Student Performance Q&A:

2014 AP® Physics C: Mechanics Free-Response Questions

The following comments on the 2014 free-response questions for AP® Physics C: Mechanics were written by the Chief Reader, Peter Sheldon of Randolph College in Lynchburg, Va. 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 assessed understanding of the relationships between force, energy, and impulse, as well as application of conservation of energy. In addition, the analysis of data was used to evaluate the students' understanding of the system and ability to provide physical explanations for the results.

How well did students perform on this question?

The mean score was 9.66 out of a possible 15 points.

What were common student errors or omissions?

- Many students did not take note of the word "derive" and stated an answer without showing any work.
- A significant number of students did not realize that integration is needed to determine potential energy from a variable force.
- Some students tried to use equations for a linear spring although the problem indicated the force was non-linear.
- Opposite of an omission, students drew "best-fit" lines through the plotted points although they were asked to only plot the 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?

- Students should be made aware of the strict definitions of various terms used in AP Physics problems as defined in the Course Description: 'derive', 'calculate', 'determine', etc.
- Students could use more practice sketching graphs and drawing conclusions from them.

Question 2

What was the intent of this question?

The primary intent of this question was to assess the students' understanding of Newton's laws as they apply to bodies moving with linear or circular motion, and with constant or non-constant acceleration. Students' ability to visualize and process physical situations from multiple perspectives was also examined.

How well did students perform on this question?

The mean score was 5.48 out of a possible 15 points.

What were common student errors or omissions?

- Algebra mistakes were very common.
- Confusion existed between v_0 and v.
- In stating conditions or writing equations, students confused acceleration and force.
- Students often stated or implied that the net force acting on the block was zero because the block was not moving rather than not accelerating.
- Students drew an arrowhead instead of 'an arrow starting on the block' as instructed.
- Students frequently failed to consider that both a normal force and a frictional force act on the block as it slides along the rough wall.
- Centripetal force was used as if it was a physical force instead of the net force.
- Students did not appropriately separate forces into separate components, especially when they found the expression for the normal force.
- Students were unclear as to the difference between centripetal and tangential acceleration.
- Students did not recognize the acceleration as non-constant, or did not know how to use this fact in a calculus expression.

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?

- Review the specific meaning of the key words 'justify', 'determine', 'calculate' and 'derive' as defined in the Course Description, so that the students understand the level of proof required for an answer.
- Consider providing situations that require the student to examine the motion of an object, or the forces acting on an object, in three dimensions.
- Students could use more practice incorporating calculus into solutions.

Question 3

What was the intent of this question?

This question dealt with interactions between two objects and the related conservation of linear and angular momentum. It also included aspects of projectile motion, friction, and moment of inertia.

How well did students perform on this question?

The mean score was 5.74 out of a possible 15 points.

What were common student errors or omissions?

- Students commonly made algebraic errors.
- Students often substituted the incorrect mass into Newton's second law.
- Students often used conservation of energy instead of conservation of momentum or angular momentum.
- Some students used conservation of momentum and angular momentum interchangeably, or combined the two quantities.

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 main message is that energy need not be conserved when momentum or angular momentum is conserved. Some students think that kinetic energy is always conserved in these situations.
- Justification of answers should be based on physics principles, as well as on the mathematical equations. Some students tried to justify answers based on mathematical equations only and ended up with wrong conclusions.