2026

BURKE TUTORING

AP® Physics 1: Kinematics

Practice Multiple-Choice Questions

Twenty questions in the format of the 2015 to 2024 exam, with an answer sheet, an answer key, and an explanation for every question.

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Online version: burketutoringinfremont.com/ap-physics-1-kinematics-mcq/

SECTION I: MULTIPLE CHOICE

AT A GLANCE

TOTAL TIME
36 minutes

NUMBER OF QUESTIONS
20

ANSWER CHOICES
4 per question

WRITING INSTRUMENT
Pencil

ELECTRONIC DEVICE
Calculator allowed

INSTRUCTIONS

This booklet contains 20 multiple-choice questions on Unit 1 of AP Physics 1. Mark your answers on the answer sheet on page 3. You may write notes and scratch work anywhere in the booklet.

Questions 1 to 18 have one correct answer each. Questions 19 and 20 have two correct answers each, and both must be marked to earn credit for the question.

Each correct answer earns one point. No points are taken off for incorrect answers, so mark an answer for every question.

Use $g = 9.8\ \text{m/s}^2$ and treat air resistance as negligible unless a question says otherwise.

Work at a steady pace. If a question is taking too long, mark your best answer, circle the question number, and come back to it if time remains.

The answer key and an explanation for every question begin on page 12.

REFERENCE FOR THIS SET

$v = v_0 + at$

$v^2 = v_0^2 + 2a\Delta x$

$v_{0x} = v_0 \cos\theta$

$\Delta x = v_0 t + \frac{1}{2}at^2$

$\Delta x = \frac{1}{2}(v_0 + v)t$

$v_{0y} = v_0 \sin\theta$

The four constant-acceleration equations apply only while the acceleration is constant. They are explained in the AP Physics 1 kinematics study guide: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#equations. College Board's full AP Physics 1 equation sheet is posted at apcentral.collegeboard.org/media/pdf/ap-physics-1-equations-sheet.pdf.

Review pages for these topics: free fall problems guide, burketutoringinfremont.com/ap-physics-1-free-fall-problems/, and kinematics FRQ practice, burketutoringinfremont.com/ap-physics-1-kinematics-frq/.

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ANSWER SHEET

AP Physics 1: Kinematics · Practice Multiple-Choice Questions

Name _____ **Date** _____ **Score (out of 20)** _____

1	A	B	C	D	**11**	A	B	C	D	
2	A	B	C	D	**12**	A	B	C	D	
3	A	B	C	D	**13**	A	B	C	D	
4	A	B	C	D	**14**	A	B	C	D	
5	A	B	C	D	**15**	A	B	C	D	
6	A	B	C	D	**16**	A	B	C	D	
7	A	B	C	D	**17**	A	B	C	D	
8	A	B	C	D	**18**	A	B	C	D	
9	A	B	C	D	**19**	A	B	C	D	Mark two answers
10	A	B	C	D	**20**	A	B	C	D	Mark two answers

Fill in one circle for each of Questions 1 to 18. Fill in two circles for each of Questions 19 and 20. If you change an answer, erase the first mark completely.

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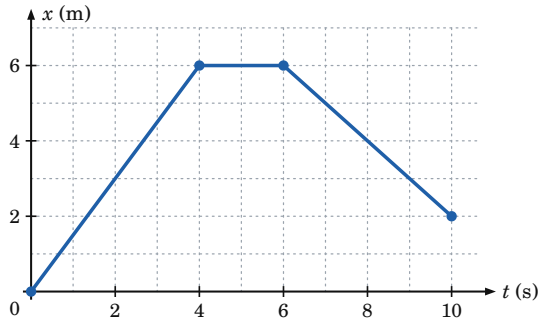
PHYSICS 1: KINEMATICS · SECTION I

Time: 36 minutes · 20 Questions

Directions: Each of Questions 1 to 18 is followed by four answer choices. Select the best answer in each case and fill in the matching circle on the answer sheet.

Note: Use $g = 9.8$ m/s^2. Rounding g to 10 m/s^2 leads to the same answer choices.

1. The graph shows the position x of a toy robot moving along a straight hallway as a function of time t.



What is the velocity of the robot at $t = 8$ s?

(A) –4.0 m/s

(B) –1.0 m/s

(C) +0.50 m/s

(D) +1.0 m/s

2. A camera records the position of a puck sliding across a floor every 0.20 s. The figure shows the images. The puck moves to the left, and its first image is the open circle at the right end.



KEY

○ First image of the puck

● Later images, taken 0.20 s apart

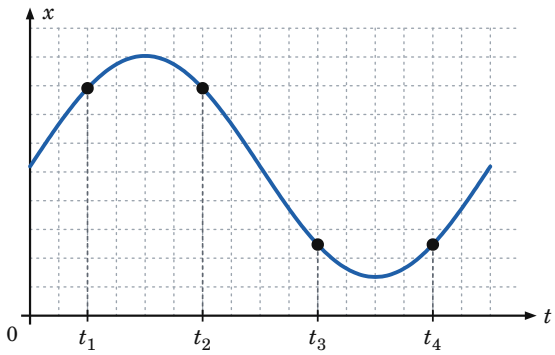
Which of the following correctly describes the directions of the puck's velocity and acceleration?

	Velocity	Acceleration
(A)	To the left	To the left
(B)	To the left	To the right
(C)	To the right	To the left
(D)	To the right	To the right

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GO ON TO THE NEXT PAGE.

3. The graph shows the position x of a cart on a straight track as a function of time t. Four times, t_1, t_2, t_3, and t_4, are marked.



At which of the marked times is the cart moving in the negative direction and slowing down?

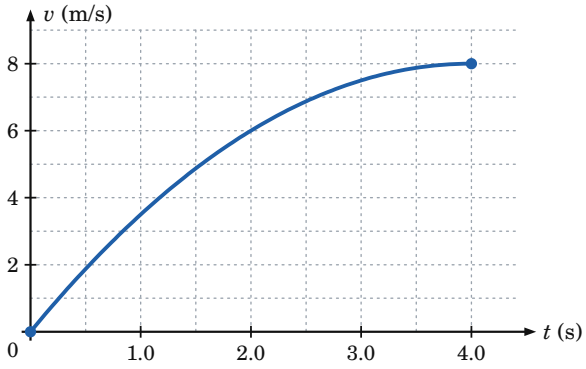
(A) t_1

(B) t_2

(C) t_3

(D) t_4

4. A sprinter starts from rest. The graph shows her velocity v as a function of time t for the first 4.0 s of a race.



Which of the following correctly compares the distance she runs in the first 4.0 s with 16 m?

(A) It is greater than 16 m, because the area under her velocity graph is greater than the area under a straight line from 0 to 8.0 m/s.

(B) It is equal to 16 m, because her average velocity is (0 + 8.0 m/s)/2.

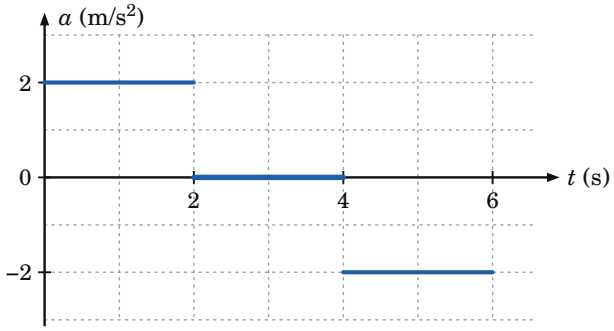
(C) It is less than 16 m, because her acceleration decreases during the 4.0 s.

(D) It cannot be determined without knowing her acceleration at each instant.

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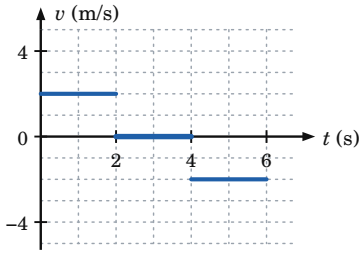
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5. A cart starts from rest at $t = 0$ and moves along a straight track. The graph shows its acceleration a as a function of time t.

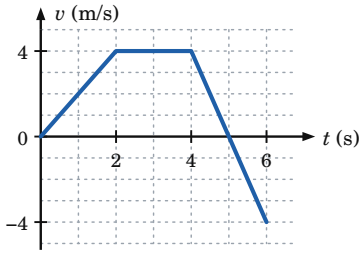


Which of the following graphs best represents the cart's velocity v as a function of time?

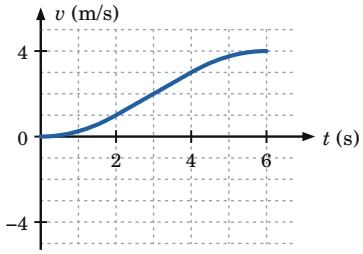
(A)



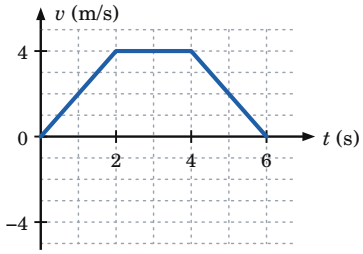
(B)



(C)



(D)



6. A cart starts from rest and moves along a straight track with constant acceleration. It takes time T to travel the first 1.0 m. How much additional time does it take to travel the next 1.0 m?

(A) $(\sqrt{2} - 1)T$

(B) $T/2$

(C) T

(D) $\sqrt{2}T$

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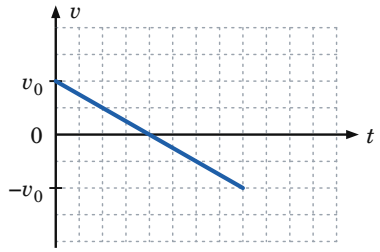
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7. A puck slides across a long horizontal table and slows down at a constant rate. When it starts with speed v, it slides a distance L and takes a time T to stop. On the same table, the puck starts with speed $2v$ and slows down at the same rate. Which of the following gives the distance it slides and the time it takes to stop?

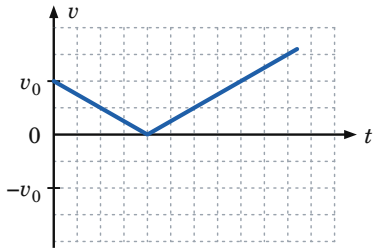
	Distance	Time
(A)	$2L$	$2T$
(B)	$2L$	$4T$
(C)	$4L$	$2T$
(D)	$4L$	$4T$

8. A ball is thrown straight up from the edge of a cliff with speed v_0. It rises, falls past the edge, and lands at the base of the cliff. Air resistance is negligible, and upward is the positive direction. Which of the following graphs best represents the ball's velocity v as a function of time t from release until just before it lands?

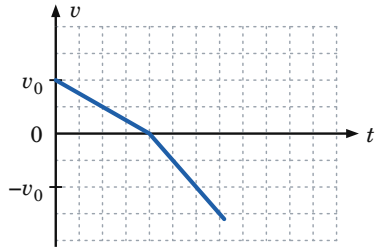
(A)



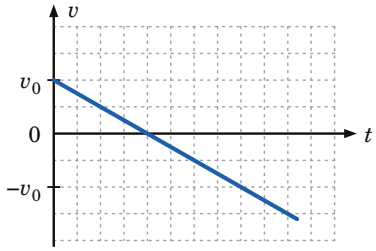
(B)



(C)



(D)

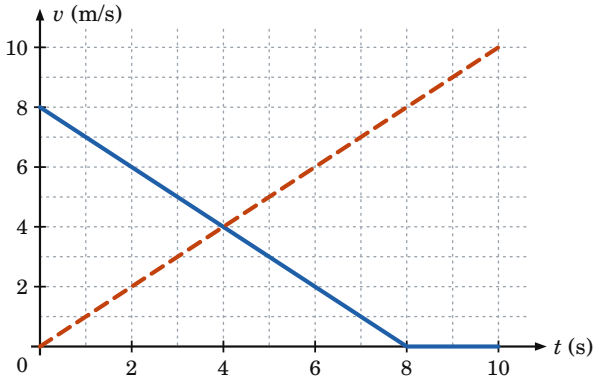


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Questions 9 and 10 refer to the following material.

Two carts, X and Y, move in the same direction on parallel straight tracks. At $t = 0$, the carts are side by side. The graph shows the velocity v of each cart as a function of time t.



9. Which of the following is true at $t = 4.0$ s?

(A) The carts are side by side.

(B) Cart Y is 16 m ahead of Cart X.

(C) Cart X is 8.0 m ahead of Cart Y.

(D) Cart X is 16 m ahead of Cart Y.

10. At what time are the carts side by side again?

(A) 4.0 s

(B) 6.9 s

(C) 8.0 s

(D) 10 s

11. A train moves east at 12 m/s relative to the ground. A passenger walks toward the back of the train at 1.5 m/s relative to the train. A cyclist on a road beside the tracks rides east at 6.0 m/s relative to the ground. What is the velocity of the passenger relative to the cyclist?

(A) 4.5 m/s east

(B) 4.5 m/s west

(C) 7.5 m/s east

(D) 10.5 m/s east

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12. A hot-air balloon rises straight up at a constant speed of 4.0 m/s. A passenger in the basket lets go of a small sandbag without throwing it. Air resistance on the sandbag is negligible. Which of the following correctly compares the motion of the sandbag as observed by the passenger and as observed by a person standing on the ground?

(A) Both observers see the sandbag start from rest, but they measure different accelerations.

(B) Both observers see the sandbag move upward at first, and both measure the same acceleration.

(C) The person on the ground sees the sandbag start from rest, and the passenger sees it move downward at 4.0 m/s at first.

(D) Both observers measure the same acceleration, but only the passenger sees the sandbag start from rest.

13. Ball X rolls off the edge of a horizontal table of height h with speed v. Ball Y rolls off the edge of a horizontal table of height $4h$ with speed $v/2$. Air resistance is negligible. How does the horizontal distance d_Y that ball Y travels before it hits the floor compare with the horizontal distance d_X traveled by ball X?

(A) $d_Y = d_X/2$

(B) $d_Y = d_X$

(C) $d_Y = 2d_X$

(D) $d_Y = 4d_X$

14. A ball is launched from level ground with a speed of 16 m/s at an angle of 60° above the horizontal. Air resistance is negligible. Which of the following gives the ball's speed and acceleration at the highest point of its path?

	Speed	Acceleration
(A)	0	9.8 m/s^2, downward
(B)	8.0 m/s	0
(C)	8.0 m/s	9.8 m/s^2, downward
(D)	14 m/s	9.8 m/s^2, downward

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15. Projectiles P and Q are launched from level ground. Projectile P is launched with speed $2v$ at 30° above the horizontal. Projectile Q is launched with speed $\sqrt{2}v$ at 45° above the horizontal. Air resistance is negligible. Which of the following correctly compares the times the projectiles spend in the air and their horizontal ranges?

	Time in the Air	Horizontal Range
(A)	Same for both	Same for both
(B)	Same for both	Greater for P
(C)	Greater for P	Greater for P
(D)	Same for both	Greater for Q

16. A delivery drone flies 160 m due north in 50 s, hovers in place for 15 s, and then flies 120 m due west in 35 s. What is the magnitude of the drone's average velocity for the entire 100 s?

(A) 2.0 m/s

(B) 2.4 m/s

(C) 2.8 m/s

(D) 3.3 m/s

17. A student drops a small steel ball from rest from several different heights h and uses an electronic timer to measure the time t the ball takes to fall to the floor. Air resistance is negligible. The student wants to graph the data so that the points fall on a straight line and then use the line to determine g. Which of the following should the student do?

(A) Graph h as a function of t. The value of g is equal to the slope.

(B) Graph h as a function of t^2. The value of g is equal to the slope.

(C) Graph $\sqrt{h}$ as a function of t. The value of g is equal to the square of the slope.

(D) Graph h as a function of t^2. The value of g is equal to twice the slope.

18. A ball is launched straight up from the ground with speed v_0 and rises to a maximum height H. Air resistance is negligible. At what height is the ball's speed equal to $v_0/2$?

(A) $H/4$

(B) $H/2$

(C) $3H/4$

(D) It depends on the value of v_0.

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Directions: For each of Questions 19 and 20, two of the answer choices are correct. Select both correct answers and fill in both matching circles on the answer sheet. A question earns credit only when both correct answers are selected.

19. A ball is launched from level ground at an angle above the horizontal and lands at the same height. Air resistance is negligible. Which of the following quantities have the same value just after launch and just before landing? Select two answers.

(A) The speed of the ball

(B) The vertical component of the ball's velocity

(C) The horizontal component of the ball's velocity

(D) The direction of the ball's velocity

20. A student wants to determine the acceleration of a cart that is released from rest and rolls down a ramp with constant acceleration. Which of the following sets of measurements, each used by itself, would allow the student to determine the acceleration? Select two answers.

(A) The cart's speed as it passes each of two marks on the ramp

(B) The distance from the release point to a mark, and the time the cart takes to reach that mark

(C) The mass of the cart, and the time the cart takes to reach a mark

(D) The distance from the release point to a mark, and the cart's speed as it passes that mark

STOP

END OF SECTION I

If you finish before time is called, check your work on this section. The answer key begins on the next page.

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Answer Key

Score one point for each correct answer. Questions 19 and 20 earn their point only when both correct answers are marked. An explanation for every question follows the table, with a link to the page on burketutoringinfremont.com that teaches the idea.

Question	Answer	Topic	What it tests
1	**(B)**	1.3	Velocity from a position-time graph
2	**(B)**	1.1	Directions of velocity and acceleration
3	**(C)**	1.3	Slowing down on a position-time graph
4	**(A)**	1.3	Distance from a curved velocity-time graph
5	**(D)**	1.3	From acceleration to velocity
6	**(A)**	1.2	Constant acceleration from rest
7	**(C)**	1.2	Stopping distance and stopping time
8	**(D)**	1.3	Velocity of a ball thrown up from a cliff
9	**(D)**	1.3	Equal velocities at one instant
10	**(C)**	1.3	When the carts meet again
11	**(A)**	1.4	Relative velocity on a train
12	**(D)**	1.4	Reference frames on a rising balloon
13	**(B)**	1.5	Horizontal launches from two heights
14	**(C)**	1.5	The top of a projectile's path
15	**(B)**	1.5	Two launches with the same vertical velocity
16	**(A)**	1.5	Average velocity in two dimensions
17	**(D)**	1.2	Finding g from lab data
18	**(C)**	1.2	Half the launch speed
19	**(A) and (C)**	1.5	Symmetry of a projectile's flight
20	**(B) and (D)**	1.2	Measurements that give acceleration

Unit 1 topics: 1.1 Scalars and vectors in one dimension · 1.2 Displacement, velocity, and acceleration · 1.3 Representing motion · 1.4 Reference frames and relative motion · 1.5 Vectors and motion in two dimensions.

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Explanations

Question 1: Velocity from a position-time graph — **Answer (B)**

Velocity is the slope of a position-time graph. From t = 6 s to t = 10 s the graph is a straight line from 6 m down to 2 m, so the slope is (2 m − 6 m)/(10 s − 6 s) = −1.0 m/s. A straight segment has the same slope at every point, so the velocity at t = 8 s is −1.0 m/s.

Why not (C)? +0.50 m/s is the position at 8 s divided by 8 s. That is the average velocity for the first 8 s, not the velocity at the instant t = 8 s.

Why not (A)? −4.0 m/s is the change in position during the last segment. It still has to be divided by the 4 s the change took.

Review: Motion graphs: slope and area in the AP Physics 1 kinematics study guide: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#graphs

Question 2: Directions of velocity and acceleration — **Answer (B)**

The puck moves to the left, so its velocity points left. The gaps between images get smaller in the direction of motion, so the puck covers less distance in each 0.20 s interval and is slowing down. An object slows down when its acceleration points opposite its velocity, so the acceleration points right.

Why not (A)? If the velocity and the acceleration both pointed left, the puck would be speeding up, and the gaps would grow from right to left.

Review: Motion diagrams and measured data in the motion graphs section of the AP Physics 1 kinematics study guide: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#graphs

Question 3: Slowing down on a position-time graph — **Answer (C)**

The slope of a position-time graph gives the velocity. The slope is negative at t_2 and at t_3, so the cart is moving in the negative direction at both times. At t_3 the graph is getting less steep as time goes on, so the speed is decreasing. The graph also curves upward there, which means the acceleration is positive, opposite to the negative velocity.

Why not (B)? At t_2 the slope is negative and getting steeper, so the cart is speeding up in the negative direction.

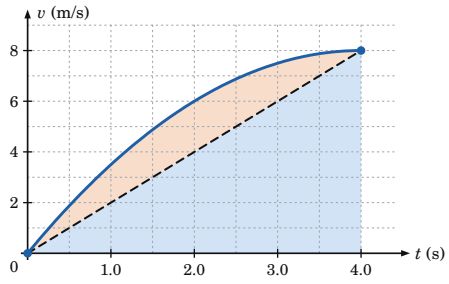
Why not (A)? At t_1 the cart is slowing down, but the slope is positive, so it is moving in the positive direction.

Review: Motion graphs: slope and area in the AP Physics 1 kinematics study guide: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#graphs

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Question 4: Distance from a curved velocity-time graph — Answer (A)

Distance is the area under the velocity-time graph. The value 16 m is the area of the triangle under a straight line from 0 to 8.0 m/s, which is the graph a constant acceleration would give. Her curve lies above that line at every time between 0 and 4.0 s, so the area under it is larger. For this curve the area is about 21 m.



KEY

- Sprinter's velocity
- Constant acceleration from 0 to 8.0 m/s
- Triangle under the dashed line: 16 m
- Extra area under the curve: about 5.3 m

Why not (B)? Averaging the starting and final velocities gives the average velocity only when the acceleration is constant. Her graph is curved, so her acceleration changes.

Why not (C)? Her acceleration does decrease, but it is largest at the start, so she reaches high speeds early and covers more ground than a steady acceleration to 8.0 m/s would.

Why not (D)? The graph already gives her velocity at every instant, which is all the area calculation needs.

Review: The constant-acceleration equations in the AP Physics 1 kinematics study guide, which lists when they apply: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#equations

Question 5: From acceleration to velocity — Answer (D)

The area under an acceleration-time graph gives the change in velocity. From 0 to 2 s the area is (2 m/s²)(2 s) = +4 m/s, so the velocity rises steadily from 0 to 4 m/s. From 2 s to 4 s the acceleration is zero, so the velocity stays at 4 m/s. From 4 s to 6 s the area is −4 m/s, so the velocity falls steadily back to 0.

Why not (A)? Choice (A) copies the shape of the acceleration graph. A constant, nonzero acceleration gives a sloped straight line on a velocity graph, not a flat one.

Why not (B)? In choice (B) the velocity changes by −8 m/s in the last 2 s, which would need an acceleration of −4 m/s².

Review: the slope and area table in the motion graphs section of the AP Physics 1 kinematics study guide: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#graphs

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Question 6: Constant acceleration from rest — **Answer (A)**

From rest with constant acceleration, $\Delta x = \frac{1}{2}at^2$, so the time to cover a distance is proportional to the square root of the distance. Reaching 2.0 m takes $\sqrt{2}T$, about $1.41T$. The second meter takes the difference, $\sqrt{2}T - T = (\sqrt{2} - 1)T$, about $0.41T$. The cart is moving faster during the second meter, so that meter takes less time.

Why not (D)? $\sqrt{2}T$ is the total time to travel 2.0 m from the start, not the time for the second meter alone.

Why not (C)? T would be correct only if the cart moved at constant speed.

Review: The constant-acceleration equations in the AP Physics 1 kinematics study guide: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#equations

Question 7: Stopping distance and stopping time — **Answer (C)**

Let a be the magnitude of the acceleration, so the puck's acceleration is $-a$. The stopping time comes from $v = v_0 - at$ with a final velocity of zero, which gives $t = v_0/a$. Doubling the starting speed doubles the time, to $2T$. The stopping distance comes from $v^2 = v_0^2 - 2a\Delta x$, which gives $\Delta x = v_0^2/(2a)$. Doubling the starting speed multiplies the distance by 4, to $4L$. As a check, the average speed doubles and the time doubles, so the distance grows by $2 \times 2 = 4$.

Why not (A)? Choice (A) treats the distance as proportional to the starting speed. That would hold only if the stopping time stayed the same.

Review: The constant-acceleration equations in the AP Physics 1 kinematics study guide, including the one that leaves out time: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#equations

Question 8: Velocity of a ball thrown up from a cliff — **Answer (D)**

In free fall the acceleration is $-g$ the whole time, including at the top, so the velocity graph is one straight line with a constant negative slope. The line crosses zero at the highest point. The ball passes the edge of the cliff moving downward at v_0 and keeps speeding up as it falls the extra height, so it lands with a speed greater than v_0. Choice (D) is the only single straight line that ends below $-v_0$.

Why not (A)? Choice (A) ends at $-v_0$, which describes a ball that lands at the height it was thrown from.

Why not (B)? Choice (B) shows speed, not velocity. With upward positive, the velocity is negative on the way down.

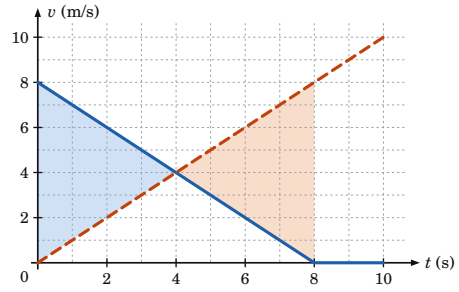
Why not (C)? Choice (C) changes slope at the top. The acceleration does not change there.

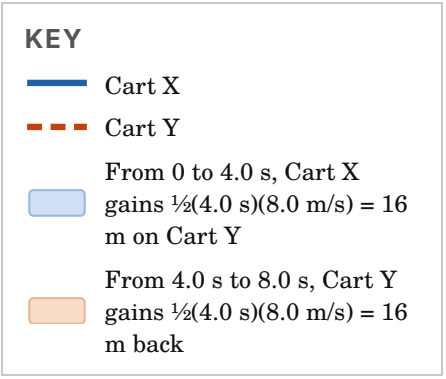
Review: Type 3: an object thrown straight up in the AP Physics 1 free fall problems guide: burketutoringinfremont.com/ap-physics-1-free-fall-problems/#thrown-up

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Question 9: Equal velocities at one instant — Answer (D)

At t = 4.0 s the two lines cross, so the carts have the same velocity, 4.0 m/s. Their positions come from the areas under their graphs. Cart X has moved ½(8.0 m/s + 4.0 m/s)(4.0 s) = 24 m, the area of a trapezoid. Cart Y has moved ½(4.0 s)(4.0 m/s) = 8.0 m, the area of a triangle. Cart X is 24 m − 8.0 m = 16 m ahead.





Why not (A)? Where two velocity graphs cross, the carts have equal velocities. Their positions are equal only when the areas under the two graphs are equal.

Why not (C)? An 8.0 m lead comes from taking Cart X's distance as (4.0 m/s)(4.0 s) = 16 m. Cart X was moving faster than 4.0 m/s the whole time before 4.0 s.

Review: Motion graphs: slope and area in the AP Physics 1 kinematics study guide: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#graphs

Question 10: When the carts meet again — Answer (C)

The carts are side by side when the areas under their graphs are equal. From 0 to 4.0 s, Cart X gains 16 m on Cart Y. After 4.0 s, Cart Y is faster, and the region between the lines from 4.0 s to 8.0 s is a triangle with area ½(4.0 s)(8.0 m/s) = 16 m. Cart Y makes up the whole 16 m at t = 8.0 s. As a check, each cart has moved 32 m at that time.

Why not (A)? 4.0 s is when the carts have equal velocities, not equal positions.

Why not (B)? At 6.9 s Cart Y reaches 24 m, where Cart X was at 4.0 s. By then Cart X has moved on to about 31 m, so Cart Y is still behind.

Review: the catch-up problem (problem 23) in the study guide's practice set, which solves the same kind of question with equations: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#practice

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Question 11: Relative velocity on a train — Answer (A)

Take east as positive. Walking toward the back of an eastbound train means moving west relative to the train, so the passenger's velocity relative to the ground is +12 m/s + (−1.5 m/s) = +10.5 m/s. To find the velocity relative to the cyclist, subtract the cyclist's velocity: +10.5 m/s − (+6.0 m/s) = +4.5 m/s, or 4.5 m/s east.

Why not (C)? 7.5 m/s east comes from adding the walking speed to the train's speed before subtracting the cyclist's velocity. The passenger walks against the train's motion, so the walking speed is subtracted.

Why not (D)? 10.5 m/s east is the passenger's velocity relative to the ground, not relative to the cyclist.

Review: Question 6 of the AP Physics 1 kinematics FRQ practice set which works through relative velocity with two travelers on a moving walkway: burketutoringinfremont.com/ap-physics-1-kinematics-frq/#question-6

Question 12: Reference frames on a rising balloon — Answer (D)

At the instant it is released, the sandbag has the same velocity as the basket: 4.0 m/s upward relative to the ground. The passenger moves with the basket, so in the passenger's frame the sandbag starts from rest. The two frames differ by a constant velocity, so the velocities the two observers measure differ by 4.0 m/s at every instant. A constant difference does not change how quickly the velocity changes, so both observers measure an acceleration of 9.8 m/s² downward.

Why not (B)? In the passenger's frame the sandbag's starting velocity is zero, because the passenger is rising with it.

Why not (C)? Choice (C) swaps the two frames. The person on the ground sees the sandbag moving upward at 4.0 m/s at first.

Review: Type 3: an object thrown straight up in the AP Physics 1 free fall problems guide, which is the motion the person on the ground sees: burketutoringinfremont.com/ap-physics-1-free-fall-problems/#thrown-up

Question 13: Horizontal launches from two heights — Answer (B)

Each ball leaves its table with zero vertical velocity, so its time in the air depends only on the height: $h = \frac{1}{2}gt^2$ gives a time proportional to the square root of the height. Four times the height gives twice the time, so ball Y is in the air for $2t$ if ball X is in the air for t. The horizontal velocity stays constant, so $d_X = vt$ and $d_Y = (v/2)(2t) = vt$. The distances are equal.

Why not (A)? $d_X/2$ ignores the height difference and assumes the two balls fall for the same time.

Why not (C)? $2d_X$ comes from making the time four times as long. The time grows with the square root of the height, not in proportion to it.

Review: Free fall and projectile motion in the AP Physics 1 kinematics study guide, under two directions, one clock: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#free-fall

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Question 14: The top of a projectile's path — **Answer (C)**

At the highest point the vertical component of the velocity is zero, but the horizontal component is the same as at launch: (16 m/s)(cos 60°) = 8.0 m/s. So the speed at the top is 8.0 m/s. Gravity still acts on the ball, so the acceleration is 9.8 m/s² downward at every point of the flight, including the top.

Why not (B)? If the acceleration were zero at the top, the velocity would stop changing there. The vertical velocity changes from upward to downward as the ball passes the top.

Why not (D)? 14 m/s is (16 m/s)(sin 60°), the vertical component at launch. That component is zero at the top.

Review: Where students lose points in the AP Physics 1 kinematics study guide, starting with setting the acceleration to zero at the top: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#mistakes

Question 15: Two launches with the same vertical velocity — **Answer (B)**

The time in the air depends only on the vertical component of the launch velocity. For P it is $(2v)(\sin 30°) = v$, and for Q it is $(\sqrt{2}v)(\sin 45°) = v$. The vertical components are equal, so the times are equal. The ranges then depend on the horizontal components: $(2v)(\cos 30°) \approx 1.7v$ for P and $(\sqrt{2}v)(\cos 45°) = v$ for Q. P covers more ground in the same time.

Why not (D)? A 45° launch gives the greatest range only when the launch speeds are the same. Here they are different.

Why not (C)? A faster launch does not always mean a longer flight. The vertical component sets the flight time, and it is the same for both.

Review: the projectile simulator in the AP Physics 1 kinematics study guide, which reports time in the air and range for any launch speed and angle: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#simulator

Question 16: Average velocity in two dimensions — **Answer (A)**

Average velocity is displacement divided by the total elapsed time. The two legs are perpendicular, so the displacement has magnitude $\sqrt{((160\text{ m})^2 + (120\text{ m})^2)} = 200$ m. The elapsed time includes the hovering: 50 s + 15 s + 35 s = 100 s. The average velocity is 200 m / 100 s = 2.0 m/s, directed about 37° west of north.

Why not (C)? 2.8 m/s is the average speed: the 280 m path length divided by 100 s.

Why not (B)? 2.4 m/s leaves out the 15 s of hovering. The elapsed time includes time spent at rest.

Review: Position, velocity, and acceleration in the AP Physics 1 kinematics study guide, including the table that separates average velocity from average speed: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#essentials

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Question 17: Finding *g* from lab data — **Answer (D)**

For a ball dropped from rest, $h = \frac{1}{2}gt^2$. Compare this with the equation of a straight line through the origin, $y = mx$. With h on the vertical axis and t^2 on the horizontal axis, the slope m equals $\frac{1}{2}g$, so g is twice the slope.

Why not (B)? The slope of h against t^2 is $\frac{1}{2}g$, not g.

Why not (C)? A graph of $\sqrt{h}$ against t is also a straight line, but its slope is $\sqrt{(g/2)}$, so g is twice the square of the slope.

Review: practice problem 8 in the AP Physics 1 kinematics study guide, which graphs displacement against time squared for a cart: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#practice

Question 18: Half the launch speed — **Answer (C)**

Use $v^2 = v_0^2 - 2gy$, which does not involve time. At the top, $v = 0$, so $H = v_0^2/(2g)$. When the speed is $v_0/2$, $(v_0/2)^2 = v_0^2 - 2gy$, which gives $y = 3v_0^2/(8g) = \frac{3}{4}H$. Losing each half of the speed takes the same amount of time, and the ball is moving faster during the first half, so it climbs more of the height then.

Why not (B)? Half the speed at half the height would hold only if the speed decreased in proportion to height. The equation $v^2 = v_0^2 - 2gy$ shows that the square of the speed decreases in proportion to height.

Why not (D)? The ratio is $\frac{3}{4}$ for any launch speed, because v_0 cancels.

Review: One set of free fall equations for all three problem types in the AP Physics 1 free fall problems guide: burketutoringinfremont.com/ap-physics-1-free-fall-problems/#free-fall-equations

Question 19: Symmetry of a projectile's flight — **Answer (A) and (C)**

There is no horizontal acceleration, so the horizontal component of the velocity never changes. The vertical component has the same size at launch and at landing, but it points up at launch and down at landing. The speed, $\sqrt{(v_x^2 + v_y^2)}$, does not depend on the sign of v_y, so it is the same at both moments.

Why not (B) and (D)? The vertical component changes from upward to downward, so the vertical component and the direction of the velocity both differ.

Review: Free fall and projectile motion in the AP Physics 1 kinematics study guide: burketutoringinfremont.com/ap-physics-1-kinematics-study-guide/#free-fall

Question 20: Measurements that give acceleration — **Answer (B) and (D)**

For a cart that starts from rest with constant acceleration, a distance d and a time t are related by $d = \frac{1}{2}at^2$, which gives $a = 2d/t^2$, choice (B). A distance and a speed are related by $v^2 = 2ad$, which gives $a = v^2/(2d)$, choice (D).

Why not (A)? Two speeds are not enough without the distance or the time between the marks. The same pair of speeds fits a large acceleration with marks close together or a small one with marks far apart.

Why not (C)? Mass does not appear in any kinematics equation, and a time alone does not fix the acceleration.

Review: Question 3 of the AP Physics 1 kinematics FRQ practice set which asks you to design this kind of ramp measurement and analyze the data: burketutoringinfremont.com/ap-physics-1-kinematics-frq/#question-3

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