2017

AP CollegeBoard

AP Physics 1: Algebra-Based

Sample Student Responses and Scoring Commentary

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AP® PHYSICS
2017 SCORING GUIDELINES

General Notes About 2017 AP Physics Scoring Guidelines

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. The requirements that have been established for the paragraph length response in Physics 1 and Physics 2 can be found on AP Central at https://secure-media.collegeboard.org/digitalServices/pdf/ap/paragraph-length-response.pdf.

3. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong, e.g., a speed faster than the speed of light in vacuum.

4. Implicit statements of concepts normally receive credit. For example, if use of the equation expressing a particular concept is worth one point, and a student's solution embeds the application of that equation to the problem in other work, the point is still awarded. However, when students are asked to derive an expression it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the exam equation sheet. For a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each, see "The Free-Response Sections—Student Presentation" in the *AP Physics; Physics C: Mechanics, Physics C: Electricity and Magnetism Course Description* or "Terms Defined" in the *AP Physics 1: Algebra-Based and AP Physics 2: Algebra-Based Course and Exam Description*.

5. The scoring guidelines typically show numerical results using the value $g = 9.8\ \text{m/s}^2$, but use of $10\ \text{m/s}^2$ is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

6. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

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Question 4

7 points total **Distribution of points**

(a) 3 points

Correct answer: "No"
Note: If the wrong answer is selected, partial credit can be earned for the justification.

For attempting to use conservation of energy to compare the two blocks — 1 point
For explicitly or implicitly indicating that the launch velocities are different — 1 point
For stating or implying that the time to reach the ground is the same for both blocks — 1 point

Example: The amount of potential energy converted to kinetic energy is different for the two blocks. The potential energy is proportional to the change in height, which is smaller for block 2. Therefore, at the edge of the table, block 1 will have more kinetic energy than block 2, and hence a larger speed. The launches are both horizontal and from the same height, so the blocks will spend the same amount of time in the air. Because $d = vt$, the distances will be different for the two blocks (as the speeds are different).

(b)

i. 2 points

Correct answer: "The two blocks land the same distance from their respective tables."

For indicating that the change in potential energy from release to launch is the same for the two cases — 1 point
For an indication (explicit or implicit) that the launch velocities are the same — 1 point

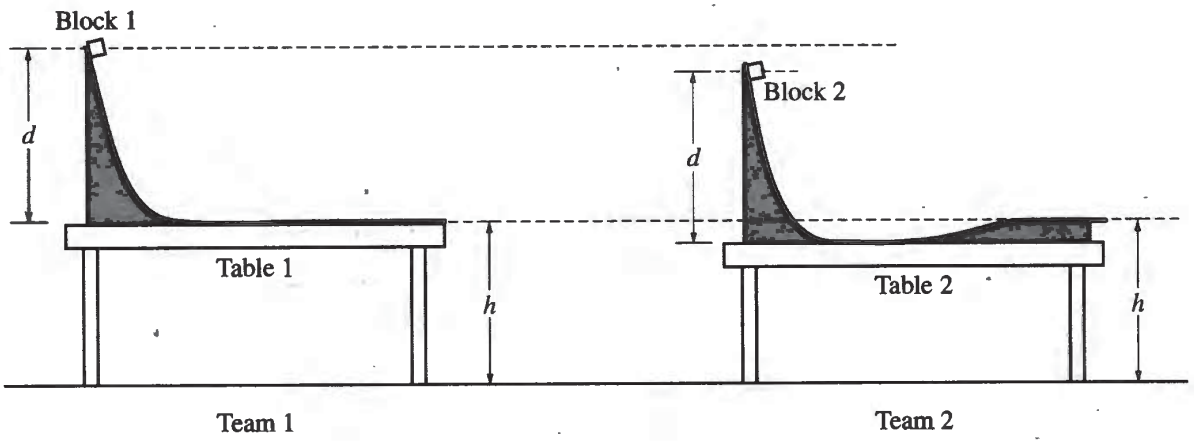
ii. 2 points

Correct answer: "Block 1"

For indicating that the average speed or velocity on the slide is higher for Team 1, OR that block 1 reaches its maximum speed in less time — 1 point
For a valid explanation of why the average speed or velocity is higher for team 1, OR why block 1 reaches its maximum speed in less time — 1 point

Example: Because the ramp on Table 1 is initially steeper, block 1 has a higher average speed while it's on the ramp so it launches off the table before block 2.

P1 Q4 A1



4. (7 points, suggested time 13 minutes)

A physics class is asked to design a low-friction slide that will launch a block horizontally from the top of a lab table. Teams 1 and 2 assemble the slides shown above and use identical blocks 1 and 2, respectively. Both slides start at the same height d above the tabletop. However, team 2's table is lower than team 1's table. To compensate for the lower table, team 2 constructs the right end of the slide to rise above the tabletop so that the block leaves the slide horizontally at the same height h above the floor as does team 1's block (see figure above).

(a) Both blocks are released from rest at the top of their respective slides. Do block 1 and block 2 land the same distance from their respective tables?

____ Yes __✓__ No

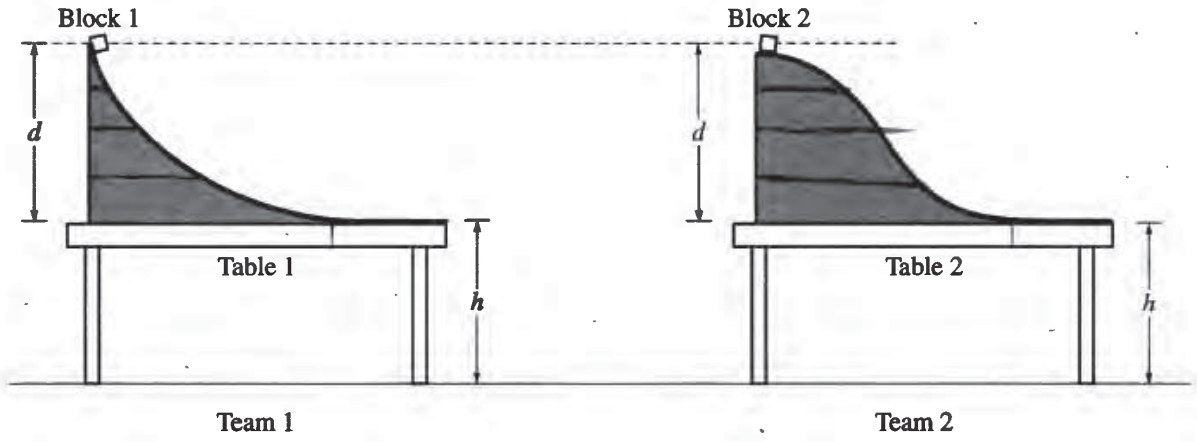
Justify your answer.

For team 1, all of the block's potential energy, gets converted into kinetic energy. This is also true for team 2, However with team 2, the block has less initial potential energy than team 1, therefore it has less kinetic energy at height h. This results in less velocity at height h for team 2 so a shorter distance travelled b/c both blocks are in the air for the same amount of time.

b/c it travels a shorter not vertical distance to h,

P1 Q4 A2

In another experiment, teams 1 and 2 use tables and low-friction slides with the same height. However, the two slides have different shapes, as shown below.



(b) Both blocks are released from rest at the top of their respective slides at the same time.

i. Which block, if either, lands farther from its respective table?

____ Block 1 ____ Block 2 ___✓___ The two blocks land the same distance from their respective tables.

Briefly explain your reasoning without manipulating equations.

Even though the slides have different heights, the changes in height are the same so they have the same potential energy at the start, and kinetic energy at the end. Since they launch from the same height h, they are in the air for the same amount of time and go the same distance.

ii. Which block, if either, hits the floor first?

___✓___ Block 1 ____ Block 2 ____ The two blocks hit the floor at the same time.

Briefly explain your reasoning without manipulating equations.

Block 1 travels a shorter horizontal distance on the table before reaching its maximum speed than block 2. This means it reaches the end of the table before block 2 and hits the ground first because they are in the air for the same amount of time.

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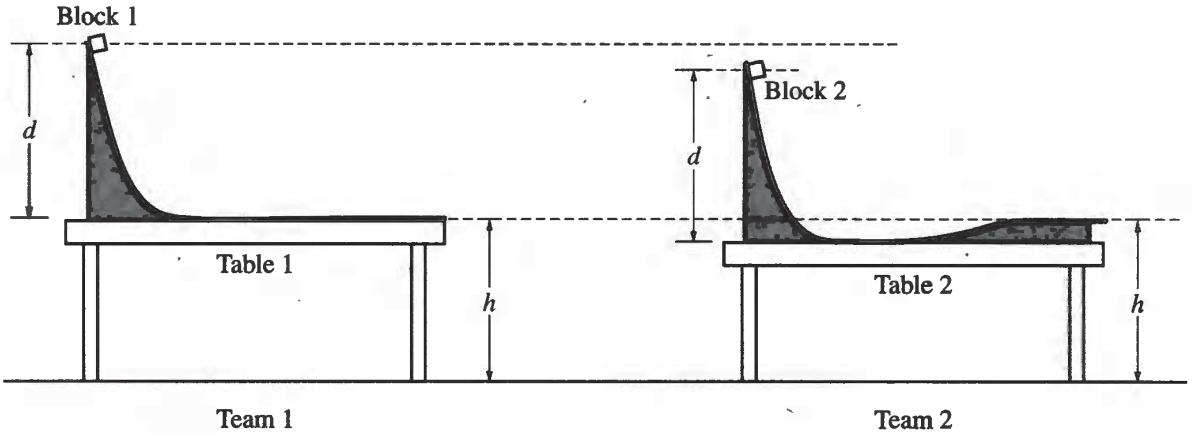
P1 Q4 B1



4. (7 points, suggested time 13 minutes)

A physics class is asked to design a low-friction slide that will launch a block horizontally from the top of a lab table. Teams 1 and 2 assemble the slides shown above and use identical blocks 1 and 2, respectively. Both slides start at the same height d above the tabletop. However, team 2's table is lower than team 1's table. To compensate for the lower table, team 2 constructs the right end of the slide to rise above the tabletop so that the block leaves the slide horizontally at the same height h above the floor as does team 1's block (see figure above).

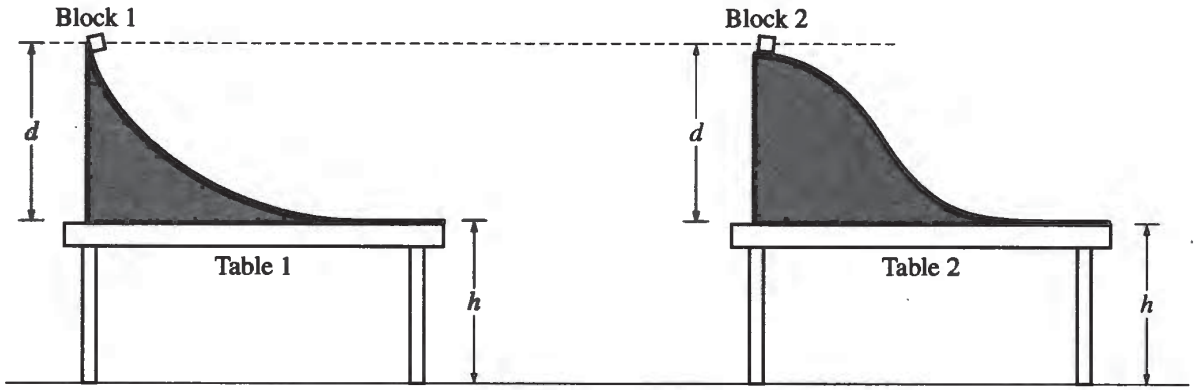
(a) Both blocks are released from rest at the top of their respective slides. Do block 1 and block 2 land the same distance from their respective tables?

____ Yes ___√___ No

Justify your answer.

For team 1, the entire distance d is used. This means that the entire potential energy of block 1 will be converted to kinetic energy. Team 2, however, has an area where d and h overlap. The total distance of d is not used, and as a result, the entire potential energy of block 2 is not converted into kinetic energy. Since the blocks are identical, block 2 will have a lower velocity than block 1 due to block 2's lower kinetic energy. Block 1 and 2 spend the same amount of time in the air since they are launched a height of h above the ground.

In another experiment, teams 1 and 2 use tables and low-friction slides with the same height. However, the two slides have different shapes, as shown below.



(b) Both blocks are released from rest at the top of their respective slides at the same time.

i. Which block, if either, lands farther from its respective table?

____ Block 1 ____ Block 2 ✓ The two blocks land the same distance from their respective tables.

Briefly explain your reasoning without manipulating equations.

Both blocks have the same potential energy due to having the same height d above the table. They are launched at the same angle. Both blocks will have the same kinetic energy, and thus the same velocity due to the blocks being identical, at the bottom of the slide. Both are in projectile motion for the same amount of time due to being launched from the same height. Thus, they will have the same landing distance. $x = vt$

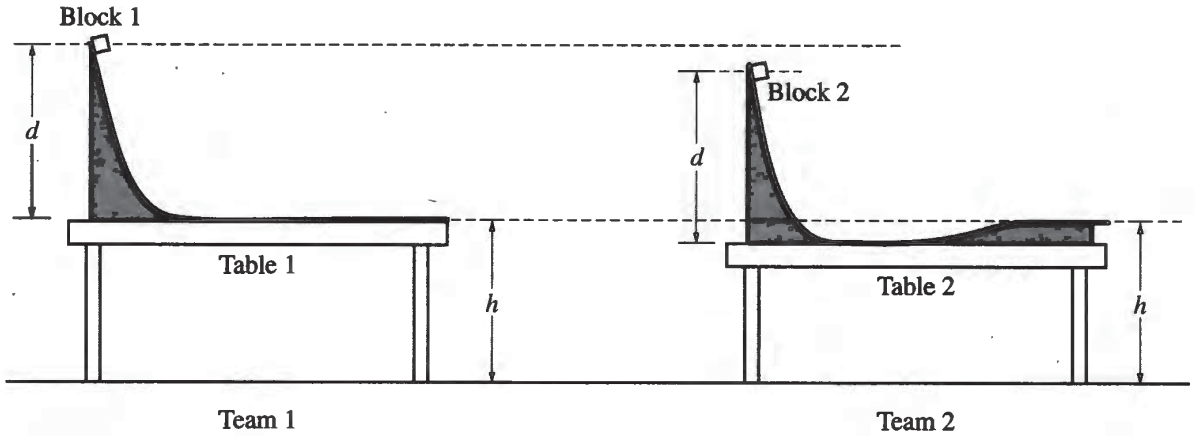
ii. Which block, if either, hits the floor first?

____ Block 1 ____ Block 2 ✓ The two blocks hit the floor at the same time.

Briefly explain your reasoning without manipulating equations.

$y = y_0 + v_{y_0}t + \frac{1}{2}a_y t^2$. Both are launched from the same starting height. They have the same velocity in the y direction due to being launched at the same angle, thus giving them the same amount of time in projectile motion.

P1 Q4 C1



4. (7 points, suggested time 13 minutes)

A physics class is asked to design a low-friction slide that will launch a block horizontally from the top of a lab table. Teams 1 and 2 assemble the slides shown above and use identical blocks 1 and 2, respectively. Both slides start at the same height d above the tabletop. However, team 2's table is lower than team 1's table. To compensate for the lower table, team 2 constructs the right end of the slide to rise above the tabletop so that the block leaves the slide horizontally at the same height h above the floor as does team 1's block (see figure above).

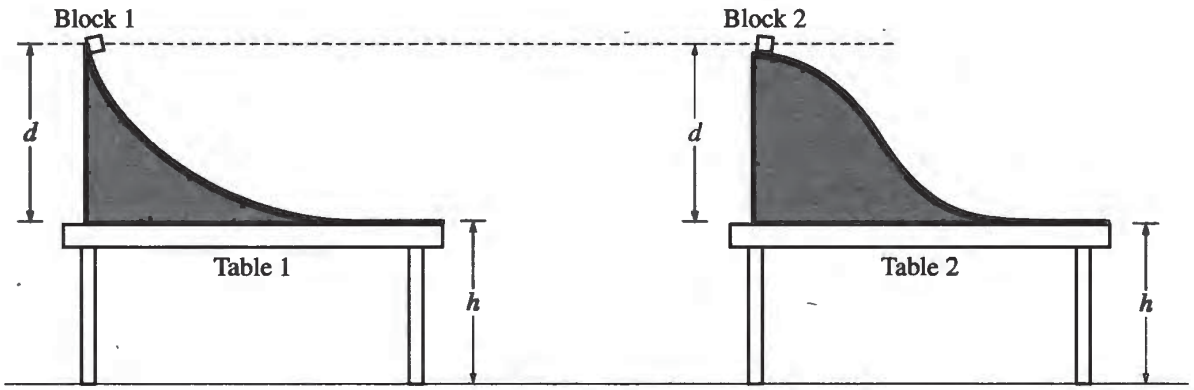
(a) Both blocks are released from rest at the top of their respective slides. Do block 1 and block 2 land the same distance from their respective tables?

___ Yes ___✓ No

Justify your answer.

The distribution of the types of energy is different for Team 1 and Team 2. In Team 1's design, the block has gravitational potential energy and kinetic energy, which equals kinetic energy. In Teams 2's design, the block has gravitational potential energy and kinetic energy, which equals kinetic energy and gravitational potential energy. Due to the varying forms of final energy, the blocks don't land the same distance from their respective tables.

In another experiment, teams 1 and 2 use tables and low-friction slides with the same height. However, the two slides have different shapes, as shown below.



(b) Both blocks are released from rest at the top of their respective slides at the same time.

i. Which block, if either, lands farther from its respective table?

___ Block 1 ___ Block 2 ___ The two blocks land the same distance from their respective tables.

Briefly explain your reasoning without manipulating equations.

Block 1 continues to rapidly increase in kinetic energy, while decreasing in gravitational potential energy. Block 2 begins with much more gravitational potential energy until the slide becomes steeper. Then, the increased amount in kinetic energy means the velocity of block 1 is greater than that of block 2. Therefore, block 1 lands farther because the greater the speed at the end of the ramp, the greater the distance.

ii. Which block, if either, hits the floor first?

___ Block 1 ___ Block 2 ___ The two blocks hit the floor at the same time.

Briefly explain your reasoning without manipulating equations.

The time it takes for the blocks to hit the floor depends on the height of the drop. Since both objects drop the same height, and the acceleration due to gravity is constant, the blocks hit the floor at the same time.

AP® PHYSICS 1
2017 SCORING COMMENTARY

Question 4

Overview

This question assessed learning objectives 3.A.1.1, 4.C.1.1, 4.C.1.2, 5.B.3.3, 5.B.4.1, 5.B.4.2, and 5.B.5.4. The responses to this question were expected to demonstrate the following:

- Understanding conservation of energy for an object moving through a height change.
- Recognizing when to treat a problem from an energy point of view.
- Recognizing that the time of flight for a horizontal projectile depends only on the height at launch.
- Understanding that the change in gravitational potential energy is path independent, dependent only on net height change.
- The ability to select an appropriate reference point for potential energy.

Sample: P1 Q4 A
Score: 6

Part (a) earned full credit for correctly using conservation of energy, concluding that the blocks leave the ramp with different velocities, and stating that the time in the air is the same for both cases. Full credit was earned in part (b)(i) for indicating that the change in potential energy is the same for both cases, and the launch velocities are the same for both cases. Part (b)(ii) earned 1 point for indicating that block 1 reaches its maximum speed before block 2, but it does not provide a valid physical reason.

Sample: P1 Q4 B
Score: 5

Part (a) earned full credit for correctly using conservation of energy, concluding that the blocks leave the ramp with different velocities, and stating that the time in the air is the same for both cases. Full credit was earned in part (b)(i) for indicating that the change in potential energy is the same for both cases, and the launch velocities are the same for both cases. No credit was earned for part (b)(ii) because the incorrect conclusion is made, and only the time the blocks are in the air is discussed.

Sample: P1 Q4 C
Score: 1

Part (a) earned 1 point for correctly attempting to use conservation of energy but earned no additional credit because it does not address the launch velocities being different, or the time in the air being the same. Part (b)(i) earned no credit for an incorrect choice and incorrect reasoning. No credit was earned for part (b)(ii) because the incorrect conclusion is made and only the time the blocks are in the air is discussed.