Computational Science and Engineering

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MISSION

Computational Science and Engineering (CSE) is an interdisciplinary graduate program (granting M. S. and Ph. D. degrees) designed for students who seek to use advanced computational methods to solve large problems in diverse fields ranging from the basic sciences (Physics, chemistry, mathematics, etc.) to sociology, biology, engineering, and economics.

The mission of Computational Science and Engineering is to graduate professionals who (a) have expertise in developing novel computational methodologies and products, and/or (b) have extended their expertise in specific disciplines (in science, technology, engineering, and socioeconomics) with computational tools.

OBJECTIVES

The Computational Science and Engineering programs have been designed with the following objectives:

- To lead graduate students to a mastery of high-performance computer programming tools as methods, as well as the acquisition, processing and analysis of large datasets.
- To educate and train students in computational modeling, simulation and visualization.
- To educate and train students in obtaining computational solutions to problems of high dimensions or involving large datasets.
- To assist students in relating and applying 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.
- To teach students to develop novel and robust computational methods and tools to solve scientific, engineering, technology, and business problems.
- 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.

- To increase the number of graduate professionals available to work in computational science and engineering.
- To increase the diversity of graduate professionals, especially underrepresented minority and African Americans available to work in the computational science and engineering field.
- 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

Two degrees are offered in Computational Science and Engineering:

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

MASTER OF SCIENCE (M. S.) DEGREE IN COMPUTATIONAL SCIENCE AND ENGINEERING

Admission Requirements

Candidates seeking admission to the Master of Science Program in Computational Science and Engineering must meet the following requirements:

1. Applicants to the M. S.in CSE degree must possess an approved Bachelor of Science or Bachelor of Engineering degree. Approved degrees include:
   a. A Bachelor of Science or of Engineering in Engineering, Physics, Computer Science, or Mathematics from an accredited program for Applicants into the Computational Methods Track; or
   b. A Bachelor of Science degree in Engineering, Physics, Computer Science, Mathematics, Chemistry, Biology, Business, Agricultural Sciences, or Technology for Applicants in the Computational Applications Track.
2. General prerequisites: All Applicants are expected to possess knowledge in (a) College chemistry and physics and (b) College mathematics. Applicants to the Computational Methods Track are also required to possess knowledge of (c) Calculus through differential equations, and (d) elementary numerical analysis or one semester of linear algebra. Programming skills and working knowledge of at least one high-level programming language such as FORTRAN, C++, or an interpreted language like Java, MATLAB, or Mathematica are required for the Computational Methods Track, and are recommended for the Computational Applications Track students on the student's area of interest.
3. Applicants to the M. S. Program must comply with the requirements for admission as specified by the School of Graduate Studies for all M. S. programs. In particular, they must comply with:
   a. The TOEFL and GRE examination requirements;

b. Requirements regarding official transcripts for all college-level academic work;
c. Requirements regarding Letters of Recommendation; and
d. Completing an Application and paying all application fees

4. In addition to the requirements of the School of Graduate Studies,
   a. The Applicant shall provide a "Statement of Purpose" in the context of pursuing the M. S. degree in Computational Science and Engineering.
   b. An applicant requesting financial aid is strongly encouraged to provide a resume.

Computational Science and Engineering Tracks

All students in the M. S. program must pass two CSE 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 Methods Track

This track is designed primarily for students with undergraduate degrees in engineering, chemistry, physics, mathematics, and computer science who will be trained to develop problem-solving methodologies and computational for solving challenging problems. Students in this track typically possess significant prior training in fields such as mathematics, numerical analysis, and high-level programming languages. Students with undergraduate degrees in other science and technology fields may also be admitted if they meet the admission and course requirements, including prerequisites of the domain department. Research in this track includes but is not limited to computational quantum chemistry, computational nuclear and high-energy physics, computational solid or fluid dynamics, computational material science, bioengineering, computational geometry, computational nonlinear dynamics, computational statistics, engineering design and automation, applied and environmental geophysics, computational seismology, nonlinear computational mechanics and dynamics, super fast algorithms for numerical and algebraic computation, and distributed and high-performance computing.

Computational Applications Track

This track is designed primarily for students with undergraduate degrees in chemistry, biology, psychology, business, finance and economics, technology and engineering, 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 their disciplines. This track often includes domain courses requiring lesser training in mathematics and computational technology. Based on their undergraduate field, the students in this track will be typically required to take additional mathematics- and programming-focused courses.

Program and Degree Requirements for an M. S.in CSE

The M. S. program in Computational Science and Engineering (CSE) 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
6 credit hours for thesis research

Project Option:

30 credit hours for course work at the graduate level
1 credit hour for seminars
3 credit hours for Master of Science Project

Core Course Requirement:

All students, and regardless of the Track in which they are registered,, must successfully complete at least two of the CSE core courses. CSE Core Courses are those numbered from CSE 701 through CSE 709 and from CSE 801 through CSE 809. A list of the currently available and planned core courses are shown below.

The currently available Core CSE Courses are:

Table CSE-1

CSE 701	Applied Probability and Statistics	3 cr
CSE 702	Comprehensive Numerical Analysis	3 cr
CSE 703	Data Structures, Software Principles and Programming in Scalable Parallel Computing	3 cr
CSE 704	Computational Modeling and Visualization	3 cr
CSE 801	Advanced Statistics and Experimental Design	3 cr
CSE 802	Advanced Numerical Analysis	3 cr
CSE 803	Advanced High Performance and Scalable Computing	3 cr
CSE 804	Advanced Scientific Visualization	3 cr
CSE 805	Visual Analytics and Data Mining	3 cr
CSE 806	Computational System Theory	3 cr

Track Course Requirement:

Students admitted in a given Track must complete at least 6 credits from a list of the corresponding Track courses. Courses for the Computational Methods Track include (a) any CSE core course not already accounted for as a core course; (b) Any of the approved Computational Methods Track courses. The currently approved courses are:

Table CSE-2		
CHEM 673	Introduction to Computational Chemistry	3 cr
CHEN 640	Computer-Aided Chemical Process Design	3 cr
CIEN 644	Finite Element Analysis I	3 cr
COMP 681	Formal Methods	3 cr
COMP 733	Parallel Computing Applications	3 cr
COMP 747	Computer Vision Methodologies	3 cr
COMP 755	Advanced Operating Systems	3 cr
ELEN 668	Automatic Control Systems	3 cr
ELEN 865	Theory of Linear Systems	3 cr
GCS 631	Advanced Computer – Aided Design	3 cr
GCS 632	Graphic Animation	3 cr
INEN 742	Linear & Integer Programming	3 cr
ITT 702	Statistical Methods for Information Tech.	3 cr
MATH 631	Linear & Non-Linear Programming	3 cr
MATH 650	Ordinary Differential Equation	3 cr
MATH 651	Partial Differential Equations	3 cr
MATH 652	Methods of Applied Mathematics	3 cr
MATH 712	Numerical Linear Algebra	3 cr
MATH 751	Solution Methods in Integral Equations	3 cr
MATH 765	Optimization Theory and Applications	3 cr
MATH 781	Mathematical and Computational Modeling	3 cr
MEEN 847	Computational Engineering Dynamics	3 cr
MEEN 716	Finite Element Methods	3 cr
MEEN 618	Numerical Analysis for Engineers	3 cr

Courses for the Computational Applications Track include the following approved courses.

Table CSE-3		
AGEC 705	Statistical Methods for Agricultural Economics	3 cr
BIOL 630	Molecular Genetics	3 cr

BIOL 640	Introduction to Bioinformatics & Genomic Research	3 cr
BIOL 755	Systems Biology	3 cr
BUED 624	E-Commerce Design & Implementations	3 cr
CHEN 600	Advanced Process Control	3 cr
CHEN 655	Nanostructured Materials & Engineering	3 cr
CHEN 760	Advanced Chemical Engineering Thermodynamics	3 cr
CHEM 673	Introduction to Computational Chemistry	3 cr
BUAD 744	Enterprise Data Modeling	3 cr
CIEN 754	Modeling of Transportation Systems	3 cr
CSE 712	Nano-Scale Technology	3 cr
CSE 713	Multi-Scale & Multi-Physics Modeling	3 cr
ELEN 650	Digital Signal Processing I	3 cr
ELEN 850	Digital Signal Processing II	3 cr
ELEN 865	Theory of Linear Systems	3 cr
MEEN 626	Advanced Fluid Dynamics	3 cr
MEEN 655	Computational Fluid Dynamics	3 cr
MEEN 847	Computational Engineering Dynamics	3 cr
MFG 674	Advanced Automation and Control	3 cr
PHYS 744	Introduction to Computational Methods in the Physical and Biological Sciences	3 cr
PHYS 745	Computational Physics	3 cr

Graded Course Requirements:

Under the Thesis Option: In addition to the credits from the CSE core, and the 6 credits from the Track courses, a student pursuing the Thesis Option must take 15 credits of approved elective courses. These courses include (a) all graduate-level courses from the College of Engineering, Mathematics, Physics, Chemistry, Biology, Economics, Business and Finance, and Agricultural Life Sciences; (b) any other course approved by the CSE Department.

Under the Project Option: In addition to the credits from the CSE core, and the 6 credits from the Track courses, A student pursuing the Project Option must take 18 credits of approved elective courses. These courses include (a) all graduate-level courses from the College of Engineering, Math, Physics, Chemistry, Biology, Economics,

Business and Finance, Agricultural Life Sciences; (b) any other course approved by the CSE Department.

Other Requirements

1. 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.
2. All M. S. students must complete one credit of the Graduate Seminar course CSE 792.
3. All M. S. students must complete a Plan of Study before completing 18 credit hours.
4. All M. S. Students must comply with the general requirements as stipulated by the School of Graduate Studies. See "Requirements for the Master of Science Degree" elsewhere in this catalog. In particular they must comply with the stipulated residence requirements, qualifying examination, preliminary examination, final oral examination, admission to candidacy, and time limit, if any.

Advisory Committee and Plan of Graduate Work

Initially the 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 Program Director. 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. Members can be from more than one School/College. The M. S. Advisory Committee will be recommended by the Major Advisor with input from the student to the Director of the CSE Program for approval by the Dean of Graduate Studies.

After completing 12 credit hours, the student shall prepare and submit a M. S. Plan of Study for approval by the Advisory Committee, the Director of Computational Science and Engineering, and the Dean of the School of Graduate Studies.

Typical M. S. Plans of Study

A typical M. S. Plan of Study under the Thesis Option is shown below.

Course(s) planned	**Requirement to satisfy**	**Credits**
Two CSE Core Courses	Core Course requirement	6 cr
Two Graded Courses	Track Course requirements	6 cr
Five graded courses	To complete 27 credits of graded coursework	15 cr
CSE 797 one time or more	M. S. Thesis (6 minimum)	6 cr

CSE 792	Graduate Seminar	1 cr
	Total Credits	**34 cr**

A typical M. S. Plan of Study under the Project Option is shown below.

Course(s) planned	**Requirement to satisfy**	**Credits**
Two CSE Core Courses	Core Course requirement	6 cr
Two Graded Courses	Track Course requirements	6 cr
Six graded courses	To complete 27 credits of graded coursework	18 cr
CSE 796	M. S. Project	3 cr
CSE 792	Graduate Seminar	1 cr
	Total Credits	**34 cr**

Other Information

Additional CSE Courses

Table CSE-4		
CSE 620	Introduction to Computational Science	3 cr
CSE 711	Computational Techniques & Modeling for Nano-science and Nano-engineering	3 cr
CSE 712	Nano-Scale Technology	3 cr
CSE 713	Multi-Scale and Multi-Physics Modeling	3 cr
CSE 750	Topics in Computational Science	3 cr
CSE 785	Special Topics	3 cr
CSE 885	Special Topics	3 cr

M. S. Level Pass/Fail Courses

Table CSE-5		
CSE 792	Graduate Seminar	1 cr
CSE 793	Master's Supervised Teaching	3 cr

CSE 794	Master's Supervised Research	3 cr
CSE 796	Master's Project	3 cr
CSE 797	Master's Thesis	3 cr
CSE 799	Continuation of Master's Thesis	1 cr

DOCTOR OF PHILOSOPHY (PH. D.) IN COMPUTATIONAL SCIENCE AND ENGINEERING

Admission Requirements for Ph. D. in CSE

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 Director through the standard admission procedure of the School of Graduate Studies. 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, and 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. A Master of Science or of Engineering degree in Computational Science and Engineering (CSE) or in science, engineering, business, economics, technology or in a field allied to computational science or computational engineering field with a minimum GPA of 3.00/4.0.
2. Applicants to the Ph. D. Program must comply with the requirements for admission as specified by the School of Graduate Studies for all M. S. programs. In particular, they must comply with the following.
    a. The TOEFL and GRE examination requirements; .
    b. Requirements regarding official transcripts for all college-level academic work;
    c. Requirements regarding Letters of Recommendation; and
    d. Completing an Application and paying all application fees.
3. In addition to the requirements of the School of Graduate Studies,
    a. The Applicant shall provide a "Statement of Purpose" in the context of pursuing the M. S. degree in Computational Science and Engineering.
    b. An Applicant requesting financial aid is strongly encouraged to provide a resume.

Ph. D. Degree Requirements

The credit hours required for the Ph. D. Program is 72 credit hours beyond the student's Bachelor of Science degree or the equivalent thereof. In general, a M. S. degree is counted as 18 credits towards the Ph. D. degree or as allowed by the School of Graduate Studies. Please consult the Graduate Catalog.

A minimum number of credit hours must be satisfied in each of the following several categories. The minimum requirements are as follows:

(a) 24 credit hours for graded course work;

(b) 2 credit hours for Ph. D. seminars;

(c) 3 credit hours are for professional practice/development;

(d) 3 credit hours for qualifying exam;

(e) 3 credit hours for Ph. D. proposal defense;

(f) 12 credit hours for dissertation research.

Graded Course Requirements

The requirements consist of the following elements:

1. The successful candidate shall pass at least 9 credits from the CSE Core courses.
2. The successful candidate shall pass a total of 2 credit seminar hours. Each seminar is for 1 credit hour.
3. The successful candidate shall pass 15 credit hours of approved Domain Courses. The approved domain courses include any graduate level course from the College of Engineering, Mathematics, Physics, Chemistry, Biology, Agribusiness, Animal Sciences, Natural Resources and Environment Design, and Business and Economics. Other courses must be approved by the CSE.

Qualifying Written Examination Requirement

The successful Ph.D candidate must pass a 3-credit hour course consisting of a comprehensive written examination in the following 3 Areas:

1. The CSE Core Area consisting of 6 credit hours from the list of CSE Core courses.
2. The CSE Area consisting of 6 additional credits from graded courses in the CSE curriculum.
3. The Application Area consisting of 6 credit hours from approved courses in the student submitted Plan of Study. The Dissertation Advisor must propose these courses and help administer the examination in this Area.

Research and Dissertation Requirements

A minimum of 12 Dissertation Research credit hours are required for all students in the Program.

Major Advisor: Initially the Director 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 Program Director. The Major Advisor must hold a tenure or tenure-track full-time faculty position at the university, and shall subsequently act as the Academic Advisor as well.

Composition of Ph. D. Committee: A Ph. D. Advisory Committee will consist of a minimum of five (5) graduate faculty 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 Director of the Computational Science and Engineering Ph. D. Program, for approval by the Dean of Graduate Studies. The Committee shall supervise the student's Program, administer dissertation review and approval, and finally recommend the awarding of the degree.

Plan of Study: Upon the student's selection of a research area, the Ph. D. Advisory Committee shall review the student's prior transcripts, evaluate and recommend any transfer credits, and provide advice to the student. The student shall subsequently prepare a Plan of Study for approval by the Ph. D. Advisory Committee, the Director of the CSE Ph. D. Program, and the Dean of the School of Graduate Studies.

Oral Defense of Dissertation Proposal (Preliminary Examination): Three (3) credit hours are 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 approved by the Committee, and the student can proceed further with his/her research.

Candidacy for Ph. D. Degree in Computational Science and Engineering: Admission to candidacy for Ph. D. degree in Computational Science and Engineering shall require compliance with all existing Graduate School policies, and shall occur after the student has successfully passed the Qualifying Examination and the Preliminary Examination.

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.

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.

Other Requirements:

Grade Point Average: The student must successfully complete the approved Plan of Study with a minimum cumulative GPA of 3.0 or better.

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 of Science degree. At least two residence credits must be secured in continuous residence (registration in consecutive semesters) as a graduate student at the university.

Other Information

Summary of a typical Ph. D. Plan of Study

In addition to naming the Major Advisor and the Ph. D. committee, the Plan of Study must specify the courses that the student intends to enroll in as well as the intended semesters.

The following table shows the structure of a typical Ph. D. Plan of a Ph. D. student, whose M. S. degree is counted as 18 credit hours towards the 72 credit hours beyond the B. S. requirement, or as allowed by the School of Graduate Studies.

Course(s) planned	**Requirement to satisfy**	**Credits**
Two CSE Core Courses	First Area of the Qualifying Exam	6 cr
One CSE Core Course + an Additional CSE Course	Second Area of the Qualifying Exam and a total of 3 CSE Core courses	6 cr
Two Domain Courses	Third Area of the Qualifying Exam	6 cr
Two Additional Courses	To complete 24 credits of graded coursework	6 cr
CSE 997 one time or more	Doctoral Dissertation (12 minimum)	15 cr
CSE 992 twice	Graduate Seminar	2 cr
CSE 993 or CSE 994	Professional Development (3 minimum)	6 cr
CSE 991	Doctoral Qualifying Exam	3 cr
CSE 995	Doctoral Preliminary Exam	3 cr
CSE 999	Continuation of Doctoral Thesis	1 cr
	Total Credits beyond the M.S.	**54 cr**
Credits Equivalent to the M.S. degree	72 Credits beyond the B.S.	18 cr
	Total Credits Beyond the B. S.	**72 cr**

Ph. D. Level Pass/Fail Courses

Table CSE-6		
CSE 991	Doctoral Qualifying Exam	3 cr
CSE 992	Graduate Seminar	1 cr
CSE 993	Doctoral Supervised Teaching	3 cr
CSE 994	Doctoral Supervised Research	3 cr

CSE 995	Doctoral Preliminary Exam	3 cr
CSE 997	Doctoral Dissertation	2 to 12 cr
CSE 999	Continuation of Doctoral Thesis	1 cr

CSE COURSE DESCRIPTION

CSE 620. Introduction to Computational Software Tools 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 705. Computational Aspects of Linear System Theory Credit 3(3-0)

This course reviews basic concepts from linear systems and considers the computational aspects of modeling, analyzing, controlling, and identifying linear systems. Topics include classification of signals and systems, an overview of system-theoretic problems such as modeling, identification, control, and simulation,

linearizations, inversion, computations based on discretization and matrix decompositions.

CSE 711. Computational Techniques and Modeling for Nanoscience and Nanoengineering Credit 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: Master's 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. Master's 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: Master's level standing.

CSE 797. Master's Thesis **Credit variable (2-6)(3-0)**

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 available only to thesis option students and can be repeated. Prerequisite: Consent of advisor.

CSE 799. Continuation of Master's 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. This course is repeatable. Prerequisite: Completion of all Thesis/Dissertation Credits.

CSE 801. Computational Statistics **Credit 3(3-0)**

This course will cover statistical methods that are applicable to large datasets. Numerical methods designed to visualize, compress, and analyze such methods will be covered. Computationally intensive methods will also be covered. Topics may include: Principal data analysis, Jackknifing, and Bootstrapping.

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 806. Computational System Theory

This course will review the fundamentals of system theory such as the classification of signals, models, and systems, and problems of system theory such simulation, system identification, and inversion. Computational themes such as decomposition, continuation, and prediction-correction will be discussed. The computational requirements and complexity of basic algorithms of system theory will also be discussed.

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 variable, 2 to 12 credits

This represents the supervised research leading to the dissertation for the doctoral student. This course is repeatable. The student receives a Pass/Fail grade only after the completion of the final Ph. D. oral defense.

CSE 999. Continuation of Dissertation 12 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.