

PHYS 272  
ELECTRIC AND MAGNETIC INTERACTIONS

CURRENT INSTRUCTOR: WEI XIE

**Project OBJECTIVES:**

1. Create a learning environment that is robust enough to enhance both novice and expert students' understanding of the fundamental concepts necessary to understand and describe electric and magnetic phenomena
2. Help all students build:
  - I. the qualitative understanding of physical principles necessary to set up physically meaningful mathematical expressions
  - II. the quantitative ability to manipulate those mathematical expressions into practical predictions

## RESEARCH QUESTION: DO QUALITATIVE INTRODUCTIONS POSITIVELY IMPACT STUDENT LEARNING?

- We seek to determine if there is a positive impact on student's overall learning gain (measured by the Brief Electricity and Magnetism Assessment – BEMA) when qualitative, tiered introductions are coupled with quantitative, collaborative group work.

### MOTIVATION: PHYS 272 IS FOUNDATIONAL

- **PHYS 272** is a foundational course that teaches fundamental principles of electricity and magnetism to about 500 students every year. If successful, introducing quantitative group work with qualitative, iClicker questions could benefit the thousands of students who take PHYS 272 in the years to come.

## INITIAL PROGRESS

Fall 2013

- Developed 11 sets of tiered, iClicker question series and ran them in 3 separate recitations of one teaching assistant
- The series were well-received by students in a survey conducted at the end of the course

Spring 2014

- Created 3 additional sets of questions and refined the others; we have 70 questions total with an average of 5 in each series
- Administered BEMA pretest and we will administer it again at the end of the course
- Currently 4 recitations have these introductions while 5 do not, there are 3 pairs with a 'control' group with the same TA

Future Plans

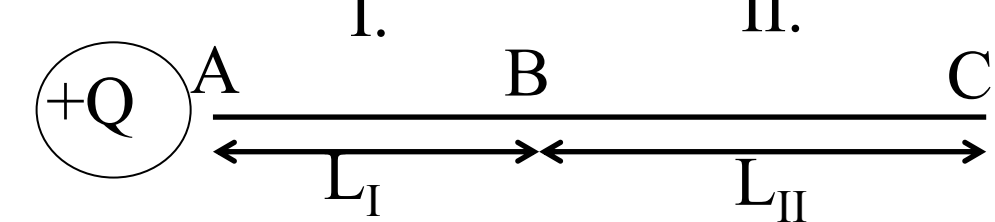
- Refinement of the project's direction based on the observed difference in learning gains between students in recitations with and without these introductions
- Possibly incorporate alpha-numeric questions and/or demographic analysis

## EXAMPLE OF A TIERED SERIES:

SAME SCENARIO BUT FOUR DIFFERENT QUESTIONS THAT PROBE THE STUDENT'S CONCEPTUAL UNDERSTANDING DEEPER AND DEEPER

PHYSICAL SCENARIO:

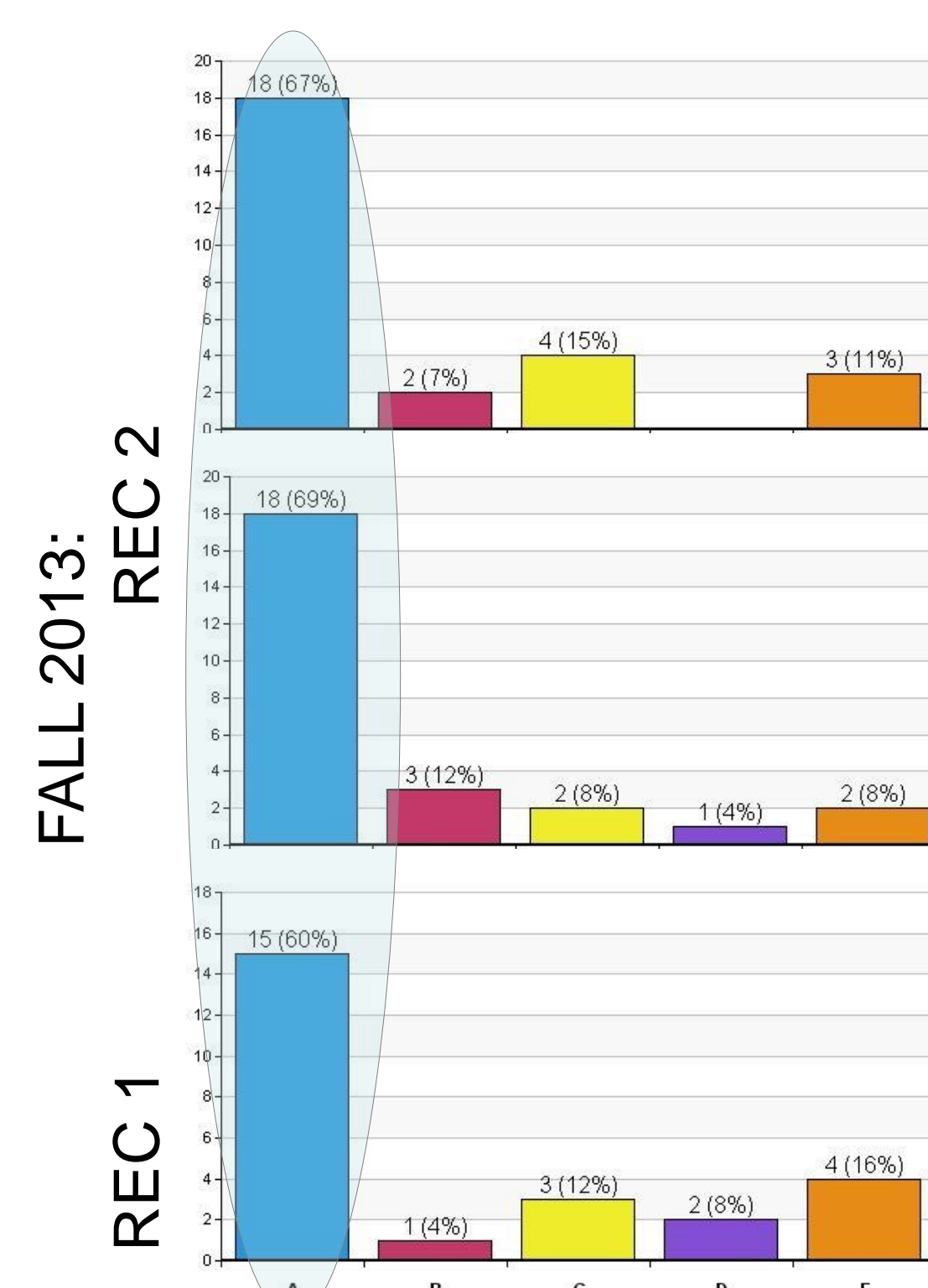
There are electric fields in region I and II shown in the figure, but their magnitudes ( $E_I$  and  $E_{II}$ ) are unknown. We introduce a sphere carrying charge  $+Q$  at location A. Its velocity is observed to increase at a constant rate until point B. After point B, its velocity decreases at a constant rate until stopping at location C. Ignore any effect from non-electric forces.



### QUESTION 1: ELECTRIC FIELD'S DIRECTION

What is the direction of the electric field in region I. (II.)?

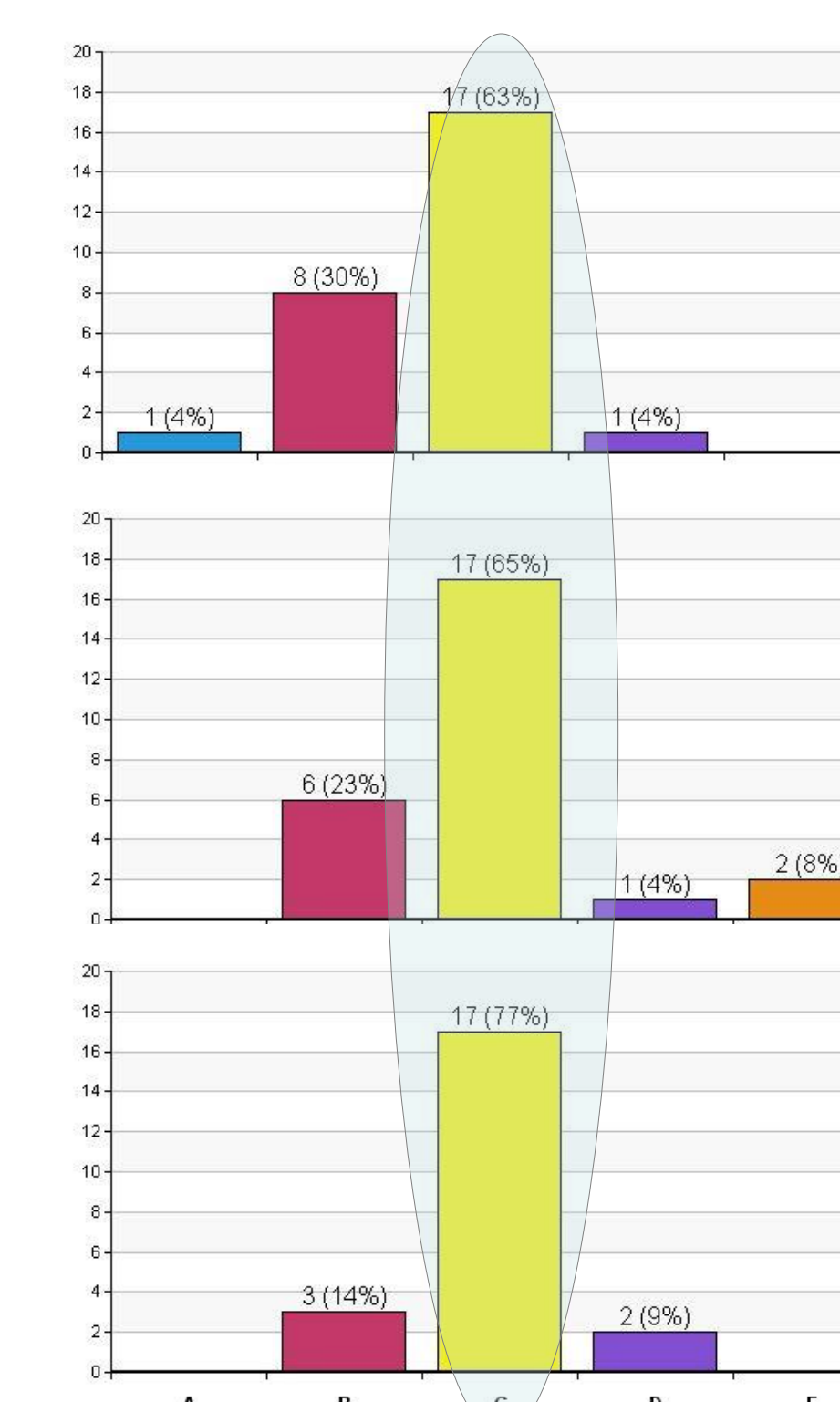
- a. Right (Left)
- b. Left (Right)
- c. Right (Right)
- d. Left (Left)
- e. I am never taking another physics class again



### QUESTION 2: ELECTRIC FIELD'S MAGNITUDE

Which of following is true?

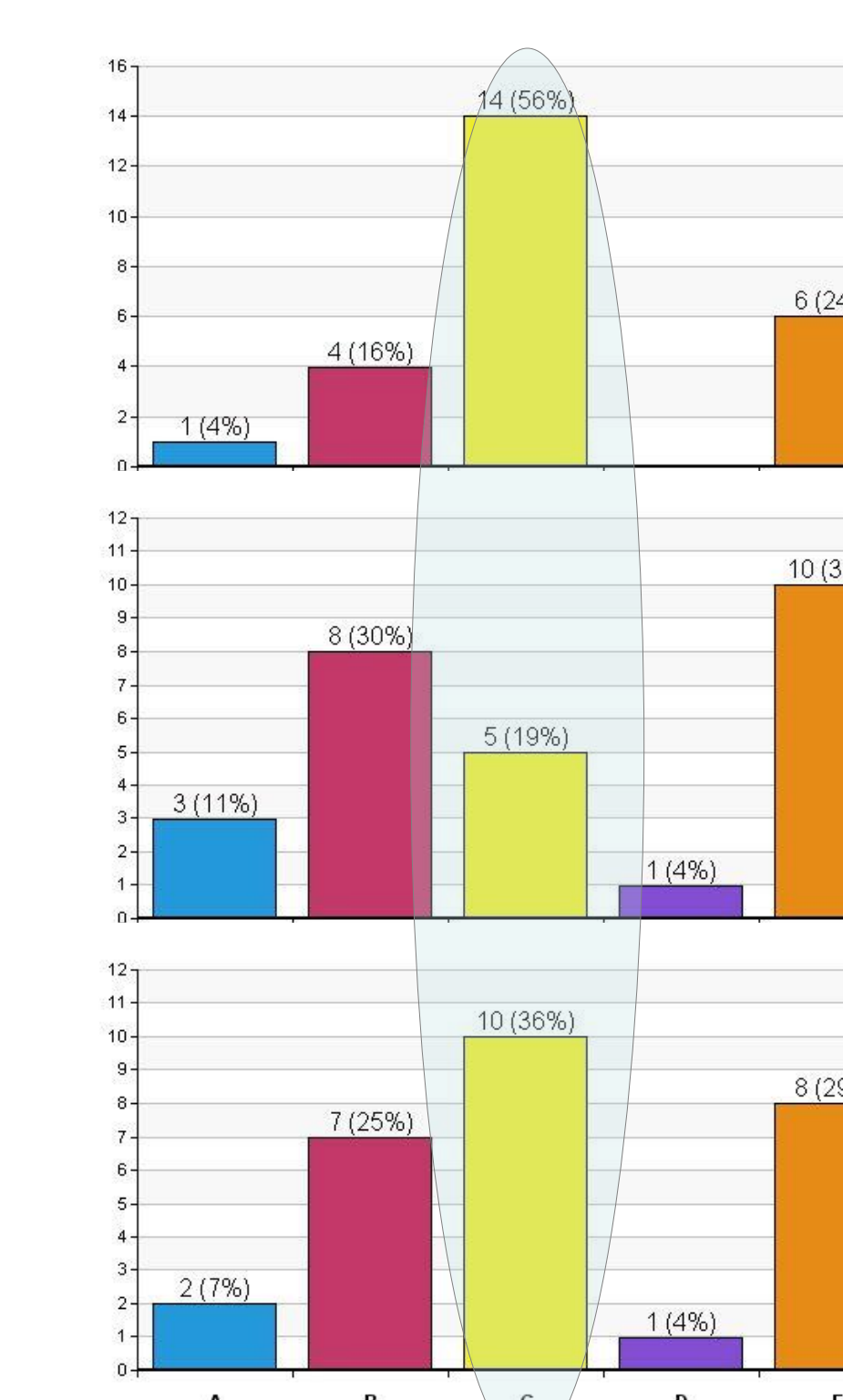
- a. The electric field is uniform throughout the whole space
- b.  $E_I$  increases at a uniform rate in region I and  $E_{II}$  decreases at a uniform rate in region II
- c.  $E_I$  is constant in region I and  $E_{II}$  is constant in region II
- d. Nothing quantitative can be deduced about  $E_I$  and  $E_{II}$
- e. None of the above statements are true



### QUESTION 3: RELATING ELECTRIC FIELD AND ENERGY CONSERVATION

If the initial point is at A, for how many final points do you know  $\Delta V = \int_A^C \vec{E} \cdot d\vec{l}$  exactly?

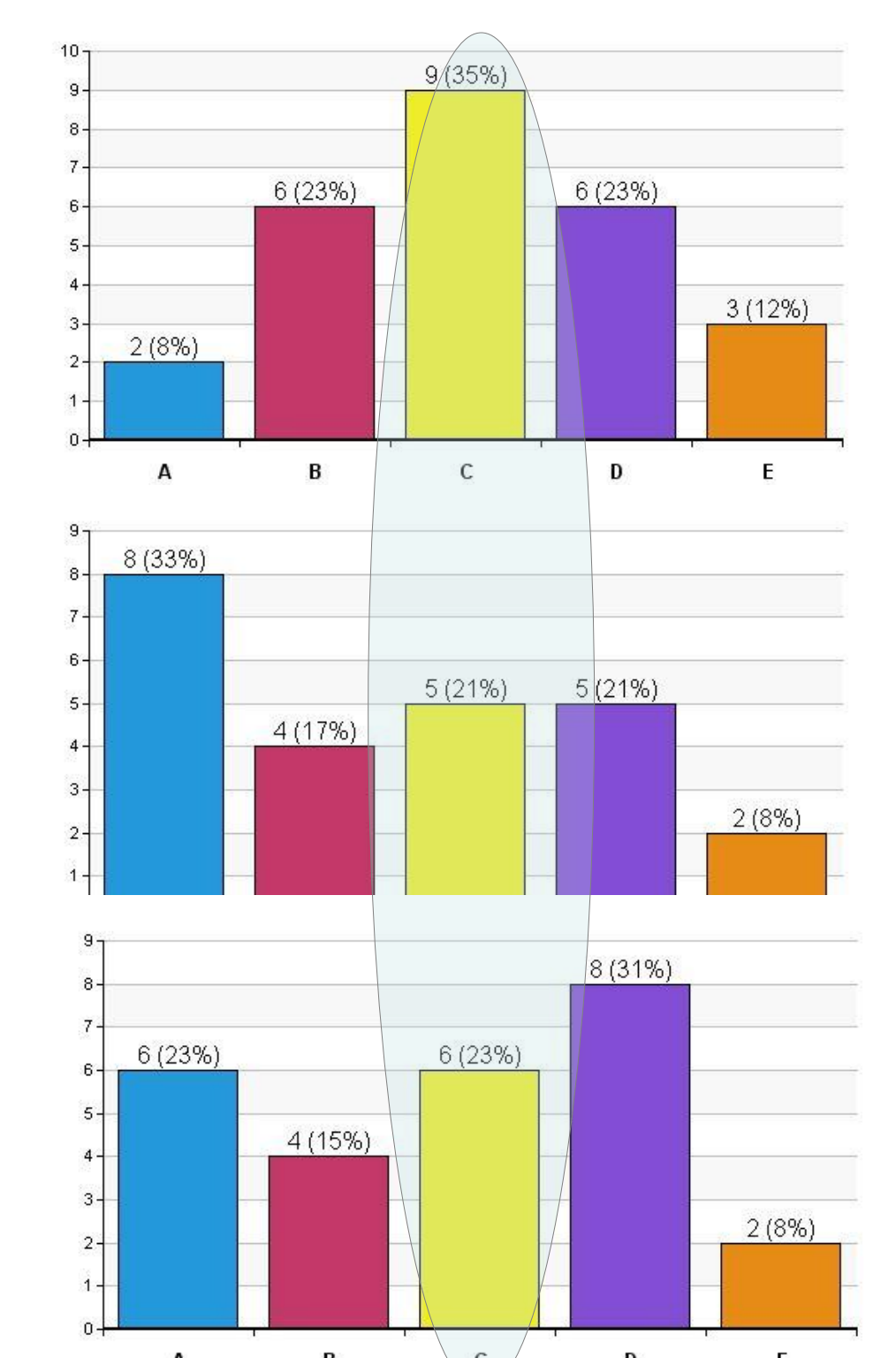
- a. 0
- b. 1
- c. 2
- d. 4
- e. An uncountable infinite number of points



### QUESTION 4: USE CONCEPTS OF QUESTION 1/3 TO FLUSH OUT 2

With initial location A and final location C, can you use  $\Delta V = \int_A^C \vec{E} \cdot d\vec{l} = 0$  to deduce any of the following about the magnitudes of the electric fields in region I and II?

- a.No
- b. $E_I = E_{II}$
- c. $E_I/E_{II} = L_I/L_{II}$
- d. $E_{II}/E_I = L_I/L_{II}$
- e. $E_I/E_{II} = (L_I/L_{II})^2$



## TIERED QUESTIONS PROVIDE AN ENVIRONMENT PROMOTING FULLER UNDERSTANDING

- Tiered nature -- questions build off of each other, grow in difficulty, and the final question often requires understanding of the principles that stand behind previous correct answers.
- The teaching assistant explains the correct answer's validity and the wrong answer's shortcomings after every question.
  - Explaining the right answer's validity helps the students understand the correct reasoning.
  - Addressing the wrong answer's shortcomings engages the students in a conversation about common misconceptions.
- We frequently use a change of representation to help guard against false positives.

EASY – STRONG CONSENSUS

DIFFICULT - WEAK CONSENSUS