forward the exam schedule to the Graduate Coordinator and the School of Graduate Studies. After their approval, post the time and place of the examination and submit a written report to all committee members including the representative of the School of Graduate Studies for their review at least two weeks before the examination date.
15. Defend your proposed research in your Doctoral Preliminary Examination. Failure to pass this exam, or failure to meet the specified conditions within the prescribed time, results in termination of your graduate study. The result is sent to the School of Graduate Studies within 48 hours. The School of Graduate Studies is also informed when conditions (if any) are met or if the prescribed time for meeting these conditions have been exceeded. You will be considered a Ph.D. candidate after passing this proposal defense (or meeting the conditions).
16. No earlier than one semester (or four months) into your candidacy, schedule your Final Oral Defense. Submit the Application for Oral Examination with the signatures of all members of your Advisory Committee to the Graduate Coordinator. Upon approval of this request, and no later than two weeks before the suggested date, you and your advisor must post the time and place of the defense and submit a copy of the draft of your dissertation to all committee members (including the representative of the School of Graduate Studies) for their review. Note that the Graduate Coordinator must be given time to review your Application for Oral Examination so that approval may be received two weeks before the suggested date for the defense.
17. Hold your oral defense. This is a public defense of your research, and its outcome is determined by your Advisory Committee. Failure results in termination of your graduate study. The result is sent within 48 hours to the School of Graduate Studies with signatures of all Advisory Committee members and the Graduate Coordinator.
18. Submit your Application for Graduation to the Graduate Coordinator. The Graduate Coordinator then submits your Final Graduate Clearance Checklist to the School of Graduate Studies.
19. Submit all required documentation to the School of Graduate Studies and to the Department of Computer Science.
20. 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 School of Graduate Studies. 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 relevant section of the application package, and submitting the assistantship application directly to the department along with the admissions application and letters of recommendation.

8. Computer Science Faculty Listing

Sharon A. Brown, B.S., M.S., North Carolina A&T State University; M.S., University of Illinois; Adjunct Associate Professor and Director of Undergraduate Studies; Artificial Intelligence.

Kelvin S. Bryant, B.S., North Carolina State University; M.S., North Carolina State University; Ph.D., North Carolina State University; Assistant Professor.

Edward C. Carr, B.S., Wingate University; M.S., North Carolina A&T State University; M.S., Western Carolina University; Adjunct Assistant Professor; Graph Theory, Concurrency, AI.

Gerry Dozier, B.S. Northeastern Illinois University; M.S. North Carolina State University; Ph.D. North Carolina State University; Professor and Chairperson; Artificial Intelligence, software Engineering.

Edmundson Effort, BS and M.S., North Carolina A&T State University; Adjunct Assistant Professor and System Administrator.

Albert C. Esterline, B.A., Lawrence University; M.Litt., Ph.D, University of St. Andrews; M.S., Ph.D., University of Minnesota; Associate Professor; Multiagent Systems, Formal Methods, Concurrency, AI.

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

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

Kenneth A. Williams, B.S., M.S., Michigan Technological University; Ph.D., University of Minnesota; Associate Professor; Information Assurance, Encryption, Computer Science education.

Jinsheng Xu, B.S., Nanjing University; M.S., Beijing University; Ph.D., Michigan State University; Associate Professor; Parallel and Distributed Simulation, Network Simulation, Parallel Algorithms, Performance Evaluation.

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; Associate Professor; Software security, information assurance, software engineering.

Huiming Yu, B.S., Xiamen University; M.S., Hefei Polytechnic University; Ph.D., Stevens Institute of Technology; Professor and Director of Graduate Studies; Visuzlization, Cyber Security, Web security and trustworth cloud computing.

Justin Zhan, B.S., Liaoning University of Engineering and Technology; M.S., Syracuce University; Ph.D., University of Ottawa; Assistant Professor; Information Assurance, Social Computing, BioMedical Computing.

9. Graduate Course Listing in Computer Science

Course	CS Graduate Courses (new)	SE Track		SSE Track		AI Track		CS Track		General		Ph.D	
		Req	Elec	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 653	Computer Graphics		√		√		√		√		√		√
COMP 663	Compiler Construction		√		√		√				√		√
COMP 670	Advanced Computer Architecture		√		√		√		√		√		√
COMP 681	Formal Methods		√		√		√			√	√		√
COMP 700	Independent Study		√		√		√		√		√		√
COMP 710	Software Spec., Analysis, &	√		√			√		√	√			√
COMP 711	SW System Design., Imptn.,	√			√						√		√
COMP 712	Software Project Management	√			√		√		√		√		√
COMP 713	Social Impacts of Software		√		√		√		√		√		√
COMP 716	Object-Oriented Program and		√		√		√		√		√		√
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		√		√		√		√		√		√
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		√		√		√		√		√		√
COMP 755	Advanced Operating Systems	√		√		√		√		√		√	
COMP 765	Data Mining		√		√		√		√		√		√
COMP 767	Computer Network Architecture		√		√		√		√		√		√
COMP 770	Computer Org. and Prog. for Sci.		√		√		√		√		√		√
COMP 780	Semantics of Programming		√		√		√		√		√		√
COMP 785	Advanced Analysis of Algorithms	√		√		√		√		√		√	
COMP 786	Multiagent Systems		√		√		√		√		√		√
COMP 790	Special Topics in Computer		√		√		√				√		√
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 829	Topics in Software Assurance												√
COMP 832	Advanced Biometrics												√
COMP 833	Gentic & Evolutionary Biometrics												
COMP 841	Computational Intelligence												√
COMP 863	Compiler Optimization												
COMP 868	Advanced Data Mining												
COMP 871	Social Network Analysis												
COMP 872	Social Semantic Web												√
COMP 874	Standards & Tech. for E-Com.												
COMP 875	Security Enhanced OS												
COMP 876	Secure Architecture												
COMP 881	Advanced Multiagent Systems												√
COMP 883	Concurrency Formisms												
COMP 884	Emergent Semantics												
COMP 885	Docotr Special Topics												
COMP 887	Formal Ontologies												
COMP 892	Doctor Research Methods											√	
COMP 991	Doctor Qualifying Exam												
COMP 993	Doctor Supervised Teaching												
COMP 994	Doctor Research Exam												
COMP 995	Doctor Preliminary Exam												
COMP 997	Doctor Dissertation Variavle												
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 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 670. Advanced Computer Architecture **Credit 3 (3-0)**

This is a course that examines the control and storage structures that facilitate the execution and management of logically segmented programs and data. Of special focus are input-output mechanisms, performance tuning, and microprogramming.

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 700. 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 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 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 785. 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 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. Special Topics in Computer Science **Credit 3 (3-0)**

This course permits research in advanced topics pertinent to the student's program of study. Students may take COMP 790 twice to cover two advanced topics. Prerequisite: Permission of advisor.

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.

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 1-6 (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 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 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. Social Network Analysis **Credit 3 (3-0)**

This course covers various concepts, theories, methods, and applications of Social Network Analysis. The topics include social network data collection and representations, graph-theoretic fundamentals including centrality, prestige, cohesion, subgroups, and structural equivalence, statistical analysis of relational networks, dynamic network analysis, and applications of social network analysis.

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 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 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 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. Doctoral Special Topics **Credit 3 (3-0)**

This course introduces computer science topics of current interest.

COMP 991. Doctoral Qualifying Examination **Credit 3 (3-0)**

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 consist 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 995. Doctoral Preliminary Examination **Credit 3 (3-0)**

This is required for students who have completed the doctoral qualifying examination and who are taking the preliminary examination (oral preliminary defense) during the semester. This is a supervised program to help prepare the student for the preliminary examination under the mentorship of the academic advisor. 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 and COMP995

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 21 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 Comprehensive Numerical Analysis
CSE 703 Data Structures, Software Principles & Programming in Scalable Parallel Computing
CSE 704 Computational Modeling and Visualization
CSE 803 Advanced High Performance and Scalable Computing
CSE 804 Advanced Scientific Visualization
CSE-8XX Quantitative Genetics and Genome Analysis
CSE-8XX Laboratory Methods for Computational Biology
CSE 8XX High Performance Computing Architecture
CSE 8XX High Performance Termination Detection Techniques
CSE 8XX Computational Methods for Text Mining
CSE 8XX Computational Approaches for Knowledge-Based Systems
CSE 8XX Supplier Chain Management Systems
CSE 8XX/CHEM 674 Computational Methods in Protein Modeling and Drug Design
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.
http://www.ncat.edu/academics/schools-colleges1/coe/comp/index.html

School of Graduate Studies web site provides study plan forms, application forms and other materials.
http://www.ncat.edu/academics/schools-colleges1/grad/index.html