CollegeBoard
Advanced Placement
Program

Student Performance Q&A:

2004 AP® Physics B Free-Response Questions

The following comments on the 2004 free-response questions for AP® Physics B 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?

Parts (a) and (b) involved the application of the principle of conservation of kinetic energy and gravitational potential energy. Part (c) centered on circular motion and dynamics. Part (d) was a further exploration of students' understanding of circular motion, conservation of energy, and dissipative work. In this final part of the question, students had to come up with a verbal justification for their response.

How well did students perform on this question?

Students performed well on this question, with over 15 percent earning a score of 12 or higher, and slightly over 15 percent earning a score of 3 or less. The mean score was 7.6 out of a possible 15 points.

What were the common student errors or omissions?

In Part (a) many students put the point at which the speed was a maximum just above the lowest point on the track. In Part (b) many students solved for the critical speed at which the car would fall off the track, rather than the actual speed at Point *B* for the given initial conditions. Part (c) was disappointing in that many students drew the free-body diagram incorrectly, with a significant number insisting on drawing the normal force upward. The final source of error was in Part (d), where students related the change in the track to the centripetal force, rather than the energy dissipated by friction.

Question 2

What was the intent of this question?

Part (a) investigated students' understanding of gauge and absolute pressure. Part (b) involved the application of Archimedes' Principle. Part (c) involved the relationship between force and pressure in a fluid. Parts (d), (e), and (f) were applications of one-dimensional kinematics to an object that undergoes constant acceleration and then descends to the ocean floor at a constant velocity.

How well did students perform on this question?

More students did well on this question than they did on Question 1, with over 20 percent earning a score of 12 or higher. But more students did poorly as well, with nearly a quarter of the students earning a score of 3 or less. Also, 10 percent of the students either earned 0 points or did not attempt to answer the question. The mean score for this question was 7.1 out of a possible 15 points.

What were the common student errors or omissions?

The errors divided neatly between those involving fluid mechanics and those involving kinematics. Some students had no idea what gauge or absolute pressures are, and so they did poorly on Part (a). Some attempted to apply Bernoulli's equation in Part (b). The errors in the kinematics part were more surprising. Some students did not realize that there were two types of motion in the problem, the first at constant acceleration and the second at constant velocity, and solved it as a free-fall problem with an acceleration of g. In Part (e) some students again applied Bernoulli's equation, again with little success.

Question 3

What was the intent of this question?

Part (a) concerned the application of the definition of magnetic flux. Part (b) asked students to calculate the electromotive force induced in a conducting loop by a changing magnetic flux through the loop. Part (c) asked students to apply Ohm's Law to find the current induced in the conducting loop and to use Lenz' Law to determine the direction of that current. Part (d) asked students to explain another method, other than changing the magnitude of the magnetic field, which would induce a current in the loop.

How well did students perform on this question?

The mean score for this question was 8.2 out of a possible 15 points, the highest mean score of any question on the AP Physics B Exam. Nearly 30 percent of the students earned a score of 11 or better; 14 percent earned a score of 3 or less.

What were the common student errors or omissions?

The most common error here was the notion that simply moving the loop would generate a current. When students got to Part (c), they plucked a large number of random formulas from the equation sheet, hoping to hit upon something that might get them a point.

Question 4

What was the intent of this question?

The entire question investigated students' understanding of interference from two-point sources of waves. The only wrinkle was that the two sources were acoustic instead of the more usual optical double-slit experiment. Students needed to understand the relationship among wave velocity, frequency, and wavelength as well. Parts (c) and (d) asked students to explain their answers regarding how the interference pattern would depend on changes in the spacing and frequency of the sources.

How well did students perform on this question?

The mean score of 6.9 out of a possible 15 points that students earned on this problem is good. Over 9 percent of the students earned the highest score of 15. There is another sizable peak in the scoring distribution at 11 points and bigger peaks at 3 and 4 points. Nearly 30 percent of the students earned a score of 12 or better, but over 30 percent of the students earned a score of 3 or less.

What were the common student errors or omissions?

The most common errors involved students using the wrong equations to find the location of the minimums. The equation for minima, $\left(m + \frac{1}{2}\right)\lambda = d\sin\theta$, was either not used or used with the value of m set equal to 1, which does not give the position of the minimum closest to the center of the interference pattern. Another set of difficulties arose when students attempted to justify their answers in Part (d). Often students simply restated the result without attempting to supply any reasoning.

Question 5

What was the intent of this question?

Part (a) required students to calculate the work done by a gas as it expands at constant pressure, the change in the internal energy of the gas, and the heat added to the gas during this expansion. Knowing the first law of thermodynamics was essential to success on this part. Part (b) required students to be able to draw an isochoric process on a *PV* diagram. Part (c) completed the thermodynamic cycle with an isothermal compression and a further application of the first law of thermodynamics.

How well did students perform on this question?

Student performance on this thermodynamics question was lower than expected. The mean score was 3.4 out of a possible 10 points. Less than 7 percent of the students earned a score of 7 or higher, and over 30 percent earned a score of 2 or less.

What were the common student errors or omissions?

Students had a great deal of difficulty with this problem, starting with their confusion regarding heat and temperature and their lack of understanding of such terms as "internal energy" and "isothermal." Students were unable to apply the first law of thermodynamics to solve for changes in heat and internal energy. Few showed an adequate knowledge of thermodynamics.

Question 6

What was the intent of this question?

Part (a) investigated whether students understood how to use ammeters and voltmeters in a circuit, in this case a circuit used in a photoelectric effect experiment. Parts (b) and (c) involved a test of students' abilities in graphical analysis of data. Part (d) allowed students to demonstrate knowledge of the physics behind the photoelectric effect and the effect that a change in the work function of the metal being illuminated would have on the data obtained in the experiment.

How well did students perform on this question?

While scores on Question 5 were lower than expected, scores on this question were higher than expected. A mean score of 4.7 out of a possible 10 points might not seem high, but it is considerably higher than scores on modern physics problems in recent years. Nearly 20 percent of the students earned a score of 8 or higher, while nearly a quarter of the students earned a score of 2 or less.

What were the common student errors or omissions?

A substantial number of students had little exposure to modern physics but were able to proceed with the analysis of the lab setup in Part (a) and the graphical analysis in Part (b). Many students were left by the wayside in the sections of the problem that probed their knowledge of modern physics, indicating that they did not know the photoelectric effect.

Overview of the AP Physics B 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?

Overall, students did well on this exam. One troubling area is that, as on last year's exam, student performance on thermodynamics was poor. However, their graphical analysis skills and their ability to solve both mechanics and electricity problems and magnetism problems are quite good.