PHYSICS VOICES

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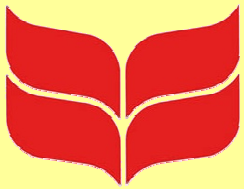
Support

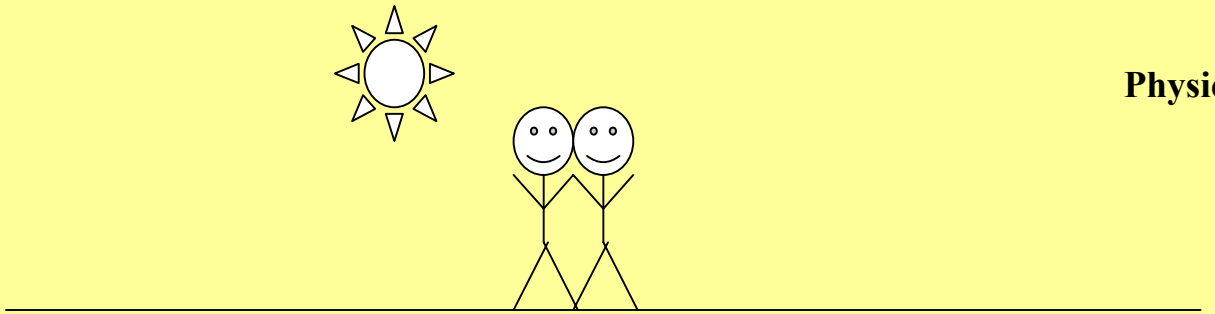
- National Science Foundation
  - DUE-9653250, 0231194
  - DUE-0088901, 0231032
- Oregon Collaborative for Excellence in the Preparation of Teachers
- Oregon State University
- Grinnell College
  - Noyce Visiting Professorship
- Mount Holyoke College
  - Hutchcroft Fund



Mathematics

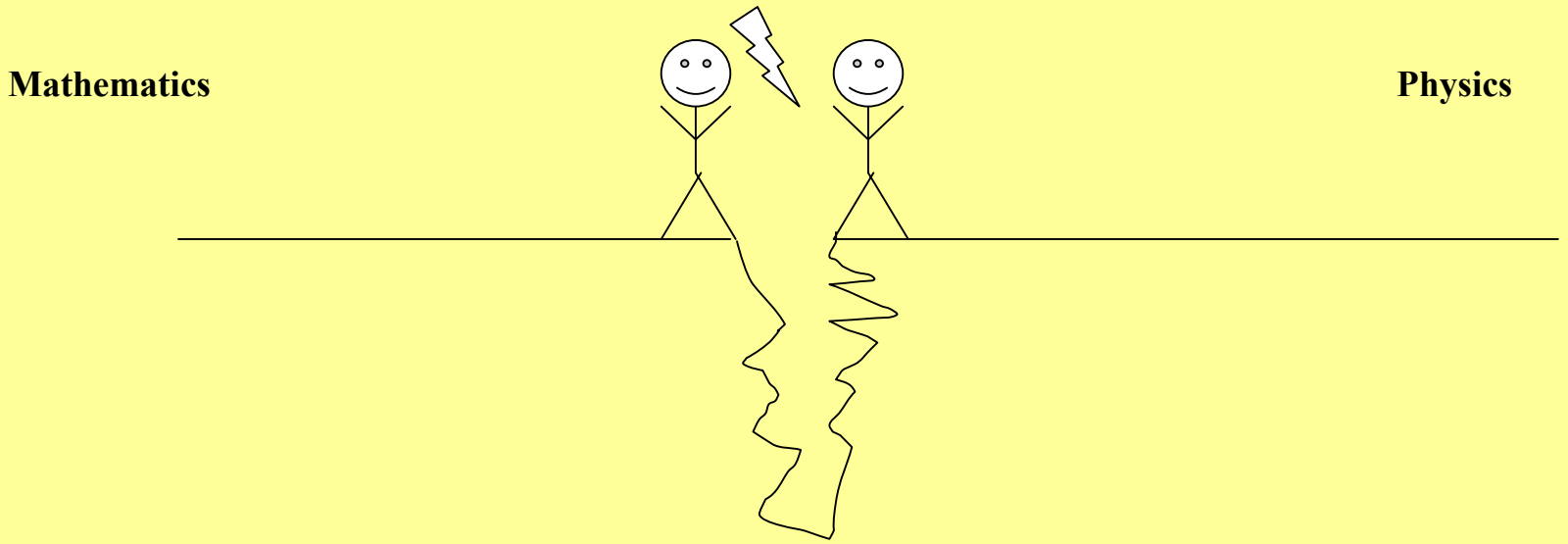
Physics

Mathematics



Physics

The Grand Canyon



Listening to Each Other

- Thanks to CUPM for their work!!!
- Thanks to CUPM & CRAFTY for this opportunity to share some thoughts.
- http://www.maa.org/cupm/cupm2004.pdf
- http://www.maa.org/cupm/crafty/
- http://www.math.oregonstate.edu/bridge
- Your colleagues in other departments.

CUPM: Physics Priority Topics

- Highest
  - Behavior of Simple Functions
  - Derivatives and Integrals of Simple Functions
- Higher
  - Limiting Cases
  - Differential Equations
  - Maximum/Minimum Problems
  - Line and Surface Integrals
  - Vector Operations
- High
  - Series and Sequences
  - Polar and Other Coordinate Systems

Things Students DO Learn

- Derivatives as slopes (and rates of change).
- How to find derivatives.
- Integrals as areas.
- Substitutions in integrals (including limits).
- Taylor series coefficients.
- Algebraic definitions of dot & cross products.
- Gradients—uphill, perpendicular to level curves.
- To be careful—definitions, singularities, limits.

Things Students Do NOT Learn

- Algebra & Trig (but you know this!)
- Integrals as chopping something up.
- Power series as approximations.
- Geometric definitions of dot and cross products,
  - esp. dot product of perpendicular vectors.
  - distinguish between dot and cross products.
- Advanced vector calculus topics.
- To be confident.

A Question for the Audience

$$T(x,y)=k(x^2+y^2)$$

$$T(r,\theta)=?$$

Main Differences

- Physics is about things.
- Physicists can’t change the problem.

Physics is about things

- What sort of a beast is it?
- Physics is independent of coordinates.
- Graphs are about the relationships of physical things.
- Fundamental physics is highly symmetric.

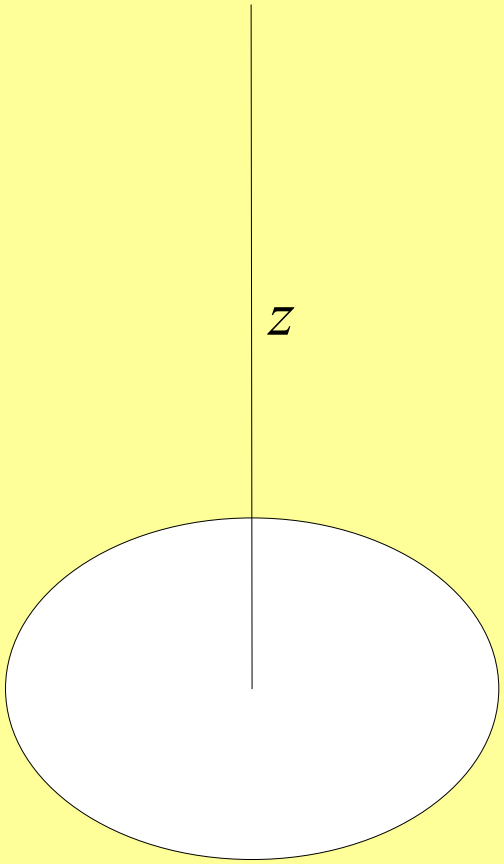
Physicists can't change the problem.

- Physics involves the creative synthesis of multiple ideas.
- Physics problems may not be well-defined math problems.
- Physics problems don't fit templates.
- Physics involves the interplay of multiple representations.

An Example

- Typical of EARLY upper-division work for physics majors and many engineers.
- Solution requires:
  - many mathematical strategies,
  - many geometrical and visualization strategies,
  - only one physics concept.
- Demonstrates different use of language.

Potential Due to Charged Disk



What is the electrostatic potential at a point, on axis, above a uniformly charged disk?

One Physics Concept

- Coulomb's Law:

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

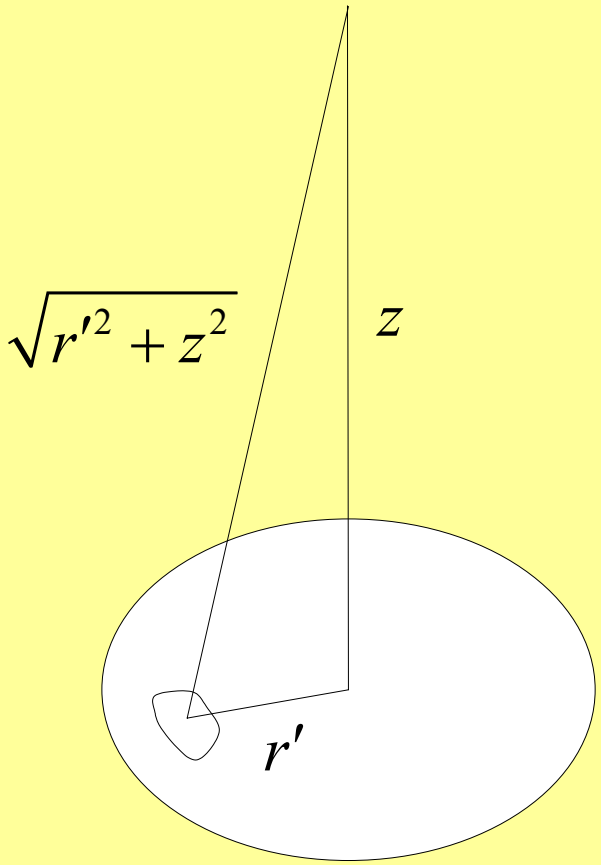
Superposition

- Superposition for solutions of linear differential equations:

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$\rightarrow V(\vec{r}) = \frac{1}{4\pi\varepsilon_0}\int \frac{\sigma(\vec{r}')da'}{\left|\vec{r}-\vec{r}'\right|}$$

Chopping and Adding



Integrals involve chopping up a part of space and adding up a physical quantity on each piece.

Computational Skill

- Can the students set-up and do the integral?

$$V(\vec{r}) = \frac{1}{4\pi\varepsilon_0}\int \frac{\sigma(\vec{r}')da'}{\left|\vec{r}-\vec{r}'\right|}$$

$$= \frac{\sigma}{4\pi\varepsilon_0}\int_0^{2\pi}\int_0^{R} \frac{dr'\,r'\,d\theta'}{\sqrt{r'^2+z^2}}$$

$$= \frac{2\pi\sigma}{4\pi\varepsilon_0}\left(\sqrt{R^2+z^2}-z\right)$$

Limits (Far Away)

$$V(\vec{r}) = \frac{2\pi\sigma}{4\pi\varepsilon_0}\left(\sqrt{R^2 + z^2} - z\right)$$

$$= \frac{2\pi\sigma}{4\pi\varepsilon_0}\left(z\sqrt{1 + \frac{R^2}{z^2}} - z\right)$$

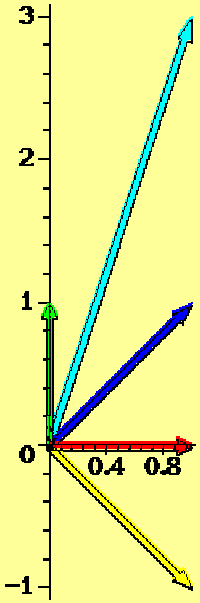
$$= \frac{2\pi\sigma}{4\pi\varepsilon_0}\left(z\left(1 + \frac{1}{2}\frac{R^2}{z^2} + \ldots\right) - z\right)$$

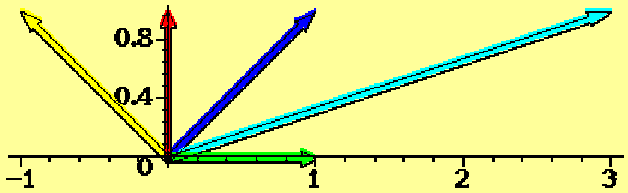
$$\approx \frac{1}{4\pi\varepsilon_0}\frac{\pi R^2\sigma}{z}$$

Simple Curriculum Additions

- Equations describe the relationship of physical quantities to other physical quantities.
- Emphasize superposition of solutions to linear differential equations.
- Integrals involve chopping a part of space and adding up a physical quantity on each piece.
- “Limits” require one to say what dimensionless quantity is small.

Eigenvectors Activity





- Draw the initial vectors below on a single graph
- Operate on the initial vectors with your group's matrix and graph the transformed vectors

Eigenvectors Activity

- Note any differences between the initial and transformed vectors. Are there any vectors which are left unchanged by your transformation?
- Sketch your transformed vectors on the chalkboard.

CUPM: Math vs. Physics

- State problems carefully, modify problems when necessary to make them tractable, articulate assumptions, appreciate the value of precise definition, reason logically to conclusions, and interpret results intelligently.
- Move from a statement of the problem in words to a mathematical model, idealize the model or approximate when necessary to make it tractable, articulate assumptions, appreciate that words have precise technical meanings, reason logically to conclusions, and interpret results intelligently.

CUPM: Math Goals

- Approach problem solving with a willingness to try multiple approaches, persist in the face of difficulties, assess the correctness of solutions, explore examples, pose questions, and devise and test conjectures.
- Yes! Yes! Yes!