An Incremental Approach to Undergraduate CSE Education

By

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Outline

- *Rational for the Incremental Approach*
- *Lower Level Courses with CSE Mode of Investigation*
- *Upper Level Courses with CSE Mode of Investigation*
- *Concluding Remarks*

Rational for Incremental Approach

Some observations:

- **Most scientific/engineering disciplines are using more computer simulations.**
- **A larger proportion of members of these disciplines are doing this.**
- **The CSE mode of investigation involves components of applications, models, methods, computer implementation and assessment.**

Therefore, there is a need to integrate the CSE topics into more of the undergraduate programs for science/engineering.

Rational for Incremental Approach

The traditional Calculus/ODE sequence of 15 credits does not have enough

- **Basic matrix algebra**

  …lacks least squares, n unknown systems and computation tools.

- **Cohesive discussion of iterative methods**

  …lacks order of convergence, adaptive methods and computation tools.

Rational for Incremental Approach

Traditional solution includes some courses on

- **Numerical analysis**
- **Matrix algebra**
- **Differential equations**
- **High performance computing**
- **Grand challenge applications.**

There is not enough room in the typical undergraduate program.
Moreover, not all students will be able or be inclined to use these tools.

Rational for Incremental Approach

Try to revise the Calculus/ODE sequence!

- **Too much inertia and tradition**
- **Political difficulties, and able and willing faculty**
- **Computation as a tool for learning versus a tool for a profession**

Rational for Incremental Approach

One possible restructuring of Calculus/ODE is to

(i). Convert the 3 four-credit Calculus to 4 three-credits courses,

(ii). A new three-credit course on "Computational" Calculus would complement Differential, Integral and Multivariable Calculus

(iii). "Computational" Calculus could include computational tools, basic matrix algebra, and iterative methods.

Rational for Incremental Approach

When discussing these ideas with faculty, there is a lot of silence and not much action!

So, any "big" changes to the traditional required courses are unlikely to happen.

The creation of supplemental or elective courses is an important alternative. This will generate course materials, a student following, and be educational to traditional faculty.

Eventually, the "big" changes will take place.

Lower Level Courses

- **Spreadsheets for the Life and Management Calculus (one credit)**
- **Numerical ODE for the Science and Engineering Calculus/ODE (one credit)**
- **Introduction to Applied Mathematics (three credit second year class)**
- **Basic Matrix Algebra (one credit)**

Lower Level Courses

Computational Math for the Life and Management Sciences

- **Students have one semester of calculus.**
- **Uses the Excel spreadsheet (graphs, trendlines, solver, macros).**
- **Models of data, optimization, information and population.**
- **Examine the models via "what if" scenarios such as incorrect or variable price data.**
- **Meets one day a week with about 7 written reports.**

Lower Level Courses

Numerical Solution and Application of ODEs

- **Students have at least two semesters of calculus.**
- **Uses Matlab (plot, given m-files, ode45 and stiff solvers).**
- **Models of mechanics, circuits, populations and chemical reactions.**
- **Examine the models via "vary the parameter" scenarios such as variable damping in the resonance of a mass-spring.**
- **Meets one day a week with about 5 written reports.**

Lower Level Courses

Introduction to Applied Math (A new course in Spring 2001)

- **Students have three semesters of calculus (second year undergraduates).**
- **Some Matlab and Maple will be used.**
- **Five three-week modules, and this spring they were**
  Heat and pollutant transfer, Cryptographic schemes,
  Acoustic waves, Biological applications and
  Modeling random phenomena.
- **Examine the models with the hope motivating the students**
  for a more detailed study, and develop math "as is needed".
- **Meets three days a week with some traditional homework and**
  a five or six page written report on
  "A Plan of Study for the Third and Fourth Years".

Lower Level Courses

Matrix Applications and Computations (A new course in Spring 2002)

- **Students have one semester of calculus.**
- **Some Matlab will be used to demonstrate computations.**
- **Topics include matrices and graphing, Gauss elimination, inverse matrices, data fitting via least squares and eigenvalues.**
- **Applications include optimization, circuits, structures, mixing, and time dependent models of lead poisoning, mixing and heat transfer.**
- **Meets three days a week during a five-week segment of a semester.**

Upper Level Courses

- **Computational Mathematics**

  Developed by Professor R. E. White

  …. supercomputing, numerical PDE, heat and mass transfer

- **Mathematical and Experimental Modeling of the Physical Sciences I**

  Developed by Professors H. T. Banks and H. T. Tran

  …. physical laboratory with heat , beam vibration, acoustics

- **Mathematical and Experimental Modeling of the Physical Sciences II**

  …. physical laboratory with structured population models,

  electromagnetism and dispersion

Concluding Remarks

- **The wide spread use of the CSE mode of investigation is driving computation science education to a much larger portion of the undergraduates.**

- **The CSE mode of investigation needs to be at least illustrated to first and second year undergraduates.**

- **All students should have an overall appreciation of the this process, to be able to use computational tools and to analyze possible errors.**

- **The implementation of these changes will be inhibited by academic tradition, the lack of understanding of CSE, cautious faculty and traditional resource allocations.**

- **An incremental approach to CSE education can effectively be implemented and gradually can lead to more enduring changes in the required course work for all undergraduate science/engineering students.**

Plan of Action