Scientific Computation

Graduate Program Handbook

University of Minnesota

2016-2017

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Welcome

The Graduate Faculty in Scientific Computation encourages your interest in this program. Please let us know your questions and suggestions as to how this Handbook could serve you better.

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Program Overview

Introduction

The Graduate Degree Program in Scientific Computation received final approvals in January 1994. It evolved from the Graduate Minor Program in Scientific Computation, which was created in 1990.

The graduate degree program in scientific computation encompasses course work and research on the fundamental principles necessary to use intensive computation to support research in the physical, biological, and social sciences, and engineering. There is a special emphasis on research issues, state-of-the-art methods, and the application of these methods to outstanding problems in science, engineering, and other fields that use scientific computation, numerical analysis and algorithm development, symbolic and logic analysis, high-performance computing tools, supercomputing and heterogeneous networks, and visualization.

Purpose of the Program

Scientific Computation is gradually emerging as an important field of its own in academia and industry. In the last decade, it has become clear that to solve a given scientific problem often requires knowledge that straddles several disciplines. This interdisciplinary program provides a new combination of studies for solving today's scientific computational problems. This degree program builds on the strength of existing programs in formulating real problems based on the physical system or the traditional discipline, and it augments the segments relating to the mathematical and numerical modeling by providing state-of-the-art theories and techniques for scientific computation in an integrated manner.

The Scientific Computation program provides new opportunities and options for graduate training in the problem-solving process and for integrating advances in all segments of the process into a coordinated program of course and thesis study. It offers a new interdisciplinary path of formal course and examination requirements toward a Ph.D. or M.S. degree, and this path should also be augmented by a strong participation in one of the more traditional disciplinary departments.

Sources of Information

Students may find general information about all graduate programs and policy requirements for graduate students in the Graduate Education Catalog. The Graduate Student Services and Progress Office is responsible for student academic matters, including monitoring student registration and degree progress, scheduling of examinations, accepting completed theses and dissertations, degree clearance, and maintaining permanent student records.

Program Options

There are four program options: Ph.D. major, Ph.D. minor, M.S. major, and M.S. minor.

Degree Options in the Scientific Computation Program

There are two options for the Ph.D. degree:

1. Ph.D. with supporting program

2. Ph.D. with minor

The course requirements for these options are detailed later.

The master's degree offered in the Scientific Computation program is a M.S. Plan A. The degree requires the student to complete a thesis and a minor, as well as a scientific computation core.

Full details on all degree programs are given in following sections.

Ph.D. Program Requirements

Each student will choose a program of study in consultation with his or her three-member advising committee.

The Ph.D. degree in Scientific Computation requires a total of 48 credits consisting of a minimum of 24 course credits and 24 thesis credits. Of the 24 required course credits, at least 12 must be in Scientific Computation core courses (see list in this handbook).

A maximum of nine 4000-level course credits may be used to satisfy degree requirements, subject to adviser and Director of Graduate Studies (DGS) approval.

A maximum of 12 graduate course credits from other University registration categories, such as non-degree seeking or non-admitted students, may be considered for transfer once the student is admitted and enrolled in a graduate program. Transfer of credits for graduate level work done at other institutions, if applicable, will be reviewed on an individual basis. A minimum of 12 course credits must be taken at the University of Minnesota. Transfer of thesis credits is not allowed.

Ph.D. with Supporting Program

Students selecting the supporting program option for the Ph.D. degree will be required to complete 24 course credits meeting the following distribution requirement:

1. At least 12 credits in the Scientific Computation degree program core.

2. A supporting program of 12 credits. The supporting program should give the degree program an interdisciplinary character.

Ph.D. with Minor

Students selecting the minor option for the Ph.D. degree are expected to satisfy the Scientific Computation core requirement and to achieve a competency in the minor field greater than that expected for supporting programs — in fact this is a mechanism for the student to establish a strong specialization in a traditional disciplinary area.

For the doctoral degree with a minor, at least 12 semester credits must be taken in the minor field. Many minor programs have greater requirements in terms of credits or examinations for a Ph.D. minor; in such cases the greater requirements will be in effect. The minor field must be declared before the student takes the preliminary oral examination.

A core course that happens to be in the designated minor area may be counted toward the core or the minor but not toward both. In any event, no more than four credits in the designated minor area may be counted as core courses for an individual student.

M. S. Degree

The Plan A Master's Degree requires a minimum of 20 course credits (14 credits in the major field and 6 in the minor) and 10 thesis credits culminating in a satisfactory dissertation. Any student wishing to plan a Master's program will be advised to consult with his or her adviser or the Three-Member Advising Committee in determining an acceptable program.

A Master's program should include at least 6 credits drawn from the Scientific Computation core courses listed later, and it must include at least 6 credits in a designated minor. A core course that happens to be in the designated minor area may be counted toward the core or the minor but not toward both; and no more than 3 credits in the designated minor may be counted toward the core.

For a Master's degree, at least 6 semester credits must be taken in the minor field. Many minor programs have greater requirements in terms of credits for a Master's minor; in such cases the greater requirements will be in effect.

A maximum of nine 4000-level course credits may be used to satisfy degree requirements, subject to adviser and Director of Graduate Studies (DGS) approval. A minimum of 60% of total course credits (not including thesis credits) required for a specific master's degree must be taken at the University. Transferred credits can include a maximum of 12 graduate course credits taken as non-degree seeking or non-admitted status. Transfer of thesis credits is not allowed.

Program Procedures

Three-Member Advising Committee

Students entering the program who have not chosen a research adviser will be assigned a three-member advising committee (TMC). The TMC will meet with the student before the beginning of his or her first semester in the program to advise on planning a course program and to talk over long- and short-range plans. After every meeting of the TMC, the student should file a report summarizing the meeting. This report should be sent electronically to the chairman and the DGS. The TMC will continue to advise the student each semester until an adviser is chosen. The chairman of the TMC will be the adviser for signatures and forms until a permanent adviser is chosen. Membership of the committee will usually be determined to the greatest extent possible from the list of research interests submitted by the student. The responsibilities of the three-member advising committee (TMC) are to:

a. Advise students on their course program.

b. Ensure that each student gets a broad range of learning experiences.

c. Review performance in courses, examinations, and research.

d. Make recommendations regarding a student's progress to the DGS.

e. Establish the written and oral prelim examination deadlines for students entering the program at times other than the beginning of fall semester or with transfer credits to be counted toward the Degree Program.

The TMC will play a role in advising students only until he or she has chosen a research adviser. After that the primary advising responsibility falls on the shoulders of the research adviser.

Permanent Adviser (Research Adviser)

Normally, a student should choose a permanent research adviser before the end of the first semester in residence. Failure to report the choice of a permanent research adviser before the end of the second semester will cause the student to no longer be considered in good academic standing. The adviser will be a member of the Graduate Faculty in Scientific Computation. The research adviser automatically assumes primary responsibility for advising the student on course work, research, and other academic matters.

Filing a Graduate Degree Plan

Graduate students are required to file a degree plan for each degree that he or she intends to complete. The degree plan form should typically be filed in the fall semester of the second year

in residence. On the form, the student should list the courses that have already been completed, including transfer courses, and those that will be taken to fulfill the degree requirements. Courses taken prior to receiving the bachelor's degree cannot be included.

The form must be approved by the student's adviser and by the DGS in Scientific Computation. If the student declares a minor on the degree plan, the DGS of the minor program must also approve it.

Changes to approved degree plans can be made by submitting a Petition form. If changes are substantial, it may be more appropriate for the student to submit a revised degree plan in lieu of the Petition form. The Petition form or the revised degree plan should be presented to the adviser and the DGS in Scientific Computation.

After approval by the adviser and DGS, degree plans and petition forms must be sent to the College of Science and Engineering, ATTN: Jill Johnson, 105 Walter Library, for a final review before they are forwarded to the Graduate Student Services and Progress Office for processing.

Thesis Credits

If all coursework is completed, then a student should complete the thesis credits as soon as possible. A Master's student can complete 10 credits in one semester. Doctoral candidates may not take thesis credits until the semester after they pass the preliminary oral exam. Once the required thesis credits are completed, the student is eligible for FTE registration. The procedures are described under Other Topics.

Examinations

Students in the Ph.D. program will be required to pass written and oral preliminary exams.

The preliminary written exam must be passed first; then the student may schedule the oral exam.

Preliminary Written Examination for the Ph.D.

The Scientific Computation format for the written preliminary examination consists of two parts:

1. a thesis-project proposal

2. a critique or research proposal based on a paper from the scientific computation literature, published within the last 3 years, not in the student's primary thesis research area

Both papers must be submitted on or before the end of the third semester of graduate study in the program.

Paper 1 should be prepared by the student in consultation with his or her adviser(s). Paper 2 should be prepared without the adviser's assistance. The choice of literature paper should be approved by the student's written preliminary examination committee chairman.

Each paper should be double-spaced and 8 to 16 pages long. The writing style and quality should be that of a journal article. Background and motivation should be given in an introductory section; the student's own contribution should be clearly identified as such. Proposals should be specific concerning the measurements or calculations to be made, the apparatus or methods to be employed, and the possible significance of the results.

The first paper will describe research actually to be undertaken for the thesis, or at least the first stages of the thesis project. The student's adviser will certainly participate in the formation and details of the research plans, but the organization and writing of the paper should be the student's own. The aim of the research dossier is to demonstrate that the candidate has attained a good understanding of the thesis project including the fundamental background and current literature. In view of the unpredictable nature of research, it is understood that specific projects described in this preliminary paper may differ from those actually reported in the Ph.D. thesis.

The first paper should succinctly describe the research the candidate is engaged in for his or her research. In particular, the following topics should be discussed in a balanced fashion:

(1) The specific objective, including a discussion of the motivation for and the potential impact of the research.

(2) A critical assessment of previous work in the scientific literature relevant to the proposed research.

(3) The thesis research plan, including a discussion of existing practical and/or fundamental problems and how initial experiments to be conducted may influence the direction of subsequent research.

(4) The research progress made to date.

The second paper is intended to demonstrate some breadth beyond the thesis area and the ability to read the literature at a reasonably critical level. The student will show this first by the quality of the article selected as the basis of the paper, and then by the appropriateness and originality of the extensions proposed for further research, in the case of a proposal, or the commentary offered, in the case of a critique. The latter may take the form of a critical analysis (could the same results have been obtained more simply by other methods, for example, or are there faults in the model used or in the working out of its consequences?) or a comparison with other work (in so far as the authors have not already done so) on the same or a related problem.

Schedule to be followed in satisfying the Written Preliminary Examination in Scientific Computation

The written preliminary examination is to be satisfied in the second year of the candidate's graduate work. The candidate should adhere to the following schedule:

Spring of 1st year: The candidate submits to the DGS of Scientific Computation a list of three faculty members of the Scientific Computation graduate program (not including the advisor(s)) whom the candidate feels would be well suited to serve on the written and oral preliminary exam committees.

Spring of 1st year: The DGS of Scientific Computation will appoint a written preliminary examination committee chairman at this time. Ordinarily this will be a member of the TMC, but not the research adviser. The preliminary examination committee chairperson will be available for consultation during the preparation of the preliminary written examination papers.

September of 2nd year: The student provides the DGS of Scientific Computation with a copy of the paper selected from the scientific computation literature for part 2.

November 1 of 2nd year: The DGS will inform the student of the names of two additional faculty members who, along with the written preliminary examination committee chairman, will constitute the student's written preliminary committee. The student's research adviser will not be a member of this committee.

December 20 of 2nd year: This is the deadline for handing in the papers. The committee chair will ordinarily send a letter to the student to inform the student of the opinions of the committee within three weeks of receipt of the papers. Sometimes this will be in the form of specific criticisms and suggested revisions for the candidate. In other cases the student will be told that he or she has passed or failed.

February 1 of 2nd year: Final drafts of the papers due to the DGS and the preliminary oral exam scheduled. The graduate degree plan must be approved and processed before scheduling the oral exam.

The above dates apply to graduate students entering in the Scientific Computation Program as new graduate students in fall semester. For students entering in spring semester or entering the program as advanced graduate students, alternate dates (if appropriate) should be determined at the first meeting with the Scientific Computation TMC.

Preliminary Oral Examination for the Ph.D.

The DGS will appoint a committee consisting of at least four members, with at least three from the graduate faculty of Scientific Computation and one representing the minor field or supporting program. (A faculty member who is on the graduate faculty of both your major and

minor may represent either but not both.) The student is responsible for submitting the online preliminary oral exam committee form at the following site: http://www.grad.umn.edu/students/forms/doctoral/index.html

Students should assign the exam committee least one month before the proposed date of the examination.

Each Ph.D. candidate must pass the oral preliminary examination. Possible outcomes of the first examination are i) pass, ii) not pass but with option to retake (one time only) the examination, or iii) fail.

Students who have not passed their oral preliminary examination by the end of their second year will no longer be in good standing in the Ph.D. Program. They will be reclassified into the M.S. Program.

The preliminary oral examination will concentrate on the student's understanding of the fundamental scientific computation background for his or her chosen thesis research and will test the student's preparedness to undertake this research. The oral preliminary examination will also test the student's understanding of the papers submitted for the preliminary written exam and their background. The oral preliminary examination will also cover course work, research topics, and material covered in or related to the written thesis proposal.

Final Oral Examination Committee for the Ph.D. degree

At least three months prior to the anticipated date of the final oral examination, the student should submit the final oral exam committee request online at http://www.grad.umn.edu/students/forms/doctoral/index.html. Ordinarily, at least three members should be the same as those who served on the preliminary oral examination, but this is not required. It is the student's responsibility to contact each of the faculty members listed regarding their willingness to serve as a committee member or reader.

For the final oral examination for the Ph.D., the adviser cannot serve as the chair. (This rule does not apply to preliminary oral exams or to final oral examinations for the M.S.).

Final Oral Examination for the M.S. Degree

A final oral examination is required for the completion of the Master's Degree in Scientific Computation. At the time that the degree plan form is submitted the student should submit the master's final exam committee request online at http://www.grad.umn.edu/students/forms/masters/index.html. The exam committee consist of three faculty including at least two members of the Scientific Computation faculty. The adviser may chair the examination or one of the other faculty may serve as chair. It is the student's responsibility to contact all three members regarding their willingness to serve.

Academic Performance Norms

Ph.D. Students

What follows is a guide to the level of academic performance that will be expected of Ph.D. students. It is necessarily approximate, since decisions regarding students' status are based on an interpretation of the entire record, including any special circumstances.

When a student is doubtful about his or her present academic status, the student will be advised to consult with his or her Three-Member Advising Committee or research adviser or with the DGS. In the following, whenever grade point average (GPA) is mentioned, it means the GPA in actual courses graded on the A, B ... system, exclusive of seminars and research credits.

Any of the following items on a student's record will be considered to be an indication of substandard performance, will be a cause for concern, and may jeopardize a student's good standing for Ph.D. degree:

a. Any course grade below B-. Grades of D, F, and N must be made up or not be included in the Degree Program.

b. Low GPA: Students must have a GPA of 3.00 or higher.

c. Failure on written preliminary examination.

d. Insufficient progress toward a degree as manifested by too few course credits completed or not meeting the deadlines for taking the preliminary oral exam or passing the preliminary oral exam.

A student will lose good standing if he or she has 12 or more credits of work with the grade of incomplete.

M.S. Students

Students who do not wish to pursue the Ph.D. degree may opt to study for the M.S. degree.

The University and the program require that M.S. candidates maintain a GPA of 2.8 among those graduate courses ultimately submitted on the M.S. degree plan form. When this requirement is not met, M.S. candidates will be dropped from the program. To be considered in good academic standing and therefore eligible for continuation of support, reasonable progress toward completion of the thesis requirements of the M.S. degree program will be expected.

A student will lose good standing if he or she has 12 or more credits with a grade of incomplete.

Other Topics

Registration

Graduate students must register every fall and spring semester to maintain their active status. Students who must register solely to meet this registration requirement can register for Grad 999, a zero-credit, zero-fee, non-graded option. Students who do not maintain active status will be required to apply for readmission if they wish to resume studies. Prior admission is not a guarantee for readmission. Those readmitted may be required to take additional classes and/or examinations to complete their degree. They may also be required to retake courses and/or examinations (such as the WPE).

Students are required to register no later than the end of the second week of the semester. Changes in registration, such as adding or dropping a course after the deadline, changing the grading option after the deadline, or registering for more than 18 credits in a semester; require submission of a registration exception request. No registration changes are permitted after the last day of instruction.

Time Limits for Earning Graduate Degrees

The University imposes time limits on the total duration of various courses of study leading to graduate degrees. The limits are as follows:

Master's:

- Students who matriculated before January 1, 2013: within 7 years of the earliest coursework on the official degree plan, including transfer coursework.
- Students who matriculated after January 1, 2013: within 5 calendar years after initial enrollment to the graduate program.

Doctoral:

- Students who matriculated before January 1, 2013: within 5 calendar years after passing the preliminary oral exam.
- Students who matriculated after January 1, 2013: within 8 calendar years after initial enrollment to the graduate program.

Students may petition to request an extension to the time limit for either degree. A one-year extension is the limit that will be granted for master's students and doctoral students who matriculated before January 2013. Doctoral students falling under the new policy may request up to 2-years extension. In either case, a second extension request will be granted only under the most extraordinary circumstances.

Procedures for FTE with One Credit for Advanced Graduate Students

The full-time equivalent courses 8333 FTE: Master's and 8444 FTE: Doctoral are one-credit registration options for eligible graduate students who must certify full-time status to be in compliance with requirements of the University and/or external agencies (e.g., employment as a graduate assistant; loan deferment). These courses are intended only for advanced students who have completed all their program coursework and required thesis credits, but are still working full-time on the research or writing of their thesis or dissertation.

Master's students become eligible to register for 8333 the term after they have applied for advanced status. Students must submit an application for Advanced Master's Status to the Graduate Student Services and Progress Office (GSSP) prior to the deadline in every term for which they intend to register for 8333. The term deadlines are:

- Fall Term: August 15th
- Spring Term: December 15th
- Summer Term: May 15th

Doctoral students become eligible to register for 8444 the term after they have successfully completed: 1) the written and oral preliminary exams, 2) the 24 required thesis credits, and 3) all coursework included on the degree plan with grades posted. The application for advanced status must be approved by the DGS every term for which they intend to register for 8444, but is not submitted to the GSSP.

The usage of FTE courses is strictly monitored and students will be required to cancel 8333/8444 registrations if they have not met the eligibility requirements. Students registered for FTE status should not register for additional courses, as these are considered outside the credit allowance and students are responsible for all attendant tuition and fees.

For more information, see Special Registration Categories.

Support for Graduate Students

Assistantships

Graduate assistants must register for the minimum number of required credits during each semester of the regular academic year in which they hold an appointment. In most cases, this would be 6 credits, unless they qualify for advanced status. Grad 999 does not fulfill the registration requirement. Failure to register by the end of the second week of class will result in termination of graduate assistantships. Benefits such as Graduate Assistant Health Plan coverage will be adversely affected. Registration is not required during the summer unless the student wishes to use tuition benefits.

Tuition is waived for all students appointed at the 50% level (RA or TA). For students appointed at levels below 50%, the percentage of tuition waived is equal to two times the percentage of support (25% appointment equals 50% tuition reduction). Tuition reductions are based on resident rates. For example, a nonresident student appointed at 12.5% would have 25% of resident tuition deducted from their nonresident tuition. Nonresident students who are appointed at levels of 25% or above qualify for Minnesota resident tuition rates for the term they are appointed. The graduate assistant's immediate family members (spouse/registered same-sex partner, children) may also enroll at the resident tuition rate.

Eligibility for resident tuition rates and the Graduate Assistant Health Plan requires that a student work at least 195 hours during a semester (195 hours equals a 25% time appointment). These benefits accrue according to the total amount of time worked during the entire semester. Therefore, a student who has a 50% appointment and who begins after the beginning of the payroll period will not be eligible for a 100% tuition benefit or fully paid insurance premium.

International students on F-1 visas are limited to 20 hours of work per week during scheduled class periods and finals week. Note that the rule is applied on a weekly basis rather than averaged over a payroll period. Therefore, it is impossible for F-1 international students to work over 20 hours per week to make up for hours not worked if they arrive late. It is important that they and the department understand that there can be no payment for work carried out prior to the authorization date on their immigration documents, normally the date they enter the U.S. or transfer from another U.S. institution.

This information and more can be found online at http://www1.umn.edu/ohr/gae/

Fellowships

Graduate fellowships, awards based on academic merit, are available to currently enrolled graduate students at the University of Minnesota. The Graduate School Fellowship Office administers University-wide fellowships and provides information on external and privately funded fellowships.

The Department of Energy Computational Science Graduate Fellowship (DOE CSGF) program provides outstanding benefits and opportunities to students pursuing doctoral degrees in fields of study that use high performance computing to solve complex science and engineering problems. The program offers an annual stipend and payment of tuition and fees for doctoral study in scientific and technical disciplines using computational science methods. The program is open to U.S. citizens and permanent resident aliens who are planning full-time, uninterrupted study toward a Ph.D. at an accredited U.S. university. Appointments are reviewed annually and may be renewed up to a limit of four years. An on-line application form and more information are found at http://www.krellinst.org/csgf/

Disability Services

Disability Services promotes access and equity for all students, faculty, staff and guests of the University of Minnesota. Accommodation units assist in implementing accommodations approved by Student Services specialists. They also collaborate and consult with colleges, departments and units to create accessible learning and working environments. The University is committed to advancing access for everyone. For more information visit https://diversity.umn.edu/disability/, or contact ds@umn.edu or 612-626-1333.

Grievance Procedures

Graduate students are encouraged to discuss any problems related to their academic program, research, or assistantship responsibilities with their adviser, the DGS, or any other faculty member they deem appropriate. In general, grievances should be resolved at the lowest level possible. If there is no satisfactory result after such discussions, students may seek free and confidential assistance from the Student Conflict Resolution Center. Student employees are eligible to receive services for workplace concerns from the Office for Conflict Resolution.

Equal Opportunity Statement

The University of Minnesota shall provide equal access to and opportunity in its programs, facilities, and employment without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression.

Scientific Computation Core Courses

The courses included in the core for the Ph.D. and Master's degrees are as follows. This is not an exhaustive list and any course with a significant computation component may be included with the approval of the director of graduate studies.

Scientific Computation Program

SciC 8001 Parallel High-Performance Computing (3 cr)

SciC 8011 Scientific Visualization (3 cr)

SciC 8021 Advanced Numerical Methods (3 cr)

SciC 8031 Modeling, Optimization, and Statistics (3 cr)

SciC 8041 Computational Aspects of Finite Element Methods (3 cr)

SciC 8095 Problems in Scientific Computation (1-3 cr)

SciC 8190 Supercomputer Research Seminar (1 cr)

SciC 8594 Scientific Computation Directed Research (1–4 cr)

Department of Aerospace Engineering and Mechanics

AEM 8251 Finite Volume Methods in Computational Fluid Dynamics (3 cr)

Department of Chemistry

Chem 8021 Computational Chemistry (4 cr)

Chem 8541 Dynamics (4 cr)

Chem 8551 Quantum Mechanics I (4 cr)

Chem 8552 Quantum Mechanics II (4 cr)

Chem 8561 Thermodynamics, Statistical Mechanics & Reaction Dynamics I (4 cr)

Chem 8562 Thermodynamics, Statistical Mechanics & Reaction Dynamics II (4 cr)

Department of Civil, Environmental and Geo- Engineering

CEGE 8022 Numerical Methods for Free and Moving Boundary Problems (3 cr)

CEGE 8361 Engineering Model Fitting (3 cr)

CEGE 8401 Fundamentals of Finite Element Method (3 cr)

CEGE 8402 Nonlinear Finite Element Analysis (3 cr)

CEGE 8561 Analysis of Modeling of Aquatic Environments I (3 cr)

CEGE 8562 Analysis of Modeling of Aquatic Environments II (3 cr)

CEGE 8572 Computational Environmental Fluid Dynamics (3 cr)

Department of Computer Science and Engineering

CSci 5107 Fundamentals of Computer Graphics I (3 cr)

CSci 5108 Fundamentals of Computer Graphics II (3 cr)

CSci 5109 Visualization (3 cr)

CSci 5302 Analysis of Numerical Algorithms (3 cr)

CSci 5304 Computational Aspects of Matrix Theory (3 cr)

CSci 5403 Computational Complexity (3 cr)

CSci 5421 Advanced Algorithms and Data Structures (3 cr)

CSci 5451 Introduction to Parallel Computing: Arch, Algorithms and Program (3 cr)

CSci 5481 Computational Techniques for Genomics (3 cr)

CSci 5561 Computer Vision (3 cr)

CSci 8314 Sparse Matrix Computations (3 cr)

Department of Curriculum and Instruction

CI 5364 Computer-Based Instruction: Games and Simulation (3 cr)

Department of Educational Psychology

EPsy 8221 Psychological Scaling (3 cr)

EPsy 8222 Advanced Measurement: Theory and Application (3 cr)

Department of Earth Sciences

ESci 5201 Time-series Analysis of Geological Phenomena (3 cr)

Department of Electrical and Computer Engineering

EE 5239 Introduction to Nonlinear Optimization (3 cr)

EE 5531 Probability and Stochastic Processes (3 cr)

EE 5561 Image Processing and Applications (3 cr)

EE 8231 Optimization Theory (3 cr)

Institute for Health Informatics

HInf 5430 Health Informatics I (4 cr)

HInf 5431 Health Informatics II (4 cr)

HInf 8434 Medical Decision Support Techniques (3 cr)

Department of Industrial and Systems Engineering

IE 5531 Engineering Optimization I (4 cr)

Institute of Linguistics

Ling 5801 Introduction to Computational Linguistics (3 cr)

School of Mathematics

Math 5467 Introduction to the Mathematics of Image and Data Analysis (4 cr)

Math 5485 Introduction to Numerical Methods I (4 cr)

Math 5486 Introduction to Numerical Methods II (4 cr)

Math 5535 Dynamical Systems and Chaos (4 cr)

Math 5651 Basic Theory of Probability and Statistics (4 cr)

Math 5705 Enumerative Combinatorics (4 cr)

Math 5707 Graph Theory and Non-enumerative Combinatorics (4 cr)

Math 8441 Numerical Analysis and Scientific Computing (3 cr)

Math 8442 Numerical Analysis and Scientific Computing (3 cr)

Math 8445 Numerical Analysis of Differential Equations (3 cr)

Math 8450 Topics in Numerical Analysis (1–3 cr)

Math 8571 Theory of Evolutionary Equations (3 cr)

Department of Mechanical Engineering

ME 5228 Introduction to Finite Element Modeling, Analysis and Design (4 cr)

ME 5351 Computational Heat Transfer (4 cr)

ME 8228 Finite Elements in Multi-Disciplinary Flow/Thermal/Stress and Manufacturing Applications (4 cr)

ME 8229 Finite Element Methods for Computational Mechanics: Transient/Dynamic Problems (4 cr)

ME 8345 Computational Heat Transfer and Fluid Flow (3 cr)

Department of Neuroscience

NSc 5201 Computational Neuroscience I: Membranes and Channels. (3 cr)

NSc 5202 Theoretical Neuroscience: Systems and Information Processing (3 cr)

School of Physics and Astronomy

Phys 5041 Mathematical Methods for Physics I (4 cr)

Phys 5042 Analytical and Numerical Methods of Physics II (4 cr)

Department of Psychology

Psy 5036W Computational Vision (3 cr)

Psy 5038W Introduction to Neural Networks (3 cr)

Psy 5960 Topics in Psychology (1-4 cr)

School of Statistics

Stat 8701 Computational Statistical Methods (3 cr)

Stat 8711 Statistical Computing (3 cr)