CollegeBoard
Advanced Placement
Program

Student Performance Q&A:

2004 AP® Physics C: Mechanics Free-Response Questions

The following comments on the 2004 free-response questions for AP® Physics C: Mechanics 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?

The solution of this question involved conservation of momentum, conservation of energy, dynamics, and two-dimensional kinematics. Part (a) involved applying the principle of conservation of energy to an object falling along a circular arc. Part (b) asked students to apply Newtonian dynamics to the falling object at the bottom of a circular arc in order to calculate the tension in a rope to which the object was attached. Part (c) involved the conservation of momentum. Part (d) asked students to calculate the ratio of kinetic energies before and after the inelastic collision of two objects. Part (e) was an exercise in two-dimensional kinematics.

How well did students perform on this question?

Student performance was as expected for this question. The mean score was 8.7 out of a possible 15 points. Over 30 percent of the students earned a score of 12 or higher. About 18 percent of the students earned a score of 3 or lower.

What were the common student errors or omissions?

The errors in this problem can be divided into those that were the result of carelessness and those that were the result of erroneous notions. Onto the pile of careless errors we can toss those that resulted from using an incorrect vertical displacement in Part (a), like assuming that the displacement was $2L$ instead of L. Similarly, a failure to add L to the horizontal distance that the objects traveled after the impact cost several students a point in Part (e). The conceptual errors included inserting a rotational kinetic energy term in the kinetic energy of the object in Part (a), ignoring the acceleration of the object in Part (b) (this yields $T = mg$), or conserving kinetic energy instead of momentum in Part (c).

Question 2

What was the intent of this question?

The question began as a straightforward, one-dimensional kinematics problem in Part (a). The question then continued in Part (b) with a graphical analysis of data to determine the acceleration of a block attached to a disk by a rope. Part (c) was the part of the problem where students applied rotational dynamics to the motion of the mass and disk. Part (d) asked students to consider a case where the experimental and calculated values did not coincide and to discuss possible sources of error.

How well did students perform on this question?

Student performance was lower than expected on this question. The mean score was 5.0 out of a possible 15 points. Slightly more than 4 percent of the students earned a score of 12 or higher, while 37 percent of the students earned a score of 3 or less. Nearly 2 percent of the students did not attempt the question, which means that many students tried the problem with little success.

What were the common student errors or omissions?

Many students failed to realize that Part (a) is a simple kinematics problem, and they immediately attempted to deploy the full apparatus of rotational dynamics, with little concomitant success. The graphical analysis also posed problems for many students, indicating that they are unfamiliar with manipulating data in order to obtain a linear graph. The final part of the problem also created difficulties for many because the problem was worded in such a way that friction, the most common answer for disagreements between theoretically and experimentally derived quantities in a lab, was not the correct answer.

Question 3

What was the intent of this question?

Part (a) asked students to calculate the moment of inertia about an axis perpendicular to a rod at a point not at the center or end of the rod. In Part (b) students applied the principle of conservation of energy to the rotational motion of the rod. Part (c) asked students to find the period of small oscillations of the rod when displaced from the vertical.

How well did students perform on this question?

Student performance on this question was much lower than expected. The mean score was 2.9 out of a possible 15 points. Nine percent of the students earned a score of 8 or higher. Over 28 percent of the students received no credit for this problem.

What were the common student errors or omissions?

On a problem where the student performance is this poor, it is difficult to pick out the most common errors. In Part (a) students were asked to calculate the moment of inertia of a rod about a point other than the end or center. Either a direct integration or the application of the parallel axis theorem would have netted them full credit here, but that rarely happened. Part (b) can be answered correctly either with the application of the principle of conservation of energy or by applying rotational dynamics and integrating over the appropriate limits of the motion. Few students were able to employ either approach. The final section, which covered the motion of the physical pendulum, was likewise rarely tackled with success.

Overview of the AP Physics C: Mechanics 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 exam was much lower overall than expected. While students did as expected on the first question, they earned much lower scores than anticipated on the second and third questions. The problem on Question 2 arose from students assuming that the question would be a standard rotational one as soon as they saw the diagram, without reading the question carefully. Students also failed to read the final part of the question carefully and simply came up with a canned answer in most cases. The greatest surprise was on the final question, where students did poorly at calculating the moment of inertia of a rod. This one-dimensional definite integral should certainly be within the mathematical ability of students, but few were successful. Students also had difficulty in properly applying the conservation of energy in the second part of this question. Students need to read the exam carefully and do more to master techniques and principles, as opposed to a set number of algorithms for solving problems, in order to succeed on this exam.