Thinking like a Physicist:
Transforming Upper-Division E&M I

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Why Transform E&M I?

Lecture with clickers

?

Washington Tutorials

Can our majors learn better from interactive techniques adapted from introductory physics?

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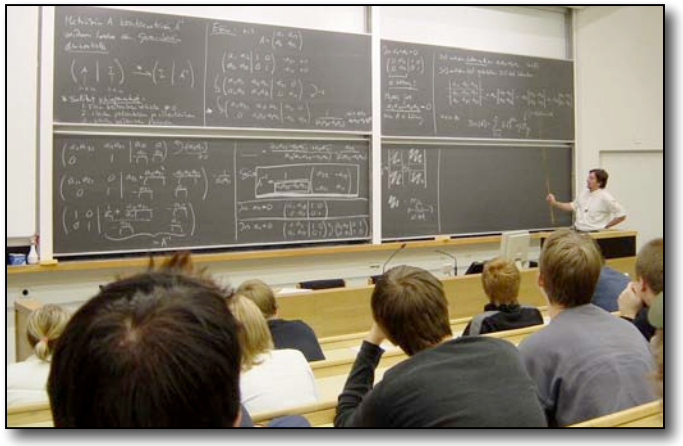
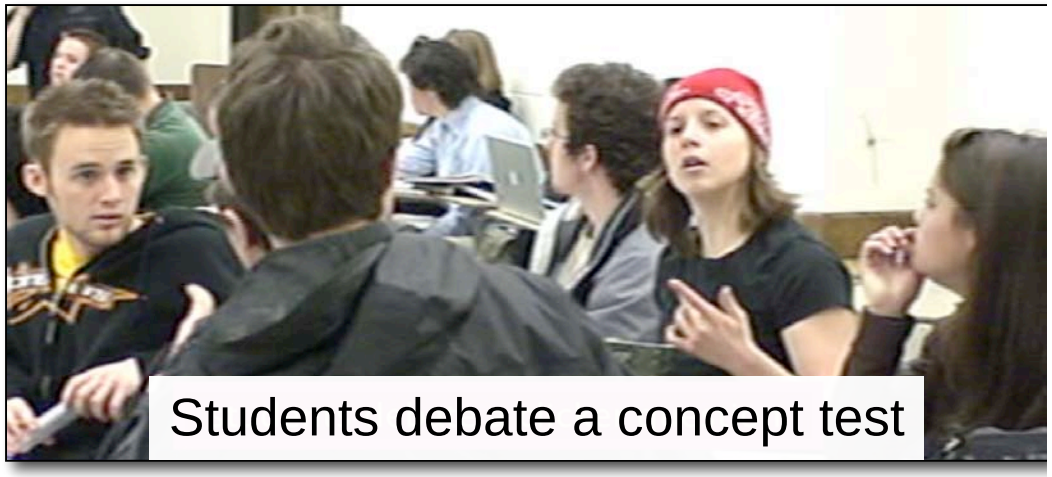
What Changed?

- Faculty collaboration
- Explicit learning goals
- Interactive classroom techniques
- Concept Tests
- Homework
- Homework Help Sessions
- Tutorials





Students debate a concept test

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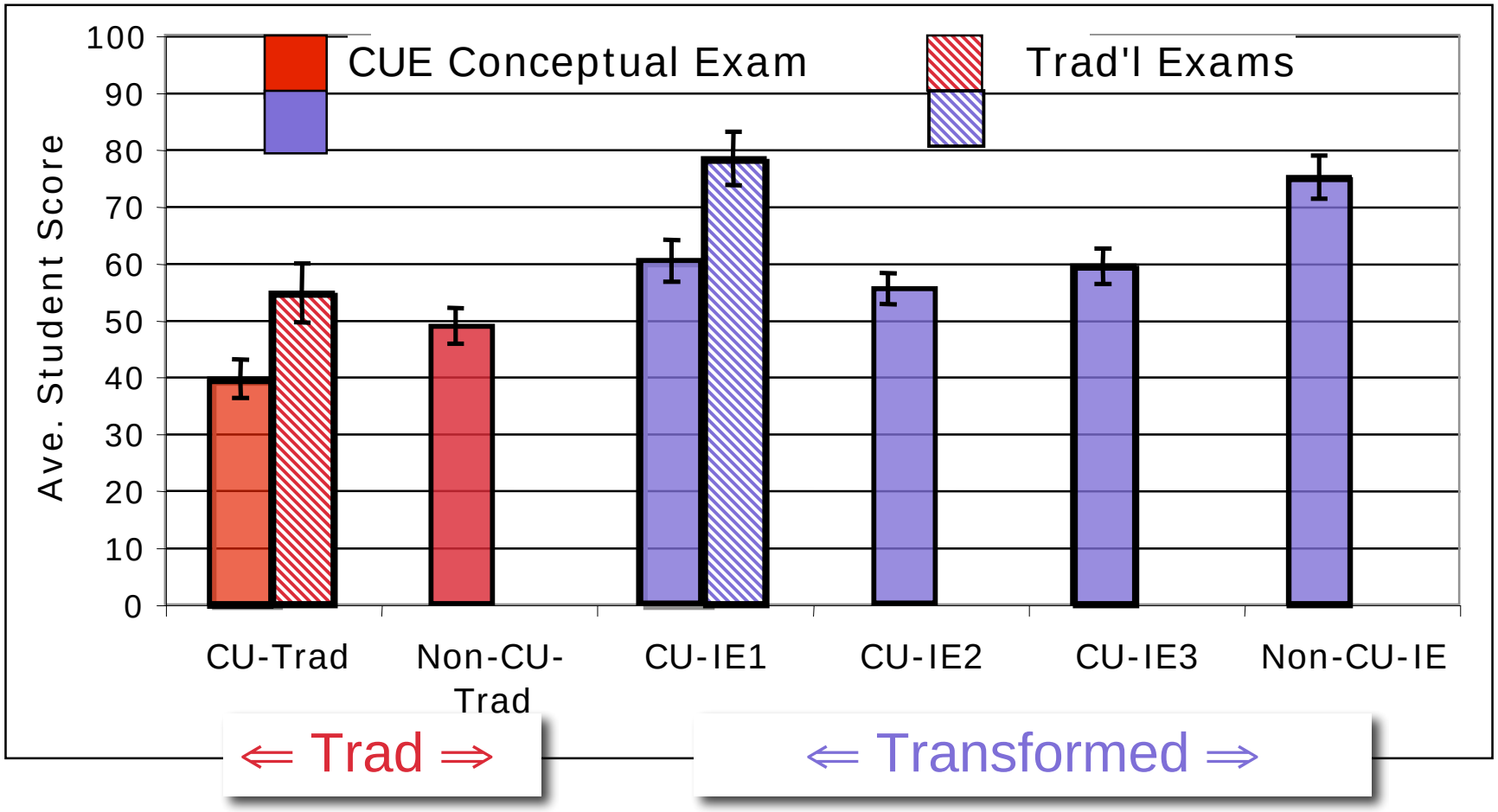
Assessments

- **Attitude surveys were positive.**
- Students **attended class more** & reported spending **more time on the course and HW** than in Traditional course.

- Developed **Colorado Upper-Division Electrostatics Assessment (CUE)** to gauge progress on learning goals
  - Open-ended, high internal reliability, high inter-rater reliability

- Gave **5 traditional exam questions** in common between two courses

Results: CUE and Trad'l Exams

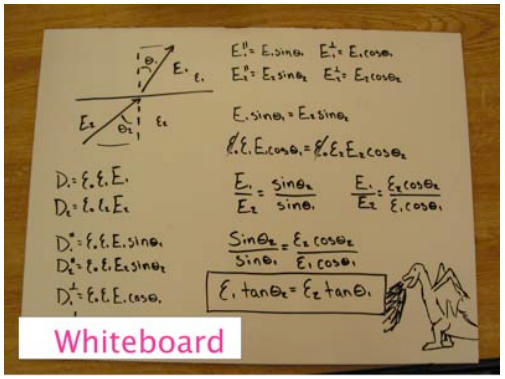


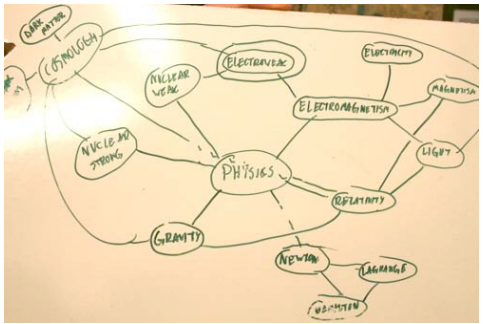
Students in 4 semesters of Transformations at CU and elsewhere performed significantly better ($p<0.05$) on all measures

Classroom Techniques

- Traditional lecture blended with interactive engagement (e.g. concept tests)
- Simulations & demos
- Kinesthetic activities
- Small handheld whiteboards

Students form a non-uniform line charge





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Concept Tests

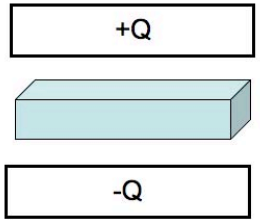
- Allowed students to **discuss & debate challenging, high-level ideas**

An ideal (large) capacitor has charge Q. A neutral *linear* dielectric is inserted into the gap (with given dielectric constant)

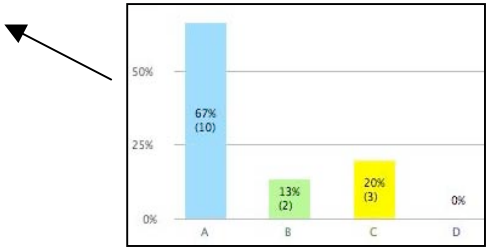
Where is D discontinuous?

i) near the free charges on the plates

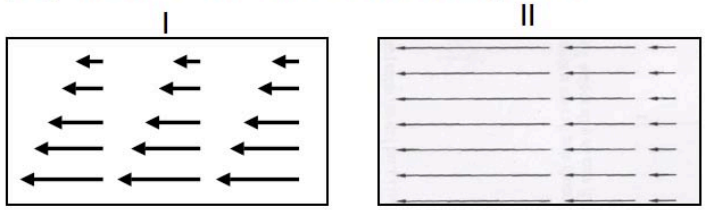
ii) near the bound charges on the dielectric surface



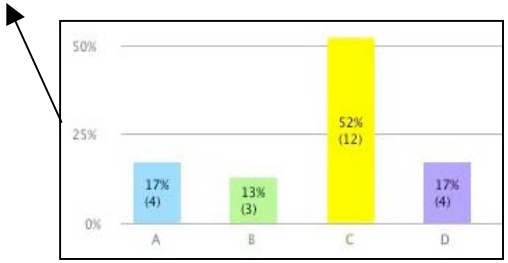
A) i only B) ii only C) i and ii ONLY
D) i and ii but also other places E) none of these/other



Which of the following *could* be a static physical E-field in a small region?



A) Both B) Only I C) Only II D) Neither



Homework

- Traditional HW problems were modified
- Sense-making, real-world context, estimations, and more.

Q2. DIVERGENCE AND CURL

Consider a field $\mathbf{E} = c\frac{\vec{\mathbf{r}}}{r^2}$ (which is NOT the field from a point charge at the origin, right?!)

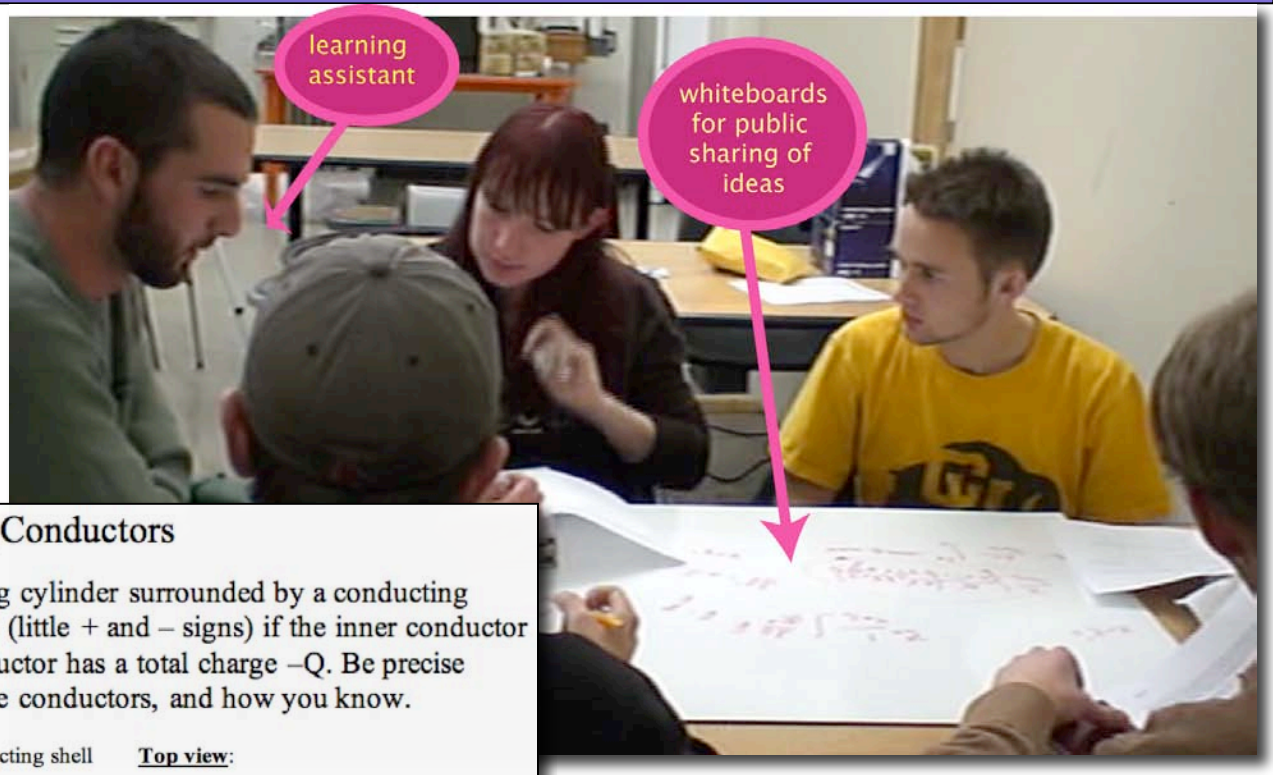
a) **Sketch it.** Calculate the divergence *and* the curl of this **E** field. Test your answers by using the divergence theorem and Stoke's theorem. **Is there a delta function at the origin like there was for a point charge field, or not?**

b) What are the units of c? **What charge distribution would you need to produce an E field like this? Describe it in words as well as formulas. (Is it physically realizable?)**

Sample HW problem aligned with learning goals. Non-traditional portions in bold.

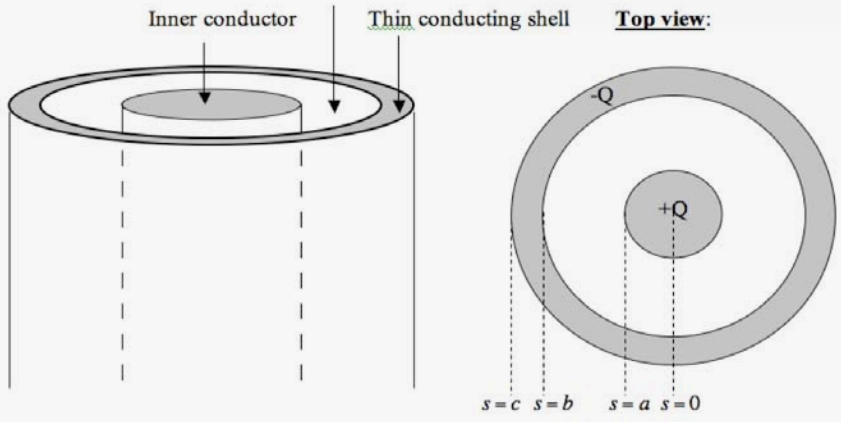
Tutorials & HW Help Sessions

Optional help sessions (2) and tutorials (1) each week



Part 1 – Conceptually Understanding Conductors

A coax cable is essentially one long conducting cylinder surrounded by a conducting cylindrical shell. Draw the charge distribution (little + and – signs) if the inner conductor has a total charge +Q on it, and the outer conductor has a total charge –Q. Be precise about exactly where the charge will be on these conductors, and how you know.



Portion of a CU tutorial

Conclusions & Acknowledgements

- **Techniques successful in lower-division can result in increased student learning in upper-division E&M, but there is a long way to go.**
- Instructors interested in using our materials or the CUE can visit the website below, or contact us.

Course materials at
http://www.colorado.edu/sei/departments/physics_3310.htm

Please visit us at poster PST2F-10
Tuesday 8:30-10:00pm, in Dana atrium

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