Student Performance Q&A:

2015 AP® Physics 2 Free-Response Questions

The following comments on the 2015 free-response questions for AP® Physics 2 were written by the Chief Reader, Peter Sheldon of Randolph College. 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?

The intent of this question was to assess student knowledge of ray optics including reflection, refraction, Snell's law, and total internal reflection. Understanding was to be conveyed in a written form using a combination of words, diagrams, and mathematics.

How well did students perform on this question?

The mean score was 2.75 out of a possible 10 points.

What were common student errors or omissions?

Common student errors included:

- not labeling relevant parts of diagrams
- thinking that the problem involved thin-film optics situation or slit diffraction
- using wrong optical terms, such as using diffraction when the student meant refraction
- confusing total internal reflection with partial internal reflection

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 should practice writing responses with the goal of emphasizing clarity and brevity.
- Students should refrain from repeating the question in their response.
- Students should be aware that if a problem does not specifically ask them to draw on a diagram, but they have and want that work to be included in the answer, they should indicate in the text that the reader refer to the diagram.

Question 2

What was the intent of this question?

The intent of the question was to assess student understanding of basic parallel and series circuits including resistors and capacitors. An understanding of Ohm's law and the relationship between current, voltage, power, and brightness of light bulbs was being tested. Students were asked to work qualitatively and quantitatively, and to be able to relate the two representations.

How well did students perform on this question?

The mean score was 4.09 out of a possible 12 points.

What were common student errors or omissions?

- A common error was thinking the potential difference across the first bulb in series was the emf of the battery.
- Another common error was confusion over how a capacitor affects light bulbs, confusing what would happen immediately after the circuit was turned on with the steady state solution that occurs after a long time.

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 should practice qualitative explanations using words, rather than numbers and symbols.
- Teachers should reinforce that if the exam asks for a calculation using given variables, students should only use those variables and should not substitute in numbers.
- When the exam asks to relate the qualitative and quantitative arguments, students should recognize that it is asking them to make physics connections between the two sections, not just to repeat what they already said or what the question asks.

Question 3

What was the intent of this question?

This was a thermodynamics lab design problem that required students to consider the Ideal Gas law and relationship between state variables. Students were asked to design an experiment to explore the relationship between pressure and temperature, and to plot and interpret results.

How well did students perform on this question?

The mean score was 5.98 out of a total of 12 points.

What were common student errors or omissions?

- While many students correctly thought to justify responses using the ideal gas law, many simply stated that pressure is proportional to temperature, without discussing what else was or was not constant.
- The most common error was not recognizing that choosing data with a constant volume would best justify the claims.
- Typical graphing mistakes included not setting up the axes correctly, not including units, and not showing the line or curve indicated by the data points.

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?

- In order to be successful at the lab question, students need to have experience with experiments, equipment, and writing or discussing procedures.
- Students need to be able to look at an equation and decide what the relationship is (or is not, if more than one quantity can vary) between two quantities in the equation.
- Specific procedures (how to determine a quantity) and proper graphing should be reinforced.

Question 4

What was the intent of this question?

An electron accelerates between two oppositely charged parallel plates and then into a region with a uniform magnetic field. Students are asked to determine various quantities such as charge, field, directions of vector quantities, and trajectories.

How well did students perform on this question?

The mean value was 3.98 out of a possible 10 points.

What were common student errors or omissions?

- Belief that electrons accelerate along the direction of electric field lines.
- Belief that the electric field determines the "movement" of charges rather than the force.
- Belief that a moving charge in a magnetic field experiences a force with a constant direction based on the initial force rather than a force that is always perpendicular to velocity of the charge.
- Students frequently cited the result of the right/left hand rule without further explanation or explained how they did the right hand rule (my thumb points here and my fingers point there) without specifying the physical variables (velocity, field, force).

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?

In a justification problem, where students are asked to explain a physical phenomenon associated with an equation, they need to refer to the associated physical quantities rather than descriptions which lack these details. Students need practice using physics in justifications, and need to try to avoid other irrelevant information.