



## **Student Performance Q&A:**

### **2012 AP<sup>®</sup> Physics C: Electricity and Magnetism**

### **Free-Response Questions**

The following comments on the 2012 free-response questions for AP<sup>®</sup> Physics C: Electricity and Magnetism were written by the Chief Reader, Jiang Yu of Fitchburg State University in Fitchburg, Mass. They give an overview of each free-response question and of how students performed on the question, including typical student errors. General comments regarding the skills and content that students frequently have the most problems with are included. Some suggestions for improving student performance in these areas are also provided. Teachers are encouraged to attend a College Board workshop to learn strategies for improving student performance in specific areas.

#### **Question 1**

##### ***What was the intent of this question?***

This question assessed students' understanding of the concepts of electric charge, electric field strength, and electric potential, and these concepts' interdependency in the given two-concentric-conducting-sphere system at various locations.

##### ***How well did students perform on this question?***

The mean score was 6.07 out of a possible 15 points. Overall, students did well on all parts of this question.

##### ***What were common student errors or omissions?***

Many students either did not know that the surface area of a sphere was the appropriate area to use for Gauss's law in this case or simply did not know the expression for the surface area of a sphere (despite the fact that it is given in the equation tables). This caused many students to miss part (a). Also in part (a) many students simply wrote the final expression without deriving it or did a very cursory derivation. Fortunately, students could get the correct expressions in parts (b) and (c) without relying on their answer to part (a), and they should have been able to do so from their experience working with point-charge problems.

Many students did not actually calculate a numerical value for the answer in part (d), even though they were asked to do so, or did not include a unit or use a unit that matched the reported order of magnitude. Many students lost points because they did not report their answers properly. Finally, there were many errors on the graphs that often conflicted with the information derived in previous parts, demonstrating that students frequently do not understand the concepts and relationships shown by these graphs.

***Based on your experience of student responses at the AP Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?***

Teachers should encourage students to read directions carefully. Teachers need to reinforce the meanings of words like “derive.” If a question asks for an answer to be reported in terms of certain variables, students need to do this.

Teachers should give practice questions that have answers expressed in variable notation. Also, they should stress the conceptual relevance of graphs, especially the concept of slope, so that students can make sketches like the ones they were asked to do on this problem (not just common graphs of motion or other common graphs).

Finally, teachers should make sure that students review items as mundane as common geometric relationships (such as the surface area of a sphere) that are critical components for using tools such as Gauss’s law.

## **Question 2**

***What was the intent of this question?***

This question assessed students’ understanding of electric resistivity of materials and resistor-capacitor (RC) circuits. To demonstrate their knowledge about electric resistivity, students were asked to plot a *linear* graph from which the resistivity of a substance could be determined. To demonstrate their knowledge about RC circuits, students were asked to calculate the time constant and sketch the voltage across the capacitor and each resistor as a function of time.

***How well did students perform on this question?***

The mean score was 8.39 out of a possible 15 points. Students did well on all parts.

***What were common student errors or omissions?***

Some students had difficulty drawing a best-fit line and determining the slope of the line from the line rather than from the given data set. Many students successfully completed the graphing portion of the problem but then simply substituted raw data into their calculation for resistivity. Students also made errors calculating the equivalent resistance of a set of parallel resistors.

***Based on your experience of student responses at the AP Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?***

Students need deliberate instruction and repeated practice in graphing and using graphical analysis to determine values for quantities having linear relationships. Stress the importance of using the line, *not* the raw data to determine the slope. Also, charging and discharging curves should have proper starting points, have correct shapes, and approach zero or the maxima as appropriate for the particular situation.

## **Question 3**

***What was the intent of this question?***

This question assessed students’ understanding of Faraday’s and Lenz’s Laws in the scenario of dropping a bar in a uniform magnetic field.

***How well did students perform on this question?***

The mean score was 5.74 out of a possible 15 points.

***What were common student errors or omissions?***

In part (a) many students began with wrong equations taken from the equation sheet. They also calculated area incorrectly. In part (b) many students did not clearly justify the right-hand rule. In part (c) many students did not derive, as the question instructed, but simply wrote their final answer.

In parts (d) and (e) many students did not show how they arrived at the differential equation. They left variables in their answers that were clearly not on the list of those allowed. Students also left out the gravitational force in their consideration and focused only on the magnetic force. In part (f) students did not use forces to justify their answer as the question instructed.

***Based on your experience of student responses at the AP Reading, what message would you like to send to teachers that might help them to improve the performance of their students on the exam?***

Teachers need to stress that their students must show work, follow instructions, and justify their answers properly when asked.