
Multiple-Choice Answer Key

The following contains the answers to the multiple-choice questions in this exam.

**Answer Key for AP Physics 1
Exam, Section I**

Question 1: C	Question 21: D
Question 2: A	Question 22: D
Question 3: C	Question 23: D
Question 4: C	Question 24: C
Question 5: D	Question 25: C
Question 6: *	Question 26: A
Question 7: C	Question 27: C
Question 8: B	Question 28: D
Question 9: B	Question 29: C
Question 10: D	Question 30: C
Question 11: B	Question 31: C
Question 12: B	Question 32: D
Question 13: D	Question 33: A
Question 14: D	Question 34: D
Question 15: D	Question 35: B
Question 16: A	Question 36: C
Question 17: B	Question 131: B, C
Question 18: D	Question 132: A, B
Question 19: A	Question 133: A, C
Question 20: A	Question 134: B, C

*Item 6 was not scored.

Free-Response Scoring Guidelines

The following contains the scoring guidelines
for the free-response questions in this exam.

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GENERAL NOTES ABOUT 2015 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. 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.
3. 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 contains the application of that equation to the problem but the student does not write the basic equation, 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*.
4. 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.
5. 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 1

7 points total

**Distribution
of points**

(a) 3 points

For any application of conservation of energy

1 point

For correctly applying conservation of energy for each cart

1 point

For any application of conservation of momentum

1 point

Example 1: The contributions of each cart to the potential energy of the carts-Earth system when the carts are at their points of release are the same, because one has twice the height and one has twice the mass of the other. All this potential energy is converted into kinetic energy when the carts reach the bottom of the ramp, so the carts have the same kinetic energy there. This means that the speed of cart A is 1.4 times the speed of Cart B. Before the collision, cart A has a momentum of about $1.4Mv$ to the right; cart B has a momentum of $2Mv$ to the left. The net momentum is to the left, so after the collision the carts move left.

Example 2:

$$Mg(2H) = Mv_A^2/2 ; \quad v_A^2 = 4gH ; \quad v_A = 2\sqrt{gH}$$

$$2Mg(H) = (2M)v_B^2/2 ; \quad v_B^2 = 2gH ; \quad v_B = \sqrt{2gH}$$

$$M(2\sqrt{gH}) - 2M(\sqrt{2gH}) = (M + 2M)v_f = 3Mv_f$$

$$v_f = \left(\frac{2 - 2\sqrt{2}}{3} \right) \sqrt{gH} = -\frac{0.83}{3} \sqrt{gH} = -0.28\sqrt{gH}$$

One earned point is deducted for any incorrect use of ramp angles.

(b)

i. 2 points

For indicating that no energy is gained as the carts move down the ramps, or using the result of the reasoning in part (a) regarding the energy for this part of the motion

1 point

For indicating that energy is dissipated in the collision and a comparison of initial and final energies consistent with the students' assumptions about energy before the collision

1 point

ii. 2 points

For indicating that the initial mechanical energy of the carts is zero

1 point

For a comparison with the energy after the collision consistent with previous responses

1 point

Example: When the carts are released, they have no mechanical energy, since they are not moving. After the collision, the carts have kinetic energy. The total mechanical energy of the cart-cart system increases.

Alternate solution

Alternate points

For identifying gravitational force as the only external force doing work

1 point

For correct use of the work-kinetic energy theorem

1 point

Example: For the system of just the two carts, there is no initial mechanical energy, since the carts are at rest. The gravitational force exerted on the carts by Earth is the only external force doing work, and the work on the system is positive. So the kinetic energy of the system increases, which increases the total mechanical energy.

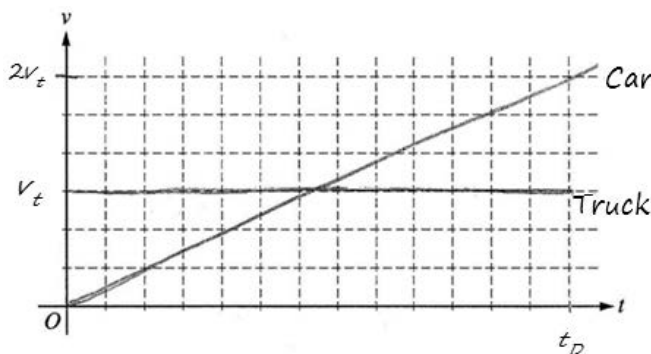
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Question 2

12 points total

**Distribution
of points**

(a) 3 points



For a clearly labeled horizontal line for the truck
 For a clearly labeled straight line with positive slope for the car
 For the speed of the car ending higher than the speed of the truck at a time labeled
 to indicate that the house has been reached

1 point
 1 point
 1 point

(b)
 i. 2 points

For indicating that student 1 is correct that the car and truck travel the same distance
 in the same time
 For identifying a feature of the graph that supports this: e.g., the area under both curves
 is the same, or the visual average of the speed of the car is the same as the speed of
 the truck

1 point
 1 point

ii. 2 points

For indicating that student 2 is correct that the car's speed is greater when the vehicles
 are in front of the house
 For identifying a feature of the graph that supports this: e.g., the final speed of the car
 is twice the speed of the truck

1 point
 1 point

(c) 3 points

For indicating that the final speed of the car is twice the speed of truck
 For applying any other appropriate kinematic relationship(s)

1 point
 1 point

$$(2v_t)^2 = v_{c0}^2 + 2aD$$

For solving for the acceleration in terms of D and v_t

1 point

$$a = 2v_t^2/D$$

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Question 2 (continued)

		Distribution of points
(d)	2 points	
	For indicating that the car and truck have the same speed at $t = t_D/2$	1 point
	For a correct justification	1 point
	Examples:	
	That's where the graphs intersect.	
	At t_D the car's speed is twice the truck's speed, so they'll be equal at $t_D/2$.	

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Question 3

12 points total

**Distribution
of points**

(a) 3 points

For describing a method for setting and changing the tension in the string (e.g., hanging the string over a pulley and attaching an object whose mass has been measured, then using objects of different mass) 1 point

For using the oscillator to create a wave on the string, adjusting the frequency of the oscillator or the length of the string for each tension until a standing wave is established 1 point

For describing a method for measuring quantities relevant to determining the wavelength of the standing wave formed on the string (e.g., measuring the length of the string with a meter stick and counting the number of nodes) 1 point

(b) 3 points

For describing a correct method of calculating the propagation speed of the wave which includes either measurement or calculation of the wavelength of the standing wave 1 point

For describing a correct method of calculating or measuring tension (e.g., when using objects of different mass, calculate $F_T = mg$) 1 point

For describing a correct method of analyzing the relationship between the wave velocity and tension (e.g. graph velocity as a function of tension) 1 point

(c) 2 points

For a reasonable attempt to check whether velocity and tension are directly proportional 1 point

For a valid justification leading to the conclusion that velocity and tension are not directly proportional (e.g., best-fit line for a plot of the data does not go through zero; doubling tension does not result in doubled propagation speed) 1 point

(d)

i. 2 points

The oscillator is doing work on the string.

For indicating that oscillator generates the wave by applying a force to the string over a distance 1 point

For indicating that work is the product of the applied force and the distance over which it is applied 1 point

Alternate solution

Alternate points

For indicating that resistive forces will take energy away from the string 1 point

For indicating that if the amplitude is constant the oscillator is supplying energy by doing work on the string 1 point

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Question 3 (continued)

		Distribution of points
(d)	(continued)	
ii.	2 points	
The string is not gaining mechanical energy.		
For indicating that the energy carried by a mechanical wave is related to its amplitude, and having no incorrect or irrelevant statements		1 point
For indicating that the wave does not gain mechanical energy because its amplitude is constant		1 point

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Question 4

7 points total

**Distribution
of points**

(a) 2 points

The correct answer is “Less than”.

For a correct justification leading to a correct conclusion

2 points

Example: The current through R_2 when the switch is open is less than when the switch is closed, because the total resistance of the circuit with the switch closed is less.

Note: One point can be earned for a reasonable but incorrect justification that is correctly used.

Examples:

The current through R_2 is the same when the switch is open or when the switch is closed, because regardless of whether the switch is open or closed, any current that is split between R_1 and AB must combine again as it moves through R_2 .

The current through R_2 when the switch is open is greater than when the switch is closed, because closing the switch adds an additional path for current flow.

(b) 5 points

When the switch is open:

For indicating that there is a potential difference across R_1 because the full current through the battery flows through the resistor

1 point

For indicating that the potential difference across the switch is equal to the potential difference across R_1

1 point

When the switch is closed:

For indicating that the resistance of the switch is zero or negligible, or assuming the switch has resistance and indicating that the resistance of the parallel combination of the switch and resistor is less than that of the resistor alone

1 point

For indicating implicitly or explicitly that the potential difference across the switch is zero (or negligible), because all (or some) current goes through the switch that has no (or little) resistance and zero (or little) current goes through R_1

1 point

For a complete explanation having no incorrect or physically irrelevant statements and indicating that the potential difference across the switch is greater when the switch is open

1 point

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Question 5

7 points total

**Distribution
of points**

(a)

i. 2 points

For indicating that the mechanical energy of the car-Earth system is constant between point A and the highest point in the car's trajectory 1 point

For indicating that the car is still moving at its highest point and has some kinetic energy so the car-Earth system must have less gravitational potential energy, therefore must be at a lower height than it was at point A 1 point

ii. 2 points

For indicating that the velocity of the car at its highest point is equal to the horizontal speed at point B 1 point

For stating that the speed at the highest point is $v_B \cos \theta$ 1 point

(b) 3 points

For implicitly or explicitly applying conservation of energy 1 point

For implicitly or explicitly indicating that the gravitational potential energy is the same at the beginning and at the end 1 point

For indicating that the speed is the same at the beginning and at the end, so $v_A = v_B \cos \theta$, or consistent with the answer in part (a-ii) 1 point