Computational Science and Engineering Program

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OBJECTIVES

The program is designed with the following objectives:

1. To educate graduate students with a mastery of high performance computer programming tools as well as processing, data acquisition, and analysis techniques that are required for computational modeling and analysis.
2. To educate and train students in computational modeling, simulation and visualization.
3. To assist students to relate and engage the acquired computational science and engineering knowledge and skills to specific application fields of engineering, science, technology and business with expertise in the associated domain fields and their computational aspects.
4. To teach students to develop novel and robust computational methods and tools to solve scientific, engineering, and technological and business problems.
5. To produce highly versatile computational scientists, engineers, technologists, or business executives with a good understanding of the connections among various disciplines, capable of interacting and collaborating effectively with scientists, engineers, and professionals in other fields.
6. To increase the number of graduate professionals available to work in computational science and engineering.
7. To increase the diversity of graduate professionals, especially underrepresented minority and African Americans available to work in the computational science and engineering field.
8. To assist the State of North Carolina and the nation to increase the pool of graduates with training and experience in computational science and engineering, interdisciplinary applications and research.

DEGREES OFFERED

Master of Science (M.S.) in Computational Science and Engineering
Doctor of Philosophy (Ph.D.) in Computational Science and Engineering

GENERAL PROGRAM ADMISSION REQUIREMENTS (MASTER OF SCIENCE)

Candidates seeking admission to the Computational Science and Engineering (CSE) Program for the Master of Science degree must meet the following requirements:

1. Computational Science and Engineering track: Bachelor's degree in engineering, physics, computer science, or mathematics from an accredited program.
2. Computational Science track: Bachelor's degree in Chemistry, Biology, Business and Agricultural Sciences.
3. Computational Technology track: Bachelor's degree in Technology or related field.
4. Official TOEFL scores of at least 550 or better (213 computer-based score) for students whose native language is other than English. In addition all international students are required to submit official GRE scores. Scores should be submitted directly to the School of Graduate Studies.
5. General prerequisites: (1) Calculus through differential equations for the computational science and engineering track, (2) college chemistry and physics, (3) college math (4) elementary numerical analysis or one semester of linear algebra for the computational science and engineering track. These are in addition to the courses in the student's principal undergraduate bachelor degree discipline. Programming and working knowledge of at least one high level programming language such as

FORTRAN, C++, or Java is also required for the computational science and engineering track, and recommended for other tracks depending on the student's area of interest. There may also be additional recommended or required prerequisites specific to the needs of a focus area.

Documentation Requirements

The following documents are to be submitted by all applicants.

1. Two official transcripts of all college-level academic work.
2. Three letters of recommendation (for study at the graduate level) from professional associates or supervising faculty/professors from the degree granting institution.
3. An official copy of the TOEFL score, if applicable, mailed directly to the University from the testing agency.
4. The completed application form and application fee stipulated by the School of Graduate Studies at NC A&T State University.
5. A "Statement of Purpose" in the context of pursuing the M.S. degree in Computational Science and Engineering.

Computational Science and Engineering Tracks

All students in the M.S. program will complete a set of four core courses. In addition, based on their domain background and undergraduate discipline, the following tracks are identified to assist with their domain course selection, guidance, and advice.

Computational Science and Engineering

This track is designed primarily for students with undergraduate degrees in engineering, physics, mathematics, and computer science who will be trained to develop problem-solving methodologies and computational tools as well as interdisciplinary technical expertise in CSE for solving challenging problems in physical science, engineering, applied mathematics or computer science. This includes domains that are both in the College of Engineering, and the College of Arts and Sciences. The curriculum will emphasize computational sciences and engineering along with training in the domain areas. The goal of this track is to produce scientists and engineers with focus, training and application in computational sciences, scalable computing, physics-based modeling and simulations, and with expertise in the application of computational techniques and principles in their primary domain areas. Qualified undergraduate students can be admitted to this stream if they also meet the admission criteria of their major domain field. Based on their undergraduate degrees, the students in this track would be required to have had an increased level of prior training, courses and exposure to mathematics, including areas such as numerical analysis, and high level programming languages. Students with undergraduate degrees in other science and technology areas may also be admitted, if they meet the admission and course requirements, including prerequisites of the domain department. The areas of specialization will include, but will not be limited to, computational quantum chemistry, computational nuclear and high energy physics, computational solid or fluid dynamics, computational material science, bioengineering, engineering design and automation, applied and environmental geophysics, computational seismology, nonlinear computational mechanics, super fast algorithms for numerical and algebraic computation, and distributed and high performance computing.

Computational Sciences

This track is designed primarily for students with undergraduate degrees in chemistry, biology, business, and agricultural sciences who will be trained to apply or extend computational tools and methods as well as data acquisition, processing and visualization techniques to study computationally intensive problems in life sciences, agricultural and environmental sciences, and business and economics. This track primarily includes domain areas with lesser training in mathematics including numerical analysis, and programming languages and focuses on domains with non-deterministic models. The domains in this track are for the College of Arts and Sciences, the School of Agriculture and Environmental Sciences and the School of Business and Economics. The goal of this track is to produce biological and life scientists, business professionals and economists, and agricultural scientists with focus and expertise in computational sciences and the primary domain areas. Qualified undergraduate students can be admitted to this stream if they also meet the admission criteria of the major domain area. Based on their undergraduate field, the students in this track would be required to take additional mathematics and programming focused courses. Students with undergraduate degrees in other science,

engineering and technology areas may also be admitted if they meet the admission and course requirements, including prerequisites for the domain department. The areas of specialization will include, but will not be limited to, bioinformatics, computational genomics, computational physical chemistry, computational biochemistry, and computational finance.

Computational Technology

This track is designed primarily for students with undergraduate degrees in technology disciplines with a focus on computational science and engineering. These technology disciplines currently include computation technology, computer numerical control machining, remote sensing, GIS/GPS data analysis, and nanotechnology with additional potential disciplines in the future. The goal of this track is to produce technologists with a focus and training in computational sciences, and in their primary technology domain area. Students with undergraduate degrees in engineering, mathematics, physics and computer science may also be admitted and must meet the course and curriculum requirements in technology.

PROGRAM OPTIONS AND DEGREE REQUIREMENTS

Master of Science

The M.S. program in computational science and engineering requires 34 credit hours at the graduate level beyond the undergraduate degree distributed as follows:

Thesis Option:
27 credit hours for course work at the graduate level,
1 credit hour for seminars, and
6 credit hours for thesis research.

Project Option:
30 credit hours for course work at the graduate level,
1 credit hour for seminars, and
3 credit hours for graduate masters project.

Year One

Fall Semester

CSE 701 - Applied Probability and Statistics	3cr
CSE 702 - Comprehensive Numerical Analysis	3cr
Domain course I	3cr

Spring Semester

CSE 703 - Data Structures, Software Principles and Programming in Scalable Parallel Computing.	3cr
CSE 704 - Computational Modeling and Visualization	3cr
Domain course II	3cr

Year Two

Fall Semester

Interdisciplinary course I	3cr
Interdisciplinary course II	3cr
Interdisciplinary course III	3cr (for project option)
Thesis	3cr (for thesis option)
Seminar	1cr

Spring Semester

Domain course III	3cr
Thesis	3cr (for thesis option)
Master's Project	3cr (for project option)

All students irrespective of the track that they are registered in must successfully complete the core courses CSE-701, CSE-702, CSE-703 and CSE-704.

All students must complete the Graduate Seminar course CSE 792, which accounts for 1 credit hour.

Students pursuing the thesis option must complete 6 credits hours of CSE 797.

Students pursuing the project option must complete 3 credits hours of CSE 796.

A partial list of Domain courses and Interdisciplinary courses from which a student can choose based on the track the student is registered in is as follows;

Computational Science and Engineering Track
Domain Courses:
Mechanical Engineering: MEEN 655, MEEN 716, MEEN 719, MEEN 822, MEEN 846, MEEN 847, MEEN 849
Civil Engineering: CIEN 600, CIEN 614, CIEN 668, CIEN 644, CIEN 660, CIEN 662, CIEN 664, CIEN 700, CIEN 702, CIEN 736, CIEN 737, CIEN 754
Industrial Engineering: INEN 615, INEN 624, INEN 665, INEN 721, INEN 742, INEN 745, INEN 813, INEN 814, INEN 822, INEN 841, INEN 843, INEN 844, INEN 853
Computer Science: COMP 653, COMP 662, COMP 670, COMP 732, COMP 733, COMP 747, COMP 753, COMP 755, COMP 770, COMP 785
Electrical Engineering: ELEN 656, ELEN 674, ELEN 678, ELEN 749, ELEN 762, ELEN 764, ELEN 821, ELEN 857, ELEN 862, ELEN 865, ELEN 867, ELEN 870, ELEN 871, ELEN 668
Chemical Engineering: CHEN 630, CHEN 620, CHEN 640, CHEN 710, CHEN 720, CHEN 730, CHEN 740, CHEN 760
Physics: PHYS 605, PHYS 630, PHYS 744, PHYS 745
Mathematics: MATH 608, MATH 624, MATH 631, MATH 652, MATH 706, MATH 708, MATH 712, MATH 721, MATH 723, MATH 731, MATH 781, MATH 782

Interdisciplinary Elective Courses:
PHYS 745, PHYS 746, BIOL 705, BIOL 706, MEEN 655, MEEN 716, PHYS 791, MATH 791, CSE 711, CSE 712, CSE 713 or any other qualifying domain courses that are not from the major domain area of the student. Students registered for the thesis option must complete 6 credit hours of course work from this list and students registered for the project option must complete 9 credit hours of course work from this list.

Computational Science Track
Domain Courses:
Chemistry: CHEM 674, CHEM 731, CHEM 732, CHEM 741, CHEM 742, CHEM 743, CHEM 749, CHEM 735, CHEM 755
Agribusiness and Science: AGEC 638, AGEC 675, AGEC 705, AGEC 708, AGEC 710, AGEC 720, AGEC 740, AGEC 756
Animal Sciences: ANSC 637, ANSC 665, ANSC 771, ANSC 782
Human Environment and Family Sciences: HEFS 653
Natural Resources and Environmental Design: SLSC 632, NARS 610, AGRI 604
Biology: BIOL 630, BIOL 640, BIOL 642, BIOL 665, BIOL 700, BIOL 703, BIOL 704
Business and Economics : BUAD 715, BUAD 713, ECON 706, ACCT 708,ACCT 714, BUAD 730, BUAD 731,BUAD 732, BUAD 733, BUAD 734, BUAD 735, BUAD 736, TRAN 701, TRAN 720, TRAN 725, TRAN 727, TRAN 730

Interdisciplinary Elective Courses:
PHYS 745, PHYS 746, BIOL 705, BIOL 706, MEEN 655, MEEN 716, PHYS 791, MATH 791, CSE 711, CSE 712, CSE 713 or any other qualifying domain courses that are not from the major domain area of the student. Students registered for the thesis option must complete 6 credit hours of course work from this list and students registered for the project option must complete 9 credit hours of course work from this list.

Computational Technology

Domain Courses:

Construction Management and Occupational Safety and Health: MSIT 610, MSIT 779,
Electronics and Computer Technology and Manufacturing Systems: ECT 600, ITT 634, ECT 635, ITT 650, ITT 629, ITT 630, ITT 665, ITT 670, ITT 680, CUIN 760, CUIN 761,
Graphics Communication Systems: GCS 631, GCS 632,
Manufacturing Systems: MFG 651, MFG 674, MFG 696, MFG 760
Interdisciplinary Elective Courses:
PHYS 745, PHYS 746, BIOL 705, BIOL 706, MEEN 655, MEEN 716, PHYS 791, MATH 791, CSE 711, CSE 712, CSE 713 or any other qualifying domain courses that are not from the major domain area of the student. Students registered for the thesis option must complete 6 credit hours of course work from this list and students registered for the project option must complete 9 credit hours of course work from this list.

ADVISORY COMMITTEE AND PLAN OF GRADUATE WORK

Initially the Chair Person/Graduate Program Coordinator of the program will serve as the academic advisor for all new students entering the program. Each student in the M.S. program is expected to select a major advisor by the beginning of the second semester with the approval of the Chairperson. The major advisor must hold a tenure or tenure-track full-time faculty position at the university. However, a co-advisor may have non-tenure-track/adjunct status.
The M.S. Advisory Committee will consist of a minimum of three (3) graduate faculty members with the major advisor as its chairperson. Committee members must be from at least two different departments. Members could represent more than one campus School/College. The M.S. Advisory Committee will be recommended by the major advisor with input from the student to the chairperson of the CSE program for approval by the Dean of Graduate Studies.

OTHER INFORMATION

See "Requirements for the Master of Science Degree" elsewhere in this catalog for information related to residence requirements, qualifying examination, preliminary examination, final oral examination, admission to candidacy, and time limit. Additional details of requirements for the program are outlined in the Computational Science and Engineering M.S. Program Student Handbook available from the Graduate School.

List of Courses	Credits
CSE 700 Introduction to Computational Science and Engineer	3
CSE 701 Applied Probability and Statistics	3
CSE 702 Comprehensive Numerical Analysis	3
CSE 703 Data Structures, Software Principles and Programming in Scalable Parallel Computing	3
CSE 704 Computational Modeling and Visualization	3
CSE 711 Computational Techniques & Modeling for Nanoscience and Nanoengineering	3
CSE 712 Nano-Scale Technology	3
CSE 713 Multi-Scale and Multi-Physics Modeling	3
CSE 750 Topics in Computational Science	3
CSE 785 Special Topics	3

M.S. Level Pass/Fail Courses

CSE 792 Graduate Seminar	1
CSE 793 Master's Supervised Teaching	3
CSE 794 Master's Supervised Research	3
CSE 796 Masters Project	3
CSE 797 Masters Thesis	3
CSE 799 Continuation of Masters Thesis	1

COURSE DESCRIPTIONS

CSE 700. Introduction to Computational Science **Credit 3(3-0)**
This course covers the introduction and application of commonly used computational tools including computer algebra systems, interpreted languages used as scripting languages, and programming. This course also covers the basics of computational science including finite precision arithmetic, logic, and algorithmic design.

CSE 701. Applied Probability and Statistics **Credit 3(3-0)**
This course addresses probability and statistics theory and techniques with common application in computational science and engineering. Topics include parameter and distribution estimation, random variables and computer generation, hypothesis testing and confidence intervals, regression analysis, and the design of experiments including analysis of variance.

CSE 702. Comprehensive Numerical Analysis **Credit 3(3-0)**
This course provides a comprehensive treatment to numerical methods for the solution of equation systems both in deterministic and non-deterministic problems. Both numerical solution techniques for differential equations, linear systems, data analysis, optimization, regression, Monte Carlo methods, forecast models, etc. will be covered.

CSE 703. Data Structures, Software Principles and Programming in Scalable Parallel Computing **Credit 3(3-0)**
This course addresses the concepts, principles hardware and software, communication and computational strategies for scalable, parallel computing systems, the associated computer data structures, programming languages and parallel programming paradigms and associated communications for parallel and scalable computing applications in engineering, sciences, and technology.

CSE 704. Computational Modeling and Visualization **Credit 3(3-0)**
This course covers computational techniques for solving deterministic physical models in engineering and sciences, as well as computational techniques for non-deterministic models in business, economics, informatics, statistics, etc. It also involves a detailed study of visualization, analysis and interpretation techniques useful in the analysis of numerical data in both deterministic and non-deterministic disciplines, as well as visualization and interpretation software tools.

CSE 711. Computational Techniques and Modeling for Nanoscience and NanoengineeringCredit 3(3-0)
This graduate level course covers computational methods and techniques that are relevant to nano science and nano engineering. Computational techniques, modeling approaches relevant to nano length and time scales will be discussed in the context of computational nano mechanics and materials. Discussions will also include relevant multi-scale methods on the current techniques for bridging across length scales.

CSE 712. Nano-Scale Technology **Credit 3(3-0)**
This course explores the creation and utilization of functional materials, devices, and systems with novel properties and functions that are achieved through the control of matter, atom-by-atom, molecule-by-molecule, or at the macro-molecular level. Nano-scale manufacturing and fabrication requires an entirely new approach: invention of new instruments, measuring tools, models, methods, and standards to characterize nano-scale materials and processes.

CSE 713. Multi-Scale and Multi-Physics Modeling **Credit 3(3-0)**
This course focuses on multi-scale, multi-physics modeling approaches, associated computational techniques involving quantum, atomistic, meso, micro, macro models and the coupling of such models and related applications in engineering, materials and physical sciences.

CSE 750. Topics in Computational Science **Credit 3(3-0)**
This course will focus on computational thinking. The student will learn how to express scientific concepts as a problem for a computer to help solve. The course covers the transformation from infinite precision mathematics to a discrete approximation which is implemented in a code or other appropriate tool for the computer.

CSE 785. Special Topics **Credit 3(3-0)**
This course is designed to allow the introduction of potential new courses on a trial basis or special content courses on a once only basis at the Master's level. The topic of the course and title are determined prior to registration.
Prerequisite: Consent of Instructor.

CSE 792. Graduate Seminar **Credit 1(1-0)**

Discussions and reports of subjects in Computational Science and Engineering and allied fields will be presented. Prerequisite: Masters level standing.

CSE 793. Master's 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 assignment. Prerequisite: Master's level standing.

CSE 794. Master's Supervised Research **Credits 3(3-0)**
This course is supervised research under the mentorship of a faculty member. It is not intended to serve as the project nor thesis topic of the master's student. Prerequisite: Consent of instructor.

CSE 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, must be submitted for approval. This course is only available to project option students. Prerequisite: Masters level standing.

CSE 797. Masters Thesis **Credit 3(3-0)**
Master of Science thesis research will be conducted under the supervision of the thesis committee chairperson leading to the completion of the Masters thesis. This course is available only to thesis option students and can be repeated. Prerequisite: Consent of advisor.

CSE 799. Continuation of Masters Thesis **Credit 1(1-0)**
This course is a continuation of CSE 797. The course is for master's students who have completed all required credit hour requirements. Prerequisite: Completion of all Thesis/Dissertation Credits.

DOCTOR OF PHILOSOPHY (Ph.D.)

The mission of the Computational Science and Engineering Ph.D. program is to create the next generation of qualified doctoral trained practitioners in the engineering disciplines, physical and biological sciences, computational science and engineering, energy and environment, technology and business and economic modeling. This interdisciplinary program has been designed for persons who desire to be proficient in computational methods and modeling analysis in the domain disciplines of engineering and sciences, and the associated practical use of advance and high-end computing architectures. The graduates of the program will have the knowledge and expertise of their domain disciplines and the associated computational modeling developments and applications in these domain disciplines. The Computational Science and Engineering PhD draw expertise and resources from among all fields of engineering, sciences, technology and business to prepare students to work effectively in today's environments.

GENERAL PROGRAM ADMISSION REQUIREMENTS
DOCTOR OF PHILOSOPHY (Ph.D.)

Admissions Requirement for Ph.D. in Computational Science and Engineering

(1) Admissions requirements for proposed program (indicate minimum requirements and general requirements

There are specific procedures in evaluating an applicant's potential for success in the Ph.D. program. Admissions decisions reflect an evaluation of the applicant's potential to engage in graduate coursework and independent and original investigations. Generally, requests for admission are considered by the program chair person through the graduate school standard admission procedure. Once an application is reviewed, an admission recommendation is forwarded to the Dean of the School of Graduate Studies. Admission is granted for a specific semester or summer term, any change in the admission date must be requested in writing and approved by the School of Graduate Studies.

To be considered for admission to the Ph.D. in Computational Science and Engineering an applicant must satisfy the following requirements:

1. Master's degree in Computational Science and Engineering (CSE) or in science, engineering, business, economics, technology or in a closely related to computational science or computational engineering field with a minimum GPA of 3.25/4.0
2. GRE score of at least 1000
3. International Students: An official score report for the Test of English as a Foreign Language (TOEFL) with the score of at least 550 (written test) or 213 (computer-based test). This requirement maybe waived if the candidate has completed a bachelors or masters degree on a full-time basis at a university in the United States.

(2) Documents to be submitted for admission

The following documents are required by the School of Graduate Studies:

1. Completed application form and application fee stipulated by School of Graduate Studies at NC A&T State University.
2. Three letters of recommendation from former college professors or supervisors. *Two of the three recommendation letters **must be** from a university professor.*
3. Statement of Purpose in the context of pursuing the Ph.D. degree in Computational Science and Engineering.
4. A resume is necessary if you are interested in receiving financial support via University fellowships and assistantships, departmental assistantships, fellowships and other awards sponsored through federal, state, and private grants and contracts.

5. Official transcripts of all college-level academic work.
6. Official copy of GRE score mailed directly to the university.
7. Official copy of TOEFL score mailed directly to the university (international students only).
8. A **course-by-course** transcript evaluation (international students only).

ADVISORY COMMITTEE AND PLAN OF GRADUATE WORK

Degree Requirements

The credit hours required for the program is 50 credit hours of core and domain courses beyond the M.S. degree. Of these 50 credit hours, 24 credit hours are for course work, 2 credit hours are for seminars, 6 credit hours are for professional practice/development, 3 credit hours for qualifying exam, 3 credit hours for PhD proposal defense, and a minimum of 12 credit hours are for dissertation research.

Other requirements (e.g. residence, comprehensive exams, thesis, dissertation, clinical or field experience, "second major," etc.)

The requirement consists of the following elements:

1. General Core: 12 credit hours (required courses for all students in the program)
2. Doctoral Seminar: 2 credit hours (2 semesters of graded seminar required for all students in the program. Each seminar is for 1 credit hour and will be taken twice during the doctoral course of study);
3. Domain Courses: 12 credit hours; 6 credit hours from the fields of Computational Physics, Computational Chemistry, Computational Biology, Computational Mathematics, Computational Business/Finance, Computational Technology, Engineering (as long as courses involves computational or computer science aspects) according ot the major and research emphasis of the student, and 6 credit hours from the fields listed above including Energy and Environment studies and Engineering/Computer Science.
4. Professional development/practice requirement: 6 credit hours (required for all students in the program this includes 3 credit hours of Doctoral Supervised Research and 3 credit hours of Doctoral Supervised Teaching);
5. Dissertation Research: 12 credit hours (required for all students in the program.
6. Major Advisor: Initially the Chairperson of the Ph.D. program will serve as an academic advisor for all new students entering the program. Each student in the Ph.D. program is expected to select a major advisor by the beginning of the second year with the approval of the Chairperson. The major advisor must hold a tenure or tenure-track full-time faculty position at the university.
7. Composition of Ph.D. Committee: A Ph.D. Advisory Committee will consist of a minimum of five (5) graduate faculties with the major advisor as its chairperson. The Ph.D. Advisory Committee will be recommended by the major advisor, with input from the student, to the chairperson of the computational science and engineering Ph.D. program, for approval by the Dean of Graduate Studies. Upon the student's selection of a research area, the Ph.D. Advisory Committee will review the student's prior transcripts, evaluate and recommend any transfer credits, and prepare a program of study for approval by the chairperson of the Ph.D. program before submission to the Dean of Graduate Studies. The Committee will supervise the student's program, administer dissertation review and approval, and finally recommend the awarding of the degree.
8. Qualifying Written Examination: 3 credit hours. A comprehensive written examination is proposed for all accepted Ph.D. students to ensure minimum competencies and to assist the students' committee in its coursework development program. All students admitted into the Ph.D. program are subject to a Qualifying Written examination after the completion of FIRST YEAR of Ph.D. coursework on an unconditional basis.
9. Oral Defense of Dissertation Proposal (Preliminary Examination): 3 credit hours (required for all students in the program). The dissertation proposal is submitted to the student's major advisor and the Ph.D. Advisory Committee for review. The committee will make recommendations as needed. The proposal must be orally defended by the candidate before the Advisory Committee, and it must be accepted by the committee. The signature of committee members on the dissertation proposal

constitutes approval to proceed with research. After approval of the dissertation proposal, the student will register for the Computational Science and Engineering Ph.D. Dissertation course.

10. Admission to Candidacy for Ph.D. Degree in Computational Science and Engineering: Admission to candidacy for Ph.D. degree in Computational Science and Engineering: Admission to candidacy for Ph.D. degree in Computational Science and Engineering will require compliance with all existing Graduate School policies.
11. Final Oral Examination: The final oral examination is scheduled after the dissertation is complete except for such revisions as may be necessary as a result of the examination, but not earlier than one semester or its equivalent after admission to candidacy and not before all required course work has been completed or is currently in progress.
12. Dissertation: The doctoral dissertation presents the results of the student's original investigation in the field of major interest. It must be a contribution to knowledge, be adequately supported by data and be written in a manner consistent with the highest standards of scholarship. Publication is expected.
13. Degree Requirements: The student must successfully complete the approved program of study with a minimum cumulative GPA of 3.0 or better
14. Residency Requirements: For the Doctor of Philosophy degree, the student is expected to be registered for graduate work for at least four semesters beyond the master's degree. At least two residence credits, as defined below, must be secured in continuous residence (registration in consecutive semesters) as a graduate student at the university.

Current List of Courses	**Credits**
CSE 801 Advanced Statistics and Experimental Design	3
CSE 802 Advanced Numerical Analysis	3
CSE 803 Advanced High Performance and Scalable Computing	3
CSE 804 Advanced Scientific Visualization	3
CSE 805 Visual Analytics and Data Mining	3
CSE 885 Special Topics	3

Ph.D. Level Pass/Fail Courses

CSE 991 Doctoral Qualifying Exam	3
CSE 992 Graduate Seminar	1
CSE 993 Doctoral Supervised Teaching	3
CSE 994 Doctoral Supervised Research	3
CSE 995 Doctoral Preliminary Exam	3
CSE 997 Doctoral Dissertation	3
CSE 999 Continuation of Doctoral Thesis	1

CSE 801, CSE 802, CSE 803, and CSE 804 are required core courses for all the students of the CSE Ph.D. program.

COURSE DESCRIPTIONS

CSE 801. Advanced Statistics and Experimental Design **Credit 3(2-2)**
This course will cover advanced topics in the design and analysis of experimental and observational studies. An accompanying statistical software laboratory is a part of the course for learning to create, import and work with SAS data setup and using SAS procedures for statistical analysis and graphical displays.

CSE 802. Advanced Numerical Analysis **Credit 3(3-0)**
This course is an advanced level treatment of computational methods, algorithms, errors, stability and accuracy considerations, solution techniques for large scale computational systems that are applicable for the computational modeling in various branches of science and engineering.

CSE 803. Advanced High Performance and Scalable Computing **Credit 3(3-0)**

This course will focus on the very high end of parallel computing to include grid computing, cloud computing and remote storage that are key concepts for the next generation of computational approaches. New emerging concepts such as graphical processing unit (GPU) computing will be discussed.

CSE 804. Advanced Scientific Visualization **Credit 3(3-0)**
This course will extend the topics from CSE 704, including a survey of current available tools. This course covers the construction of visualization applications for specific analysis or display devices. The focus will be a project to write visualization codes using OpenGL or VTK specifically for 3D displays.

CSE 805. Visual Analytics and Data Mining **Credit 3(3-0)**
This course will focus on the use of visualization techniques to manage large data collections, and the use of visual tools to analyze data. This includes diverse areas of data acquisition such as web searching, bioinformatics and conformation analysis.

CSE 885. Special Topics **Credit 3(3-0)**
This course is designed to allow the introduction of potential new courses on a trial basis or special content course as required at the doctoral level.

CSE 991. Doctoral Qualifying Exam **Credit 3(3-0)**
This supervised program is for students who are taking the CSE Ph.D. program qualifying examination to demonstrate the understanding of the core areas of CSE and their domain research area. It culminates in a scheduled written examination administered on a Pass/Fail basis and must be passed after the completion of the first year of Ph.D. coursework or an unconditional basis.

CSE 992. Doctoral Seminar **Credit 1(0-2)**
Seminars delivered by student researchers, faculty, and invited speakers. Participation in these seminars will count for 2 credit hours (1 credit hour for each academic year). The student receives a Pass/Fail and no letter grade is given upon completion.

CSE 993. Doctoral Supervised Teaching **Credit 3(0-6)**
This course introduces the doctoral student to classroom or laboratory teaching under the supervision of a faculty mentor. The student receives a Pass/Fail and no letter grade is given upon completion.

CSE 994. Doctoral Supervised Research **Credit 3(3-0)**
This is supervised research under the mentorship of a member of the graduate faculty. It is not intended to serve as the dissertation topic of the doctoral student. The student receives a Pass/Fail and no letter grade is given upon completion.

CSE 995. Doctoral Preliminary Examination **Credit 3(3-0)**
This is required for students who have completed the CSE doctoral qualifying examination and who are taking the preliminary examination (oral preliminary defense). The student receives a Pass/Fail and no letter grade is given upon completion.

CSE 997. Doctoral Dissertation **Credit 3(3-0)**
This represents the supervised research leading to the dissertation for the doctoral student. The student receives a Pass/Fail grade only after the completion of the final Ph.D. oral defense.

CSE 999. Continuation of Dissertation **Credit 1(1-0)**
This course is for doctoral students who have completed all required credit hour requirements. This can be repeated by the students as required. The student receives a Pass/Fail and no letter grade given upon completion.