A Progress Report?
Math Educ for Engineering at OSU

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Motivation

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- Standard Textbooks reflect current curriculum
  To ensure uniform instruction, many large sections in lockstep with topics in the textbooks.

Physics: Halliday/Resnick/Walker. *Fundamentals of Physics* (8th spec ed)
Math: Stewart. *Calculus: Early Transcendentals* (6th spec ed)

Activities associated with the Taskforce

- Survey of engineering faculty:
  - what math topics are needed
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- Comparison of the content in the textbooks:
  - Physical concepts in math textbook
  - Math concepts in physics textbook
- New approach to teaching Differential equations
  - math modeling - context of science and engineering
  - coherent development of key concepts.

Survey - Part I

Math content:

1. How important is it for students who graduate from your undergraduate program to be able to competently apply concepts from each of the areas listed?

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2. How competent is the average graduate of your program in each of the following areas?

Survey Results - Part I

Topic	Ave Importance	Ave competence
Calculus	4.3	3.3
Linear algebra	4.1	2.9
Analysis of nonlinear phenomena	3.3	2.5
Ordinary differential equations	3.9	3.0
Partial differential equations	3.4	2.6
Complex variable/functions	3.2	2.6
Numerical simulations	4.1	3.1
Use of vectors	4.1	3.2

Table: Overall faculty ratings (5 point scale)

Survey - Part II

Math abilities:

1. In the context of the undergraduate course you teach the most, how important is it that students understand each of the items below in order to do well?

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1. In the context of the undergraduate course you teach the most, how important is it that students understand each of the items below in order to do well?

2. Please rate each of the items listed below according to the preparation of the students entering the undergraduate course you teach the most

Survey Results - Part II

Skill	Ave Importance	Ave competence
Evaluating solutions/checking results	4.5	2.7
Familiarity with units and dimensions	4.4	3.1
Ability to create and interpret graphs	4.4	3.2
Algebraic manipulations	4.3	3.3
Interpret relationships through math expressions	4.3	2.8
Using symbols in analysis	4.2	2.9
Interpreting parameters	4.0	2.7
Formulating math models	4.0	2.6
Estimation of magnitudes	4.0	2.8
Knowing when to differentiate/integrate	3.7	2.9
Working with multivariate problems	3.7	2.7
Creating algorithms	3.3	2.4

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Math Curriculum Overview

Stated Purpose
Focus on conceptual understanding

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Focus on conceptual understanding — What concepts?

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Math Curriculum Overview

Stated Purpose

Focus on conceptual understanding — What concepts?

Rule of Four: geometric, numeric, algebraic, verbal — Pedagogic

Outline of two semester sequence:

1. Scalar Functions of one variable; limits, continuity; differentiation; sketching functions
2. Single integrals; methods of integration, applications of integration; volume and area integrals
3. Series representations; improper integrals; parametric curves; vectors; curves and surfaces

Physics Curriculum Overview

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Teach students to reason through challenging situations:

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- To read scientific material effectively — expressed mathematically?
- To identify fundamental concepts — without math?

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- To identify fundamental concepts — without math?
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- To solve quantitative problems — mostly algebraic

Outline of two semester sequence:

1. Mechanics; kinematics; vectors; dynamics; Friction; conservation of energy, momentum; rotational dynamics
2. Electricity and Magnetism; Electric force, charge; electric field; flux and potential; resistance; circuits; magnetism
3. Waves; vibrations of mass/spring; standing waves; wave superposition; microwave interference; special relativity; photoelectric effect; spectroscopy

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Let's look more carefully at how physical concepts are expressed mathematically.

More Detailed Observations

- Downplay of notation for functions
- Emphasis on graphical display of functions
- Emphasis on algebra in place of calculus
- Vectors viewed only as quantities with magnitude and direction
- Lack of discussion of the origin of a vector space
- Abuse of math notation, e.g. integration
- In general, little re-enforcement of mathematical concepts

A Different Approach to Differential Equations

The course design is based on:

- show students how to use mathematics in science and engineering
  - use math modeling to connect math with physics and engineering
  - start with simple models that contain only ordinary differential equations
  - proceed to partial differential equations
  - emphasize the need for additional conditions (initial and boundary).
  - emphasize role of parameters (options for design)
  - interpret results

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  - interpret results
- develop a coherent and consistent view of linear differential equations
  - differential equations determine functions
  - exponentials solve homogeneous equations
  - inhomogeneous solution mimic behavior of forcing effects.
  - general solutions are compose of a combination of homogeneous and inhomogeneous solutions.
  - specific solution are obtained with the application of initial and boundary conditions

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  - strong demand for enrollment
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  - engineering faculty notice a difference
- Common exams
  Statistically significant improvement in conceptual understanding.

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A few educators in math, physics and engineering at OSU plan to discuss the possibilities of improved coordination. I hope to report major success next year.