Active-Learning Course Materials for Upper-Division Electrodynamics

AAPT Winter Meeting

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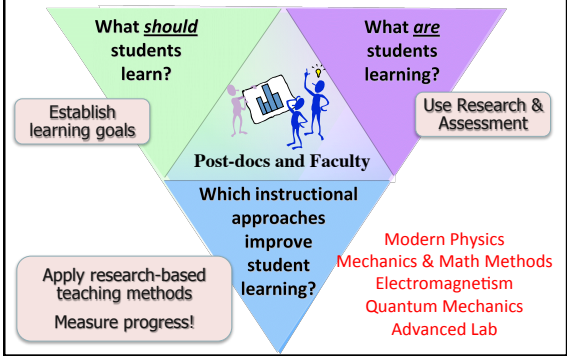
Upper-Division Course Transformation

Typical Advanced Course

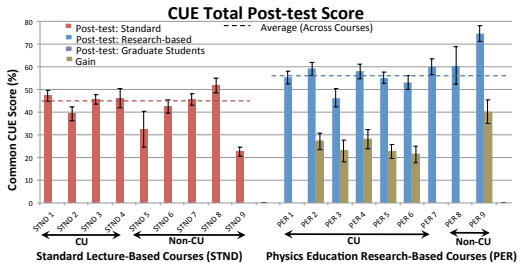
Can advanced students learn more from interactive methods adapted from introductory physics?

?

SEI Model for Course Transformation



Electrostatics



Electrodynamics

2nd semester upper-division physics course (primarily junior physics/astrophysics majors)

- Time-dependent Maxwell equations
- Conservation principles
- Potentials and fields
- EM waves
- Radiation
- Special relativity

Standard textbook:

Introduction to Electrodynamics, D. J. Griffiths, 3rd Ed.

In-Class Activities

CONCEPT TESTS

- Actively engage students in learning process
- Encourage group discussion and scientific argumentation skills
- Provide valuable real-time feedback to instructors

Concept Tests

Which of the following is a correct statement of charge conservation?

A) $\frac{\partial \rho}{\partial t} = -\int \vec{\mathbf{J}} \bullet d\vec{\mathbf{l}}$

B) $\frac{\partial \rho}{\partial t} = -\iint \vec{\mathbf{J}} \bullet d\vec{\mathbf{A}}$

C) $\frac{\partial \rho}{\partial t} = -\iiint (\nabla \bullet \vec{\mathbf{J}})\, d\tau$

D) $\frac{\partial \rho}{\partial t} = -\nabla \bullet \vec{\mathbf{J}}$

E) Not sure/can't remember

In-Class Activities/Tutorials

Different Implementation styles:

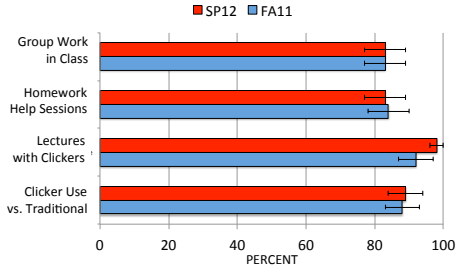
- 5 minutes for important derivations
- Interspersed with short lectures
- Partial or entire class periods

Emphasis on conceptual & procedural knowledge:

- Are quantities *zero* or *non-zero*?
- Simple derivations or calculations

Student Perceptions

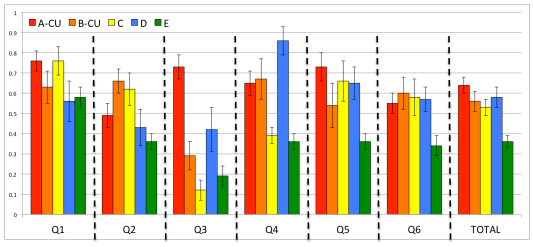
Percentage of class rating these as "useful" or "very useful"



CURrENT Assessment

Colorado UppeR-division ElectrodyNamics Test

- Important concepts as defined by learning goals
- Useful for students to assess own understanding



CURrENT Assessment

1. You are given Maxwell's equations in integral form as written below:

I. $\oiint \vec{\mathbf{E}} \cdot d\vec{\mathbf{a}} = \iiint \frac{\rho}{\varepsilon_0} d\tau$

II. $\oiint \vec{\mathbf{B}} \cdot d\vec{\mathbf{a}} = 0$

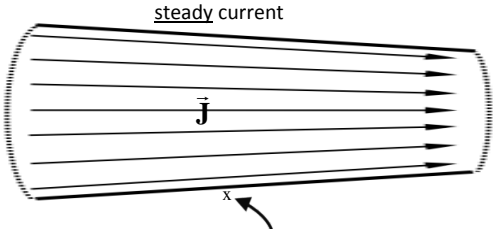
For example: $\int$ or $\oint$? $\iint$ or $\oiint$?

III. $\oint \vec{\mathbf{E}} \cdot d\vec{l} = -\frac{d}{dt} \iint \vec{\mathbf{B}} \cdot d\vec{\mathbf{a}}$

IV. $\oint \vec{\mathbf{B}} \cdot d\vec{l} = \iint \mu_0 \vec{\mathbf{J}} \cdot d\vec{\mathbf{a}} + \frac{1}{c^2} \frac{d}{dt} \iint \vec{\mathbf{E}} \cdot d\vec{\mathbf{a}}$

A: 38% B: 43% C: 45% D: 36% E: 14%
(all correct)

steady current



3.a) Electric field *zero* or *nonzero*?

A: 67% B: 7% C: 9% D: 36% E: 17%

3.b) $\nabla \cdot \vec{J}$ *zero* or *nonzero*?

A: 54% B: 29% C: 0% D: 36% E: 10%

Online Resources

- Consensus Learning Goals
- In-Class Activities/Tutorials
- Clicker Questions
- Assessments
- Student Difficulties

All materials freely available at:
http://per.colorado.edu/Electrodynamics