Documents for proposed Computational Science and Engineering minor field for presentation to the General Committee of the Graduate School, April 25, 2005.
1. Proposal (7 pages)
2. Supporting letter from Robert Constable, Dean of Computing and Information Science (1 page)
3. Supporting letter from Steven Strogatz, DGS for Applied Mathematics (1 page)
4. Supporting letter from Joseph Halpern, DGS for Computer Science (1 page)

Cover Sheet

Title of Proposal

Creation of a graduate minor field entitled Computational Science and Engineering (CS&E).

Proposer/Contact Information

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Program Information: Please provide the following information, if applicable:
Current Program Title: none (related existing fields include Computer Science, Applied Mathematics, Computational Biology)

Proposed Program Title: ***Computer Science and Engineering*** **minor field**

Award (e.g., degree; certificate): na

HEGIS Code: na

Program Code: na

Proposal Narrative

There is no standard format for writing a field change proposal. The ideal narrative reflects the character, interests, and strengths of the field and its faculty. In general, proposals should be academically sound, structurally feasible, and institutionally warranted. This checklist is meant to let you know what information your proposal should include, as understood by the Graduate School and the State Education Department in Albany. In your narrative, address only those items that apply to your proposal.

Please return the cover sheet and your narrative as an attached file to Kat Empson, the Graduate School Deans' Office, kle6@cornell.edu. Questions can be directed to her at 5-7374

Summarize the proposed field change, its educational and career objectives, and its relationship to existing programs at Cornell, in New York State, and in the nation. Comment on the proposed program's relevance to students and their needs. If applicable, discuss the availability of faculty, facilities, and other support services; special admission and course requirements; plans to recruit and retain students (especially those from historically underrepresented groups, and women); and provisions to ensure that each student has the instructional and financial support needed to complete the program.

Proposal for a graduate minor in Computational Science and Engineering

Background and rationale

The Faculty on Computing and Information Sciences propose the establishment of a graduate minor field in Computational Science and Engineering (CSE). Throughout this document, science is understood to include mathematics. Nationally, computational science and engineering has developed an identity that is recognized by an increasing number of universities and research agencies. A working group of the Society for Industrial and Applied Mathematics has issued a report Graduate Education for Computational Science and Engineering (http://www.siam.org/cse/report.htm) that defines CSE and describes several types of recommended CSE programs. They state

CSE is a broad multidisciplinary area that encompasses applications in science/engineering, applied mathematics, numerical analysis, and computer science. Computer models and computer simulations have become an important part of the research repertoire, supplementing (and in some cases replacing) experimentation. Going from application area to computational results requires domain expertise, mathematical modeling, numerical analysis, algorithm development, software implementation, program execution, analysis, validation and visualization of results. CSE involves all of this. ... Although it includes elements from computer science, applied mathematics, engineering and science, CSE focuses on the integration of knowledge and methodologies from all of these disciplines, and as such is a subject which is distinct from any of them.

One of the types of programs described in the SIAM report is an "MS/PhD in traditional area, with specialization in CSE." The graduate field structure at Cornell facilitates the development of a CSE minor field consistent with these programs described in the SIAM report.

Cornell has an outstanding faculty engaged in computational research in the sciences and engineering. These faculty are located in departments throughout the university. In addition, the Cornell Theory Center is major asset to the university, hosting one of the largest Windows clusters in the world. Unlike the UIUC and San Diego supercomputer facilities, which both have a national mission, the Cornell Theory Center is devoted to supporting CSE work at Cornell alone. Indeed, some of the major university-wide thrusts, including the Life Sciences and Computing/Information Science, involve "grand challenge" CSE style problems. Despite all of this activity, there has been little coordination of curricula designed to teach students core skills that are shared across computational science and engineering. The Center for Applied Mathematics has provided an interdisciplinary focal point for many of these faculty, but the growth of computation as a mode of scientific research transcends its origins in mathematics and engineering. Students in diverse scientific disciplines want to become computational scientists within those disciplines, but they have limited time to acquire an extensive background in mathematics or computer science. In particular, completion of a minor in applied mathematics or computer science would require them to take many of the core undergraduate courses in mathematics and/or computer science. They want and need instruction that is directed specifically at computational science. Providing that instruction is a substantial challenge, one that can best be met by the joint efforts of faculty from many departments rather than the individual efforts of faculty trying to satisfy the needs of computational science students in their department. Some coordination happens in an informal manner, but more would be better.

The Computer and Information Sciences program has an academic mandate that reaches across the university. It has the academic infrastructure and resources to address the issues of computational science and engineering described above. We propose that a CSE graduate Minor Field be established as a CIS program.

History of this proposal

The Dean of Computing and Information Science (CIS), Robert Constable, assembled a faculty committee to propose curricular innovations in the area of CSE. The initial membership of this committee consisted of Charles Van Loan (Computer Science and committee chair), John Guckenheimer (Mathematics), Stephen Pope (Mechanical and Aerospace Engineering) and Christine Shoemaker (Civil and Environmental Engineering). Later Stephen Vavasis (Computer Science) was added to the committee. The committee wrote this document over the course of a year of meetings. In one meeting in December, 2004, six additional faculty members were invited for comments on the first draft.

One important decision reached by the committee at an early stage was not to propose creation of a CSE major field. The committee believed that CSE is not an academic discipline per se but is rather the notion that significant progress can be made in most branches of science and engineering through the advanced use of computing. Thus, it is most sensible for a graduate student interested in CSE to major in an existing branch of science or engineering while minoring in CSE.

The committee considered the effect of the creation of the CSE minor on other programs at Cornell. The program would compete to some extent with the Computer Science minor and the Applied Mathematics minor. The committee felt, however, that the CSE minor fills a need that neither of these existing minors can fill. In particular, the Computer Science minor is focused on computer science classes with no allowance for application of the concepts to other disciplines. The Applied Mathematics minor may involve more mathematics than is necessary for a CSE student. If this proposal is approved, both of these fields may see some shrinkage in their number of minor students. The leadership of these fields felt that this impact would not be particularly harmful.

The CSE minor also has some overlap with the Computational Biology minor. (Computational Biology is a major and minor PhD field that has recently received approval from Albany.) PhD students focusing on biology would be best served by major and minor programs in that field, while CSE is intended for all other branches of science and engineering. The director of the proposed program in Computational Biology (D. Shalloway) did not feel that CSE would have a significant impact on Computational Biology. It was the opinion of the committee that the CSE minor would not be appropriate for a PhD student majoring in Computational Biology.

On January 28, 2005, an open meeting was held (using a slot in the colloquium series of the Center for Applied Mathematics) to further discuss the proposal. Although no formal vote was conducted, the attendees were unanimously in favor of the proposal. The ensuing discussion focused mainly on the details of the degree requirements.

Resources and administration

1. The CSE Field will have a Director of Graduate Studies elected according to graduate school rules.

2. The field will also have an executive committee composed of the DGS and four other field members. The executive committee will be responsible for updating the lists of courses appearing in the requirements. Any other modification to the requirements must be approved by a majority of the full field.

3. Administrative support for CSE will come from the office of the Dean of CIS. These resources are expected to be fairly minimal. One of the main resources will be web pages describing the program.

Director of Graduate Studies
The initial interim Director of Graduate Studies for the CSE field will be Charles Van Loan. After the field is approved, he will appoint a nomination and election committee to set up the procedure for choosing a permanent director.

Field faculty members
The following is a list of initial members of the CSE field. Most of the field faculty will come from the College of Engineering and College of Arts and Sciences, but it is expected that faculty from many other colleges including Agriculture and Life Sciences will become members. All of the faculty in this list have agreed to become field members.

1. Tomas Arias (Physics)
2. Adam Bojanczyk (ECE)
3. David Caughey (M&AE)
4. Garnet Chan (Chem)
5. Paulette Clancy (CBE)
6. Lance Collins (M&AE)
7. Kerry Cook (EAS)
8. Ashim Datta (BEE)
9. Paul Dawson (M&AE)
10. Greg Ezra (Chem)
11. Johannes Gehrke (CS)
12. John Guckenheimer (Math)
13. Anthony Ingraffea (CEE)
14. Adrian Lewis (ORIE)
15. Hod Lipson (M&AE)
16. Roger Loring (Chem)
17. Subrata Mukherjee (T&AM)
18. Katerina Papoulia (CEE)
19. Stephen Pope (M&AE)
20. Sergio Servetto (ECE)
21. James Sethna (Physics)
22. David Shalloway (Mol. Bio.)
23. Jayavel Shanmugasundaram (CS)
24. David Shmoys (ORIE)
25. Christine Shoemaker (CEE)
26. Paul Steen (CBE)
27. Saul Teukolsky (Physics and Astronomy)
28. Michael Todd (ORIE)
29. Les Trotter (ORIE)
30. Charles Van Loan (CS)
31. Stephen Vavasis (CS)
32. Alexander Vladimirsky (Math)
33. Z. Jane Wang (T&AM)
34. David Williamson (ORIE)
35. Nicholas Zabaras (M&AE)

Requirements for the CSE minor
In order to ensure uniformity across the many disciplines participating in CSE, it is desirable that there should be a detailed list of requirements for the minor. At the time of submission of this proposal, consensus has not been reached on all the details, so it is expected that one of the first orders of business of the newly formed field will be appoint a requirements committee to draft and approve a detailed list of requirements. A draft of the requirements written by the CSE committee circulated at the meeting of January 28, 2005 was greeted favorably, although a few issues were left unresolved. There is broad consensus that the requirements will be based on the following principles.

1. The student must have a special committee member representing the CSE field.

2. The students must complete a specified number of CSE courses (probably either three or four). Among these courses should be at least one "core algorithms" course. The courses should be at a sufficiently advanced level and should reflect the interdisciplinary nature of CSE.

3. The student should complete a substantial CSE software project and a report (either oral or written) on the project. In most cases, the project and report will naturally be part of the student's PhD dissertation research.

Text for the grad school catalog
The text for the graduate school catalog will roughly appear as follows.
http://www.cis.cornell.edu/cse/
cse@cis.cornell.edu
XXXX Upson Hall
Cornell University
Ithaca, NY 14853-0000
607 255-XXXX

Applying:
Requirements summary:
See below.

Computational Science and Engineering application information:
Computational Science and Engineering is a minor field. Application for admission is made only to the major fields. After matriculation, a student may select minor subjects from the major or minor fields.

Degrees, Subjects & Concentrations:

Degrees: No degrees offered.

[Minor] Subjects: Computational Science and Engineering

[Minor] concentrations: Computational Science and Engineering

Course descriptions and rosters:
[Here would appear a list of courses considered to be CSE. Some would be designated as "core algorithms."]

Description: Computational Science and Engineering (CSE) is a graduate minor intended for students majoring in a field of science and engineering who wish to use sophisticated computational methods to advance their research. Students in this minor program must have a CSE special committee member, must take at least [three][four] approved CSE courses, and must complete a CSE project. Visit the CSE office listed above for the details of the requirements.

Faculty:
[Here would appear the list of field members.]