Student Performance Q&A:

2003 AP® Physics C: Mechanics Free-Response Questions

The following comments on the 2003 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?

In this question students were given the position $x(t)$ of a box pulled by a student. They were then asked to find the velocity of the box, net force on the box, kinetic energy of the box, and net work done on the box in a given time interval. A knowledge of the definitions of velocity, acceleration, force, and kinetic energy sufficed to do well on the problem. The caveat was that students also had to apply differential calculus in the evaluation of the various quantities.

How well did students perform on this question?

The mean score for this question was 9.8 out of a possible 15 points, which indicated most students did well. More than a quarter of the students earned a score of 13 or better, while fewer than 12 percent earned a score less than 6. The question provided good discrimination among students of moderate and low abilities.

What were common student errors or omissions?

Scores this high indicate there were few major problems or student misconceptions. Students commonly erred by failing to differentiate properly or by making careless algebraic errors. The final section of the problem, in which students were asked a question concerning conservation of energy, elicited responses that indicated most students had a sound grasp of the concept of dissipative work done by frictional forces.

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 message is "keep up the good work." Students did a good job on this problem and demonstrated a mastery of the concepts involved in translational dynamics and the application of calculus to dynamics.

Question 2

What was the intent of this question?

This problem involved the concepts of conservation of momentum, conservation of energy, and simple harmonic motion. In the first two parts, students needed to know when to apply conservation of momentum and when to apply conservation of energy. The last three parts of the problem tested students' knowledge of Hooke's law and simple harmonic motion.

How well did students perform on this question?

The mean score for this question was 8 out of a possible 15 points. Fewer than 14 percent of the students earned a score of 13 or better, while over a third earned a score of 6 or less. On average, students performed as expected on this problem.

What were common student errors or omissions?

Parts (a) and (b) involved a totally inelastic collision between a pan of mass M and a lump of clay of mass M falling from a height H. Most of the errors that occurred here involved algebraic mistakes. Parts (c), (d), and (e) involved simple harmonic motion. Part (d) was difficult for many students, who assumed that the maximum velocity of the pan was the velocity it had immediately after the collision. The "justify your answer" section of Part (e) received mostly sound responses, in that few of the students who checked the proper box gave an incorrect explanation.

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?

It would be good to walk students through the solution of Part (d) and the correct explanation for Part (e). Many students started off well on these two sections, particularly in (d), but did not follow their thinking through.

Question 3

What was the intent of this question?

This question tested students' ability to apply the concepts of kinematics, conservation of energy, and rotational motion to a catapult. These concepts were to be deployed to determine the range of a projectile launched from the catapult. A number of simplifying assumptions made the problem tractable. The problem also included graphical analysis of data.

How well did students perform on this question?

The mean score for this question was 5.99 out of a possible 15 points. While low, this is in line with expectations for the rotational problem on the AP Exam. Fourteen percent of the students earned a score of 11 or better, while over 40 percent earned a score of 4 or less.

What were common student errors or omissions?

The problems students had began in Part (a) (i). Many students confused the idea of a best-fit curve with that of a best-fit straight line. Students who plugged the data into their graphing calculators and graphed the best-fit straight line lost points for the graph and had an incorrect answer for the range of a 250 kg counterweight. No points were deducted for having the best-fit line go through 0 instead of having an x-intercept of 60 kg. Part (b) (i), an exercise in kinematics, presented few problems. Some students began to have difficulty beginning with Part (b) (ii). Many students failed to determine the initial potential energy of the system correctly. More of them failed to realize that the change in gravitational potential energy and the kinetic energy of all parts of the system had to be considered in Part (b) (iii). In addition to conceptual errors, many students made an algebraic or arithmetical error here. The final part of the problem posed little trouble for the students who made it this far. But the difficulty of the problem may be gauged from the fact that only 65 students earned a score of 15 and just 88 earned a score of 14. The real bottleneck in the problem was not in the final section but rather in Part (b) (iii).

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 more practice in analyzing systems in which the conservation of energy and rotational motion are involved. Some students did attempt to solve Part (b) (iii) using torques and integrating over the angle through which the catapult moved. While that is a valid approach, it was rarely carried through correctly. This is a difficult question, but one on which students could earn points by systematically applying the core concepts of mechanics.

Overview of the AP Physics C: Mechanics Exam

Students' performance on the exam was good this year, with only a few areas of concern. On the plus side, students are giving better answers to the "justify your answer" sections of questions than in years past. This indicates that verbalizing conceptual understanding has become more important in the C courses. On the minus side, students have trouble bringing together different aspects of mechanics in a single problem. They also have trouble with the graphical analysis of data. On the whole, students performed admirably on a rigorous exam.