CollegeBoard
Advanced Placement Program

Student Performance Q&A:

2004 AP® Physics C: Electricity & Magnetism Free-Response Questions

The following comments on the 2004 free-response questions for AP® Physics C: Electricity and Magnetism were written by the Chief Reader, Patrick Polley of Beloit College in Beloit, Wisconsin. 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 posed two different types of problems regarding electrostatics. In Parts (a) and (b) students were asked to show qualitative understanding regarding the direction of electric field lines in the presence of a conductor and to complete a ranking task involving the electric potential arising from a linear charge distribution in the presence of a conductor. Part (c) was quantitative. Students were asked to apply Gauss' Law to determine the electric field at a distance r from a linear charge distribution, and a concentric nonconducting cylindrical volume charge distribution.

How well did students perform on this question?

With a mean score of 6.3 out of a possible 15 points, students earned lower scores than expected on this straightforward electrostatics problem. About 10 percent of the students earned a score of 12 or higher, and nearly 22 percent of the students earned a score of 3 or less.

What were the common student errors or omissions?

The most common errors in Part (a) were the failure to draw the field lines at right angles to the inside surface of the conductor and the failure to distribute the charge properly on the conductor. Some students assigned charges to the interior of the conductor, and others assigned a random mix of positive and negative charges on the inner and outer surfaces of the conductor. The integration required by the application of Gauss' Law also gave students difficulty, as many got the limits of integration wrong or failed to integrate along the axis of the cylinder.

Question 2

What was the intent of this question?

This question was centered on the behavior of an *RC* circuit. Parts (a) and (b) related to the short-term and long-term behavior of a capacitor when a voltage is applied across it. Part (c) had students find the value of a second resistor in the circuit, using the information garnered in Parts (a) and (b). Part (d) was a straightforward calculation of the energy stored in the capacitor when it was charged. Part (e) asked students to perform graphical analysis of the circuit in the light of another graph given in the problem. Finally, Part (f) asked students to explain how the energy stored in the capacitor would change if one of the resistors in the circuit were changed.

How well did students perform on this question?

Scores on this *RC* circuit problem were lower than expected. Students usually do well on circuit problems, but this year they earned a mean score of only 5.5 out of a possible 15 points on this problem. Slightly less than 11 percent of the students earned a score of 12 or better, while over 37 percent of the students earned a score of 3 or less. Since only 3 percent of the students made no attempt on this problem, these low scores indicate that many students had little idea of how to answer the question.

What were the common student errors or omissions?

Students seemed perplexed by the circuit and were unable to analyze its short-term or long-term behavior. This is surprising because this is a standard problem in *RC* circuits. Parts (a) through (d) should have given students few problems, but many of them did poorly there. Students also had difficulty with the graph in Part (e), which is not a surprise because they had difficulty in analyzing the circuit. The final part of the question also generated few correct responses, which indicates that students had difficulty analyzing circuits that contain resistors in series.

Question 3

What was the intent of this question?

Part (a) asked students to calculate the magnetic flux through a rectangular loop, where the source of the field was a long straight wire parallel to one side of the loop. In Parts (b) and (c) students were told that the current in the wire had a decreasing exponential dependence on time, and they were asked to find the direction of the current induced in the loop and the current's magnitude as a function of time. In Part (d) students were asked to determine the energy dissipated in the loop as the current decreased to zero.

How well did students perform on this question?

The scores for this question were much lower than expected. The mean score was 3.8 out of a possible 15 points. As for the other two questions, there were few high scores, with slightly more than 9 percent of the students earning a score of 12 or better. The surprise came in that nearly two out of three students earned a score of 3 or less. While approximately 3 percent of the students did not attempt the question, some 20 percent did attempt it and earned a score of 0 for their response. Students often earn low scores on questions on magnetism, but this was much lower than expected.

What were the common student errors or omissions?

The most common error in Part (a) was the failure to integrate the field over the area of the rectangular loop. Many students simply multiplied the area of the loop by the field strength along the side of the loop closest to the wire. Students often failed to apply Faraday's Law appropriately in their solution of Part (b). In Part (d) students often showed confusion between power and energy, and they rarely carried out the integration of power over time that was necessary for the correct solution.

Overview of the AP Physics C: Electricity & Magnetism Exam

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?

Student performance on this year's AP Physics C: Electricity and Magnetism Exam was lower than expected overall. While students performed as expected on the first question, they had a great deal of difficulty with the second question, a question involving the analysis of an *RC* circuit. The difficulty that students had on the final question was not surprising because magnetism, and especially induction, is a topic with which students often have difficulty. What was surprising was that, on a problem that was straightforward and standard, students still had a great deal of difficulty. It is clear that the analysis and presentation of electric fields (Question 1) and magnetic fields (Question 3) still need attention.