2017

AP CollegeBoard

AP Physics 1: Algebra-Based

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 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.

Question 1

7 points total **Distribution of points**

(a) 2 points

Correct ranking: $(A = D = E) > (B = C)$ OR $A = D = E$, $B = C$

Note: A ranking must be given for any points to be earned for the explanation.

Note: The ranking must be correct to earn the full 2 points for the explanation.

For indicating $A = D = E$ in the ranking, with a valid explanation — 1 point

Example: "*A*, *D*, and *E* are all connected across the battery, so they must have the same ΔV as the battery."

For indicating $B = C$ in the ranking, with a valid explanation — 1 point

Example: "The same current flows through both bulbs *B* and *C*, so they have the same voltage drop across them. By Kirchhoff's voltage rule, the sum of the voltages in this circuit must add to zero, so each bulb has half the battery voltage."

Example 1: For each of bulbs *A*, *D*, and *E*, current can go around the circuit passing through only that bulb and the battery, and hence the potential drop across all three bulbs equals the voltage of the battery (because $\Delta V = 0$ for a complete loop). In circuit 2, *B* and *C* are in series so the overall potential drop (equal to the battery's voltage) is "shared" equally between the two bulbs (because they are identical) and the potential difference across each is half is the battery's voltage.

Example 2: *A*, *D*, and *E* are all connected directly across the battery terminals and therefore "get" the full battery potential difference. By contrast, the potential drop across the *BC* part of the circuit is "split" between *B* and *C*, and split equally.

Question 1 (continued)

Distribution of points

(b) 5 points

Correct answers: Circuit 3 runs out first, circuit 2 runs out last

Note: In the paragraph response, "energy dissipation" or "current" are acceptable substitutes for "power."

For indicating that all three circuits draw different amounts of power — 1 point

Note: This point may be earned by addressing only two circuits in the response.

For explaining that the battery in circuit 2 delivers the least power using correct physical reasoning by addressing potential difference OR resistance — 1 point

For explaining that the battery in circuit 3 delivers the most power using correct physical reasoning by addressing potential difference OR resistance — 1 point

For an implicit or explicit statement that greater power results in shorter battery life — 1 point

For a logical, relevant, and internally consistent argument that addresses the required argument or question asked, and follows the guidelines described in the published requirements for the paragraph-length response — 1 point

Example: The battery in circuit 3 runs out first, then the battery in circuit 1, and finally the battery in circuit 2. The power (rate of energy loss) of a battery is $P = I\Delta V$, and all three batteries have the same potential difference. So the rate of energy loss, and hence the order in which the batteries "die," is given by the ranking of the currents through the batteries. Circuit 3 has the most current because the availability of two paths (loops) makes the overall resistance of this circuit the lowest. Circuit 2 has the least current because there is only one loop, and it contains two bulbs, making the overall resistance greater than that of circuit 1.

Question 2

12 points total | **Distribution of points**

(a)

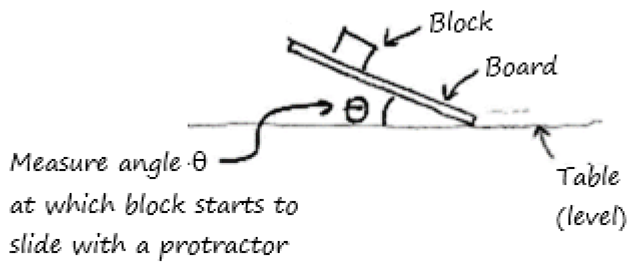
i. 3 points

For drawing a diagram of an experimental setup to measure the coefficient of friction that is feasible in a school physics lab — 1 point

For indicating the measurements necessary for calculating the coefficient of friction — 1 point

For indicating equipment necessary for measuring the quantities required to calculate the coefficient of friction — 1 point

Example:



ii. 3 points

For a description that is consistent with the diagram in part (a)(i), in enough detail that another student could replicate the experiment — 1 point

For a description that is a conceptually valid method to find quantities that would allow a calculation of a friction coefficient — 1 point

For including a valid method for reducing experimental error — 1 point

Example:

With the block at rest on the board, slowly lift one end of board until the block just begins to slide. Measure the angle between board and table and repeat several times with block at different locations on the board (with multiple trials at each location).

(b) 3 points

Note: In order to earn full credit for part (b), all terms (variables) must be indicated in the diagram and/or procedure of part (a).

For using Newton's second law (or reasoning in terms of zero net force) in one dimension, parallel to the board's surface, either explicitly or implicitly — 1 point

For using Newton's second law (or reasoning in terms of zero net force) in one dimension, perpendicular to the board's surface, either explicitly or implicitly — 1 point

Note: Replacing the normal force with mg is "implicit" use of Newton's second law in the perpendicular direction for a horizontal surface. For a tilted surface, the appropriate trigonometric term should be included.

For a correct derived expression of the coefficient of static friction in terms of quantities indicated in part (a) — 1 point

Question 2 (continued)

	Distribution of points
(c) 2 points	
Correct answer: "The static and kinetic coefficients are not equal." Reasoning cannot earn credit if the incorrect selection is made.	
For identifying group 5's results as outliers, or indicating the presence of an outlier	1 point
For a conclusion that coefficients are not the same, justified by either removing the outlier or noting the coefficients are different for each group	1 point
(d) 1 point	
For a valid argument that indicates the coefficient of static friction is a property of the two surfaces, and is consistent with the selected answer	1 point

Example 1: Selects "Remain the same"
Referring to the equation in part (b), coefficient does not depend on mass.
Example 2: Selects "Remain the same"
The coefficient depends on the nature of the surfaces involved, not the masses or normal force of the objects involved.
Example 3: Selects "Decrease"
The increased normal force will cause smoothing of the surfaces, decreasing the coefficient of friction.
Example 4: Selects "Increase"
The increased normal force will cause the surfaces to become gouged, increasing the coefficient of friction.

Question 3

12 points total | **Distribution of points**

(a) 1 point

Correct answer: "To the right of *C*"
Reasoning cannot earn credit if the incorrect selection is made.

For an explanation that the torque exerted by the disk or the angular momentum of the disk is greater when farther from the pivot — 1 point

Example 1: The disk exerts a greater torque on the rod when it pushes the rod farther from the pivot.
Example 2: The disk has greater angular momentum when it's farther from the pivot. The disk loses almost all its speed during the collision and hence gives the rod almost all its angular momentum. So the rod ends up with more angular momentum when the disk hits it farther from the pivot.

(b) 2 points

Correct answer: "Yes"
If "No" is selected, the explanation may still earn full credit if an incorrect selection was made in part (a).

For a selection consistent with the selection from part (a) — 1 point
For indicating that the equation shows that ω increases with increasing x — 1 point

Example: According to the equation, ω increases with x; a bigger x produces a bigger angular speed. This agrees with my reasoning from part (a), where I said a bigger x creates a bigger angular speed after the collision.

(c) 3 points

For focusing on functional dependence (instead of, for example, considering units/dimensions) — 1 point
For addressing m_{disk}, I, or both — 1 point
For correctly concluding that the equation is wrong because of the dependence on m_{disk}, I, or both — 1 point

Example: If m_{disk} is large, then more angular momentum will be transferred during the collision. But the equation shows the angular speed decreasing with increasing m_{disk}, because it is in the denominator.

Question 3 (continued)

	Distribution of points
(d) 4 points	
For using an expression of conservation of angular momentum for the disk and rod Note: This point is not awarded for equating angular and linear momentum.	1 point
For indicating that the initial angular momentum of the system is equal to $m_{\text{disk}} v_0 x$	1 point
For a dimensionally correct expression for the post-collision angular momentum that includes $I\omega$	1 point
For indicating the correct rotational inertia of the system after the collision: $I + m_{\text{disk}} x^2$	1 point
(e) 2 points	
Correct answer: "Greater than"	
For indicating, either directly or by analogy to the linear case, that the disk's angular momentum with respect to the pivot changes more in the bouncy scenario than in the original scenario OR for using a similar argument in terms of impulse Note: This point is for describing what happens to the disk.	1 point
For using conservation of angular momentum or momentum-impulse reasoning to conclude that the rod gains more angular momentum, and hence more angular speed, in the bouncy scenario Note: This point is for describing what happens to the rod.	1 point
Example: After the bouncy collision, the disk has angular momentum in the clockwise direction. To keep the system angular momentum constant, the magnitude of the rod's counterclockwise angular momentum must be greater than before.	

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"

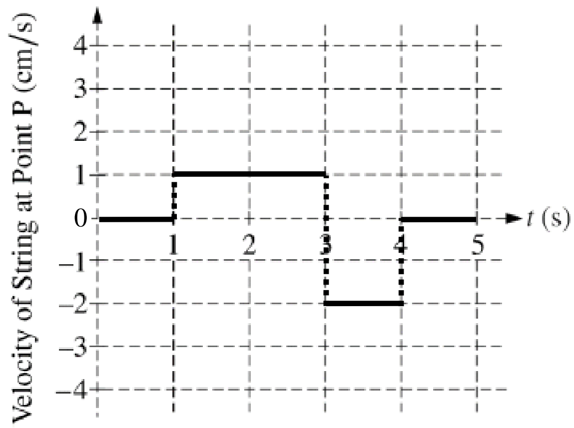
For indicating that the average speed or velocity on the slide is higher for Team 1, OR that block 1 reaches its maximum speed in less time	1 point
For a valid explanation of why the average speed or velocity is higher for team 1, OR why block 1 reaches its maximum speed in less time	1 point

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.

Question 5

7 points total **Distribution of points**

(a) 3 points

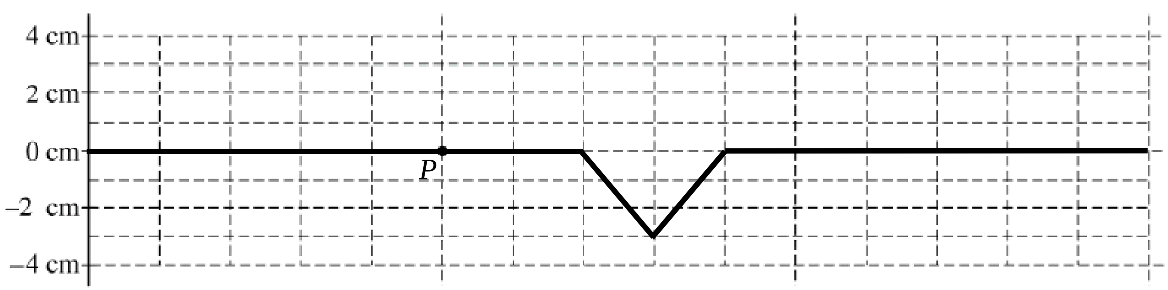


For indicating zero velocity for $0 < t < 1$ s and $4 \text{ s} < t < 5$ s — 1 point

For indicating two different non-zero constant velocities, one at the interval $1 \text{ s} < t < 3 \text{ s}$ and the other at the interval $3 \text{ s} < t < 4 \text{ s}$ — 1 point

For indicating a maximum velocity of $+1$ cm/s and a minimum velocity of -2 cm/s — 1 point

(b) 4 points



For drawing a single pulse and zero elsewhere — 1 point

For drawing a single pulse that is triangular (need not be isosceles or of two-unit extent) — 1 point

For drawing a single pulse with the correct maximum displacement from equilibrium of -3 cm — 1 point

For drawing a single pulse at the correct location that is two units wide between the 7th and 9th grid lines (i.e., 2 grid lines to the right of *P* to 4 grid lines to the right of *P*) and zero elsewhere — 1 point