Transforming Upper-Division Electrodynamics (E&M II)
http://per.colorado.edu/Electrodynamics
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Course Description
2nd semester upper-division physics course on electrodynamics (primarily junior physics majors)
– Time-dependent Maxwell equations
– Conservation principles
– Potentials and fields
– EM waves
– Radiation
– Special relativity

Standard textbook:
D. J. Griffiths, Introduction to Electrodynamics, 3rd Ed.

Research on Student Learning
IDENTIFYING STUDENT DIFFICULTIES
– Analyze and archive responses to homework and exam questions, clicker questions, in-class activities
– Observe discussions/questions in class and during HW problem-solving sessions
– Listen to experienced instructors

1-ON-1 & GROUP STUDENT INTERVIEWS
– Confirm student difficulties and discover new ones
– Validate tutorial problem statements and diagrams
– Simulate group activities during tutorial development

Explicit Learning Goals
EXAMPLES OF CONTENT LEARNING GOALS
Students should be able to:
– Correctly apply Stokes’ Law and the Divergence theorem, and be able to use them to convert equations from differential to integral form (and vice-versa).
– Apply Ohm’s Law (in the form $J = \sigma E$) to relate the current density to the electric field, and calculate the total current for a given situation.
– Find the boundary conditions for EM waves starting from Maxwell’s Equations, and apply the correct boundary conditions to solve for and interpret reflected and transmitted waves.

EXAMPLES OF BROADER LEARNING GOALS
Students should be able to:
– Translate a physical description of a problem to a mathematical equation necessary to solve it.
– Articulate their expectations for the solution to a problem, such as direction of the field, dependence on coordinate variables, and behavior at large distances.
– Recognize symmetries and be able to take advantage of them in order to choose the appropriate method for solving a problem.
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

TUTORIALS
- Used during class to supplement lectures
- Guided tasks help students develop important concepts for themselves
- Require from 5 to 45 minutes, depending on tasks

Concept Tests

CAN BE USED FOR A VARIETY OF PURPOSES

CONCEPTUAL: Questions that don’t rely on complex mathematics.
APPLICATION: Use an abstract idea in the context of a real-world situation
NEXT STEP: Underscore key ideas in a long derivation, proof or in-class calculation
MATH/PHYSICS: Make connections between equations and the physical situations they describe

Tutorials

In-class activities have been implemented in several ways:
- Taking 5 minutes to do important derivations
- Section by section, interspersed with short lectures
- Using partial or entire class periods uninterrupted

Mixed emphasis on conceptual vs. procedural knowledge:
- Conceptually challenging materials focus, e.g., on whether quantities are zero or non-zero
- Simple derivations or calculations help develop math skills and lasting understanding

Assessments

CONCEPTUAL & FUNDAMENTAL SKILLS
- Pre/post-instruction versions
- Focus on important topics (as defined by learning goals)
- Useful for students to assess their own understanding

STUDENT PERCEPTIONS
- Online end-of-semester student survey
- Focus on perceived usefulness of transformed curriculum for their learning
- Opportunity for essential student feedback

Conceptual & Fundamentals

- Given at CU and one other institution in SP12
- Required 1 class period
- Significant differences seen in areas targeted by in-class activities used at CU

Student Perceptions

Percentage of class rating these as “useful” or “very useful” for their learning