

09/22/2014



PROPOSAL TO THE SENATE COMMITTEE ON EDUCATIONAL POLICY TO ESTABLISH OR MODIFY AN UNDERGRADUATE MINOR

PROPOSAL TITLE: Establish an undergraduate minor in Computational Science and Engineering (CSE) in the College of Engineering

SPONSORING UNIT(s): Professor Narayana Aluru, Director, Computational Science and Engineering and Kritzer Professor in Mechanical Engineering, 217-333-1180, aluru@illinois.edu; and Professor Umberto Ravaioli, Interim Assoc Dean of Undergraduate Programs, College of Engineering, 217-333-2280, ravaoli@illinois.edu

BRIEF DESCRIPTION:

This proposal requests the establishment of an undergraduate minor in Computational Science and Engineering (CSE) in the College of Engineering. CSE fosters and coordinates interdisciplinary, computationally oriented research and education across all fields of science and engineering. CSE is housed in the College of Engineering, but participation is not limited to academic departments within the College. Both graduate and undergraduate certification programs are offered for students enrolled in affiliated departments listed below.

The CSE minor is designed to provide undergraduate students with a solid base in problem-solving using computation as a major tool for modeling complicated problems in science and engineering. The CSE minor is also aimed at helping students develop competencies in computational methods required to conduct computer experiments. The CSE minor comprises 18 total hours. The curriculum consists of a) 9 hours of Core Course Work in topics relevant to scientific computing and drawn from a menu of courses; b) 9 hours of Application Course Work or replacing 3 of the 9 course hours with an optional undergraduate research project providing students the opportunity to work with a faculty member using their acquired computational skills in solving real problems.

JUSTIFICATION: *(Please provide a brief but complete rationale for your request.)*

Computation is widely considered as the "third pillar" of science, alongside theory and experiment. The heart of Computational Science and Engineering is to develop innovative ways of solving engineering and scientific problems using computation as a tool. This new form of science compresses the development pipeline by eliminating laborious, costly, and lengthy trial and error experiments. This proposal addresses the pedagogical challenge of training undergraduate students to understand the harnessing of high-performance computers and exploiting them to solve practical applications in science and engineering. In many instances, computational (*in silico*) experiments facilitate the study of scientific problems that would be too costly or even dangerous to

study by direct experimentation. In order to train students to develop virtual experiments that mimic physical phenomena, they must first know how to abstract the physical phenomenon to a conceptual model and then translate this into a computational model that can be validated. This minor aims to navigate the existing steep learning curve by introducing students to a systematic curriculum building upon existing course work offered at the university.

Budgetary and Staff Implications:

- a. ***Additional staff and dollars needed:*** No additional support is needed. The proposed Core Course Work comprises courses already included in the curricula of many of the students who will be interested in this minor. Students will be advised to select computing electives that are closely affiliated with their primary field of study. No new courses are being proposed to support this minor.
- b. ***Internal reallocations (e.g. change in class size, teaching loads, student-faculty ratio, etc.):*** CSE minor students will enroll in preexisting courses offered by our affiliated departments and focusing on scientific computing and its application. We anticipate that most of the enrollment in this program will come from students who are enrolled in CSE affiliate programs. Because of the wide selection of courses to choose from and the moderate expected number of students enrolling in this program, we do not expect there to be any significant change in class size, teaching load, or faculty-student ratios.
- c. ***Effect on course enrollment in other departments and explanations of discussions with representatives of those departments:*** With the expected number of students spread through courses widely distributed across the campus, it is not anticipated that additional course sections will be needed to accommodate the students in this minor. More than half of the 18 hours required for the minor are allocated within College of Engineering rubrics (as electives). The remaining hours of the minor are outlined in a very flexible framework among an extensive list of courses. The Applications course work is strongly recommended to be in the student's primary field of study. This provides the students working with their advisors ample opportunity to select courses that have open enrollment/availability
- d. ***Impact on library, computer use, laboratory use, equipment, etc.:*** No additional impact on university resources are anticipated due to this proposal. Letter Provided.

Requirements: There are two basic requirements for the minor: 1) Core Course Work in topics relevant to scientific computing and drawn from a menu of courses; 2) Application Course Work applying the fundamentals of computation to solve real scientific computing problems. The Applications course work is strongly encouraged to be in the student's primary field of study. The minimum course work required to fulfill this minor is 18 hours.

1. Core Courses (9 hours)

- a. **Programming*** (3 hours)
 - CS 101: Intro Computing: Engrg & Sci (C/Matlab)

- AE 199 IAC Introduction to Aerospace Computing (C/Matlab)
- ECE 190/ECE 198KL: Intro to Computing Systems (C/Assembly)
- CS 125 Intro to Computer Science (Java)
- LING 402 Tools and Techniques in Language and Speech processing
- CS 225 Data Structures (C++)

*An equivalent (or advance) programming course may be used to satisfy this requirement.

b. Applied Math (3 hours)

- PDE/ODE:
 - MATH 441 Differential Equations/ MATH 442 Intro Partial Diff Equations/ MATH 489 Dynamics & Differential Eqns
- Linear Algebra:
 - MATH 415 Applied Linear Algebra
- Mathematical Methods:
 - ECE 493 Advanced Engineering Math
- Statistics/Probability:
 - STAT 408 Actuarial Statistics I/ STAT 409 Actuarial Statistics II/ STAT 410 Statistics and Probability II/ STAT 420 Methods of Applied Statistics/ STAT 430 Topics in Applied Statistics
- Optimization
 - MATH 482 Linear Programming/ MATH 484 Nonlinear Programming
- Complex Variables:
 - MATH 446 Applied Complex Variables/ MATH 448 Complex Variables
- Real Analysis:
 - MATH 444 Elementary Real Analysis/ MATH 447 Real Variables
- Any advanced corresponding course from the above list of topics may be taken in lieu of an equivalent introductory course.

c. Computational Methods (3 hours)

- CS 450/CSE 401 Numerical Analysis
- TAM 470/CSE 450 Computational Mechanics
- ECE 448 Artificial Intelligence
- CS 411 Database systems
- STAT 440 Statistical Data Management
- LIS 490DB Introduction to Database Systems
- LING 402 Tools and Tech. for Language and Speech Processing
- CS 466 Introduction to Bioinformatics
- GEOG 489 Programming for Geographic Information Science

2. Application Course work/Computing Elective (9 hours):

- **(OPTION 1)** Three 400-level CSE courses
 - CSE courses are listed here: <http://cse.illinois.edu/courses>
- **(OPTION 2)** Two 400-level CSE courses **AND** an independent study on a computational topic
 - In order for an independent study to fulfill the minor requirement, the student must conduct the undergraduate research with one of the CSE affiliated faculty listed in the Computational Science and Engineering website: <http://cse.illinois.edu/directory/faculty-affiliates>.

Prerequisites for the minor: The minor is designed to be self-contained. We anticipate the enrollment to be mainly from students in the sciences and engineering. Since we suggest that the student choose application courses within their home department, they should have the required fundamentals without the need for additional courses.

Expected enrollment in the minor: Forecasting the enrollment in a new undergraduate minor is somewhat challenging. As noted above, we have been offering a less-rigorous certificate program in CSE for graduate students and have recently added a similar program for undergraduate students. Our current enrollment in the undergraduate certificate program is approximately 20 students. Based on this number, our projected enrollment in the CSE minor is expected to be small, initially growing to 30 students after 4 years. Since we are offering students a wide selection of courses to choose from, we anticipate that the enrollment will be spread across the various participating departments.

Admission to the minor: Admission will be consistent with guidelines set for campus-approved minors and will be administered by the Undergraduate Programs Office of the College of Engineering. CSE does not intend to limit the enrollment to this minor since we do not anticipate large enrollment that warrants tight regulation.

Minor advisor: Advising will be administered by CSE staff and the CSE Steering Committee, which is composed of a faculty representative from each CSE participating department. Affiliated departments include:

| | |
|---|---|
| Aerospace Engineering | Computer Science |
| Agricultural and Biological Engineering | Electrical and Computer Engineering |
| Astronomy | Industrial and Enterprise Systems Engineering |
| Atmospheric Sciences | Materials Science and Engineering |
| Bioengineering | Mathematics |
| Biophysics and Computational Biology | Mechanical Science and Engineering |
| Chemical and Biomolecular Engineering | Nuclear, Plasma and Radiological Engineering |
| Chemistry | Physics |
| Civil and Environmental Engineering | Statistics |

Students enrolled in one of the CSE affiliated departments will be advised by a CSE affiliated faculty from within their home department; undergraduates enrolled in non-CSE affiliated departments will be advised by CSE staff. Affiliated faculty from the various departments are listed in the Computational Science and Engineering website: <http://cse.illinois.edu/directory/faculty-affiliates>

Certification of successful completion: Upon the completion of the set requirements, the minor will be recognized on the transcript. Verification will be consistent with existing campus minor guidelines. CSE may provide assistance with the verification process as needed. No additional certification will be provided by CSE.

Proposed Effective Date: Fall 2014

Statement for the Programs of Study: See Appendix A

CLEARANCES:

Signatures:

Head/chair of the co-sponsoring department or unit:

Date:

Head/chair of the co-sponsoring department or unit:

Date:

Dean of the college of the sponsoring department or unit:

Date:

Council on Teacher Education Representative:

Date:

Chair, Senate Educational Policy Committee:

Date:

Appendix A: Statement for the Programs of Study

(For insertion in: Undergraduate Programs, Majors, College of Engineering, Program Information, Minors Offered by the College of Engineering section)

Computational Science and Engineering Minor

The heart of Computational Science and Engineering is to develop innovative ways of solving engineering and scientific problems using computation as a tool. This new form of science compresses the development process in engineering, and engenders knowledge discovery with a new paradigm in many areas, because it enables “virtual experiments” and helps focus physical experiments to reduce or eliminate trial-and-error laboratory-based approaches. Further, it teaches students to solve complex problems with prevailing computer technology. The CSE minor is designed to provide undergraduate students with a solid base in problem-solving using computation as a major tool for modeling complicated problems in science and engineering.

| Hours | Required Courses |
|-------|--|
| 9 | Core Course Work |
| 3 | Programming course chosen from an approved list |
| 3 | Applied Math course chosen from an approved list |
| 3 | Computational Methods course chosen from an approved list |
| 9 | Computing Elective |
| | Any three CSE courses at the 400-level from an approved list or Two CSE course at the 400-level from an approved list AND an independent study on a computational topic with CSE-affiliated advisor |
| 18 | Total |

For more information regarding the Computational Science and Engineering (CSE) minor, visit the [Computational Science and Engineering minor Web site](#), contact the CSE Office (2270 DCL, 217-333-3247, cse@cse.illinois.edu), or visit the Office of the Associate Dean for Undergraduate Programs, 206 Engineering Hall.

From: "Ando, Matthew A" <

mando@illinois.edu>

Date: Sep 11, 2014 4:42 PM

Subject: e-mail supporting minor

To: "Mohamed, Mohamed Y" <mohamed@illinois.edu>

Cc: "Bergman, Jane Frances" <jbergman@illinois.edu>

Dear Dr. Mohamed,

Thank you for contacting me about proposed minor in Computational Science and Engineering. After consulting with those in charge of Math's undergraduate program and considering your responses to the questions they raise, I am satisfied that the Department of Mathematics can support the minor as you have proposed it. I do recommend that you include Math 461 as a possible course to satisfy the Probability/Statistics requirement.

Unfortunately I have been traveling all week, and so it is not easy for me to produce a formal letter on letterhead. I hope that this e-mail will be satisfactory for the Ed. Pol. Committee, but if not I can have Jane Bergman prepare a formal signed letter tomorrow.

Regards,

Matt

Matthew Ando
Professor and Chair
Department of Mathematics
University of Illinois at Urbana-Champaign