Student Performance Q&A:

2015 AP® Physics C-Mechanics Free-Response Questions

The following comments on the 2015 free-response questions for AP® Physics C-Mechanics 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 question required kinematics, Newton's laws, and energy considerations to describe the motion of a block on an inclined plane with friction, using equations and a graph.

How well did students perform on this question?

The mean score was 5.09 out of a possible 15 points.

What were common student errors or omissions?

- The most common mistake was not accounting for the given frame of reference correctly. The block was launched up the ramp, but the frame of reference was given as opposite (down the incline) to the initial velocity of the block. Many of the responses considered the initial velocity to be positive.
- Many responses showed an understanding of how to treat uniform acceleration but again did not take into account correct signs and directions.
- Once friction was added, students often did not recognize that acceleration up the incline would be different than that down the incline.
- Few students followed the direction to "label intercepts, asymptotes, maxima, or minima with numerical values or algebraic expressions" on the graphs.
- Students often were not able to consistently or correctly graph position, velocity and acceleration for the constant acceleration motion.

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?

- The problem is based on one of the most classic physics problems that is likely worked through in every physics classroom. However, the performance on the question indicates that students perhaps need to practice variations on the standard problems.
- More experimental work could help the students truly understand the physics behind this problem.
- Students likely need more practice with graphing and understanding what the graphs physically describe.
- Students rely too much on problems they remember doing in the past. They try to apply things they have memorized that are incorrect or not relevant, rather than solving the problem they are given.

Question 2

What was the intent of this question?

The intent of this question was to engage the students with a classic ballistic pendulum problem. This question tested student understanding of projectile motion, inelastic collisions, conservation of energy, and simple harmonic motion.

How well did students perform on this question?

The mean score was 8.61out of a possible 15 points.

What were common student errors or omissions?

- There were not too many error trends, as students performed reasonably well, and errors were distributed over all of the parts of the question.
- Perhaps the most common error was that some students tried to use constant acceleration kinematics (instead of energy conservation) to describe the motion of the pendulum and determine the maximum angle of deflection.
- Another relatively common error was using incorrect algebra, and incorrectly using degrees or radians.
- Students interchanged the sine and cosine functions when calculating vector components.
- When asked for the time for one half the cycle, students would often give the full period.
- Some students did not use small angle approximation when it was appropriate.

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 to learn what is expected when asked to "justify" a response, need to have more practice using physics concepts to do so, and need to not simply restate the conclusion.
- Students should be instructed, and perhaps need to practice, writing legibly.
- Students need to show more of their work and should practice deriving answers symbolically, not plugging numbers in until necessary.

Question 3

What was the intent of this question?

This is a rotational dynamics question that requires integration and graphical analysis of data (identifying sources of error) to determine *g*.

How well did students perform on this question?

The mean score was 4.41 out of a possible 15 points.

What were common student errors or omissions?

- The first part of the problem was a classic rotational inertia integration that includes a substitution of variables using a density function. Many students clearly did not understand this process.
- A common error was to incorrectly use Newton's second law for rotation, assuming a constant angular acceleration, instead of using conservation of energy where appropriate.
- A common error was to apply gravity to the end of the rod rather than to the center of mass.
- The most common mistake on the graphing part was to simply plot the given data and find the slope without taking the necessary steps to linearize the data.
- A very common error was to find the slope of the best-fit line using data points rather than using points that were on the line.

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 could apparently use more practice with, and examples of, integration with a change in variable such as that found in this problem.
- Students need to understand better how to linearize an equation, and how to determine the slope of a best-fit line.