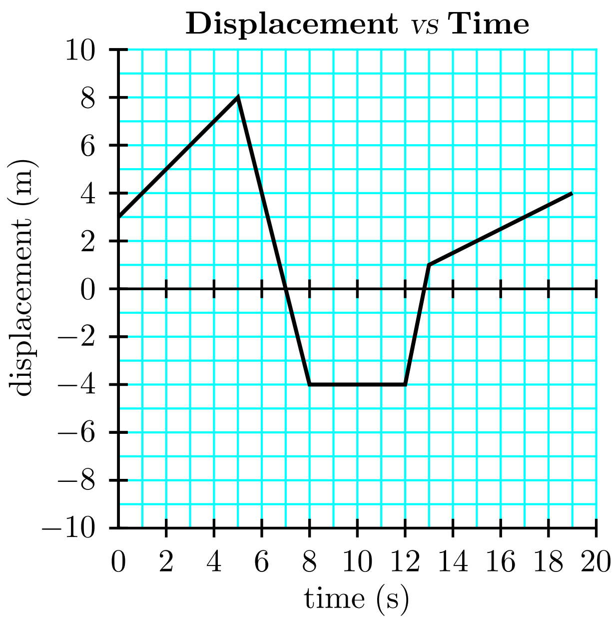
This print-out should have 30 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering. The due time is Central time.

**Displacement vs Time 04**

02:02, trigonometry, multiple choice, > 1 min, fixed.

**001**

Consider the following graph




What is the position at 10 s?

**1.** 3 m

**2.** Unable to determine

**3.** 2 m

**4.** −4 m **correct**

**5.** −2 m

**6.** 1 m

**7.** −3 m

**8.** None of these

**9.** 0 m

**10.** −1 m

**Explanation:**

Read the position from the graph.

**002**

What is the velocity at 10 s?

**1.** −1 m/s

**2.** Unable to determine

**3.** −2 m/s

**4.** −3 m/s

**5.** None of these

**6.** 4 m/s

**7.** 3 m/s

**8.** 2 m/s

**9.** 0 m/s **correct**

**10.** 1 m/s

**Explanation:**

At 10 s, the slope is 0.

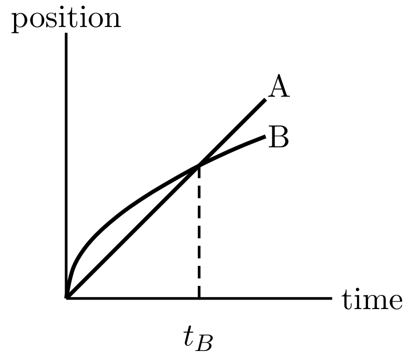
keywords:

**Kinematics2 v1**

02:02, trigonometry, multiple choice, < 1 min, fixed.

**003**

The graph shows position as a function of time for two trains running on parallel tracks. At time $t = 0$ (origin) the position of both trains is 0.




Which is true?

**1.** At time $t_B$, both trains have the same velocity

**2.** Both trains speed up all the time

**3.** Both trains have the same velocity at some time before $t_B$ **correct**

**4.** Somewhere before time $t_B$, both trains have the same acceleration

**5.** In the time interval from $t$=0 to $t$=$t_B$, train B covers more distance than train A

**Explanation:**

The slope of the curve B is parallel to line A at some point $t < t_B$.

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keywords:

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**Velocity Time Graph**

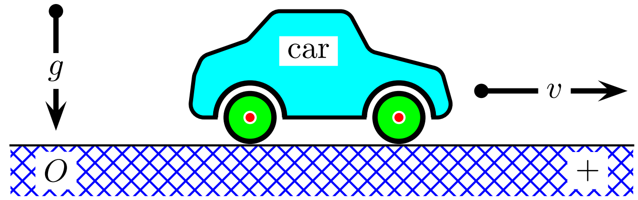
02:02, trigonometry, multiple choice, < 1 min, wording-variable.

**004**

The following 4 questions refer to a toy car which can move to the right or left along a horizontal line. The positive direction is to the right.

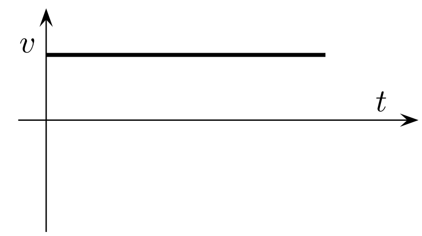
Choose the correct velocity-time graph for each of the following questions.

*Assume:* Friction is so small that it can be ignored.



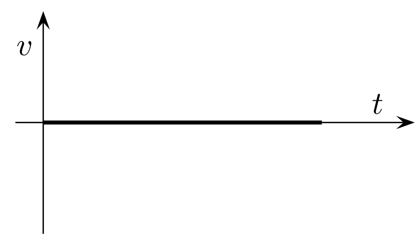

Which velocity graph shows the car moving toward the right (away from the origin) at a steady (constant) velocity?

**1.**

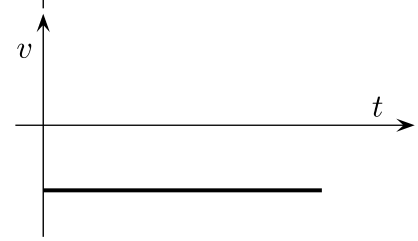



**correct**

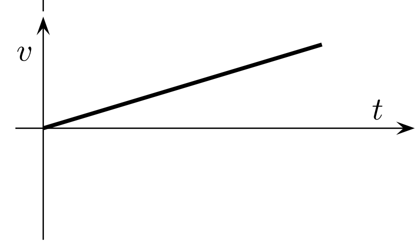
**2.**



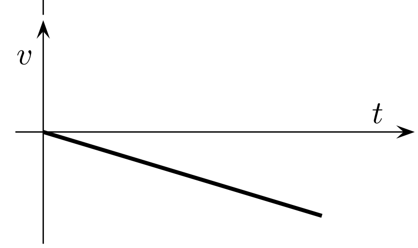

**3.**



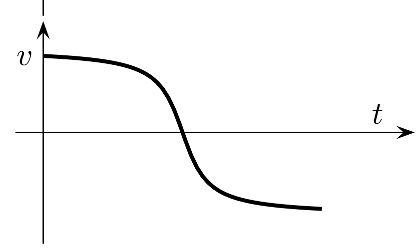

**4.**

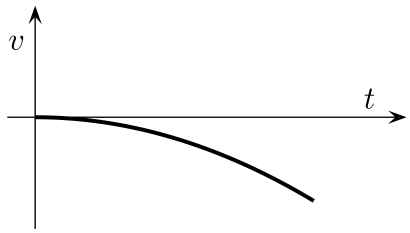


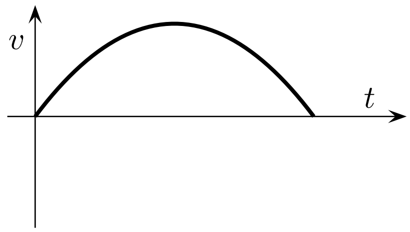

**5.**

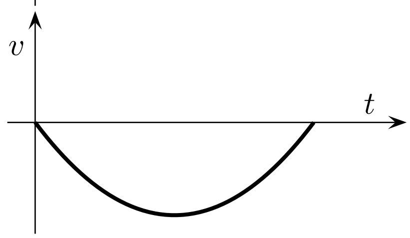



**6.**



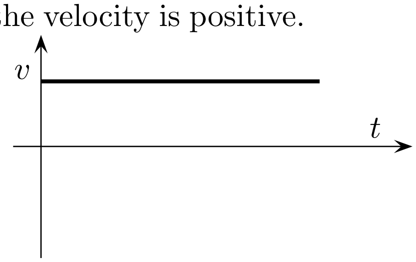
**7.**



**8.**



**9.**


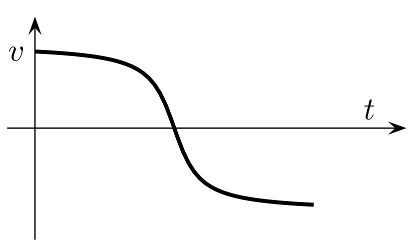

**10.** None of these graphs are correct.

**Explanation:**
Since the velocity is constant, the graph is a straight line. Since the car is moving to the right the velocity is positive.

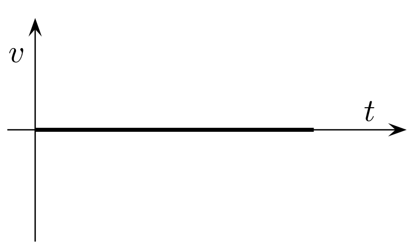


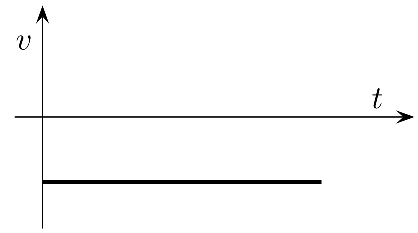

**005**

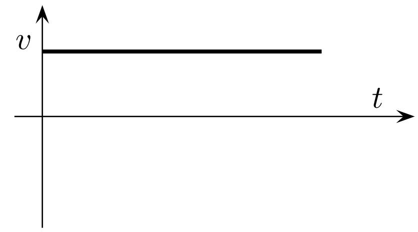
Which velocity graph shows the car moving towards the right (away from the origin) reversing direction and then moving to the left?

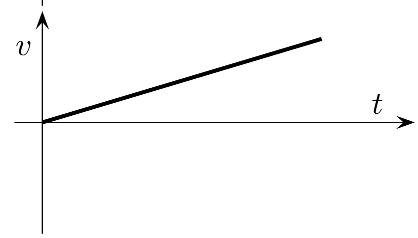
**1.**


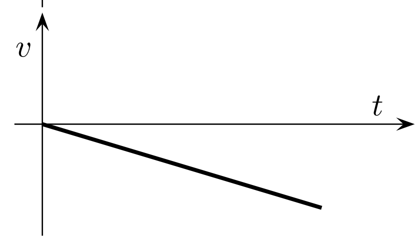

**correct**

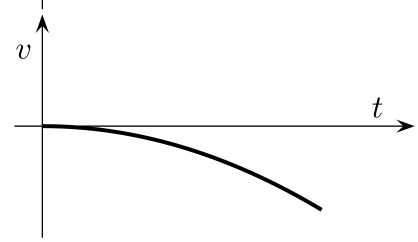
**2.**


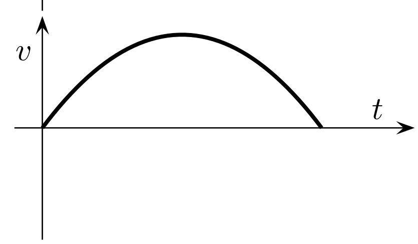

**3.**


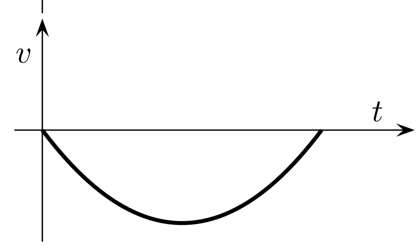

**4.**



**5.**



**6.**


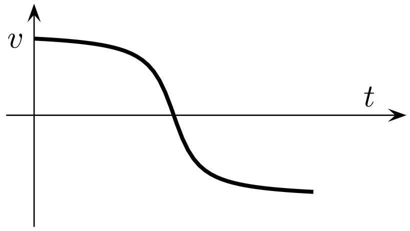

**7.**



**8.**



**9.**


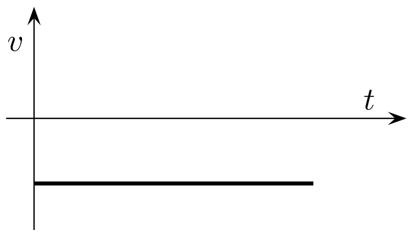

**10.** None of these graphs are correct.

**Explanation:**
Since the car reverses its direction, the velocity is positive and then negative.

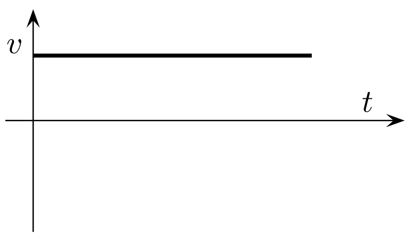


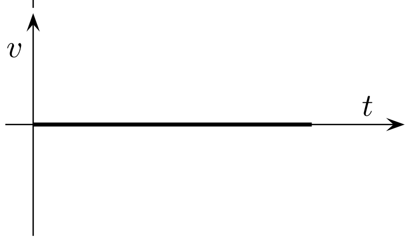

**006**

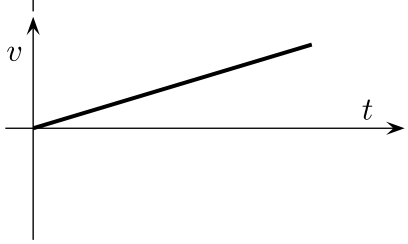
Which velocity graph shows the car moving toward the left (toward the origin) at a steady (constant) velocity?

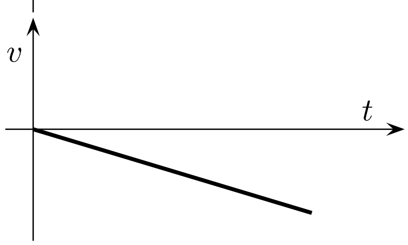
**1.** 

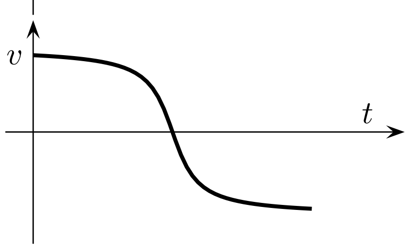

**correct**

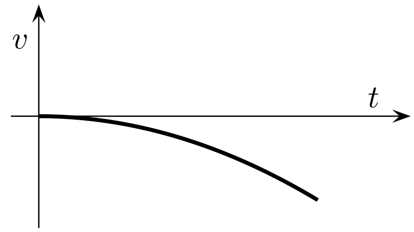
**2.** 

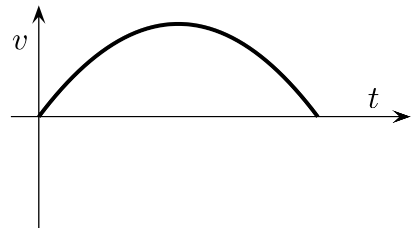

**3.** 

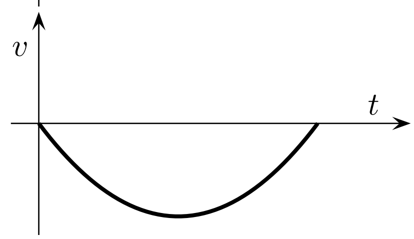

**4.** 


**5.** 


**6.** 


**7.** 


**8.** 


**9.** 

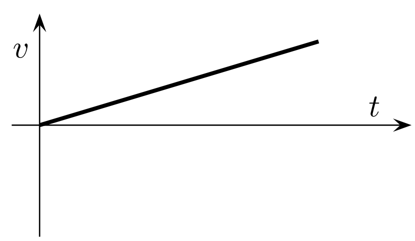

**10.** None of these graphs are correct.

**Explanation:**

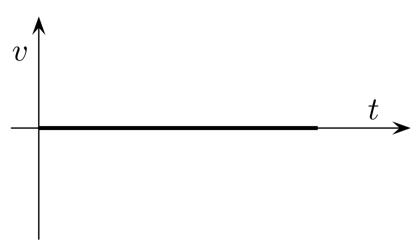
The same reason as Part 1.

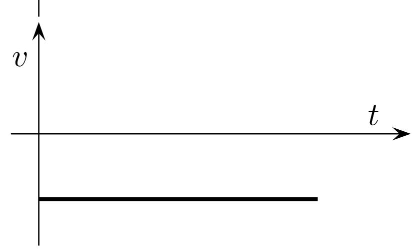
**007**

Which velocity graph shows the car increasing its **speed** towards the right (away from the origin) at a steady (constant) rate?

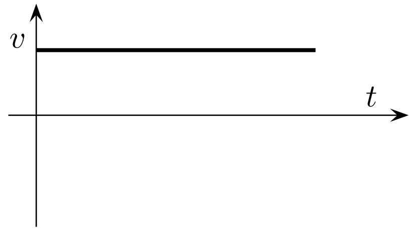
**1.** 


**correct**

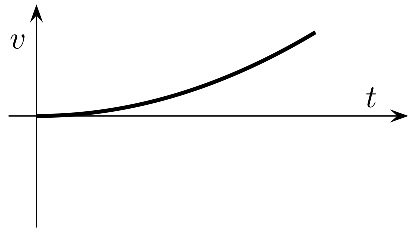
**2.** 


**3.** 

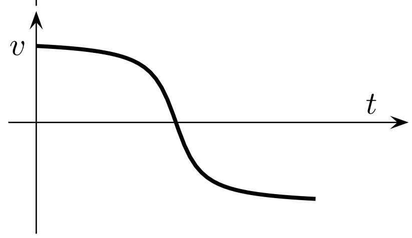
**4.**



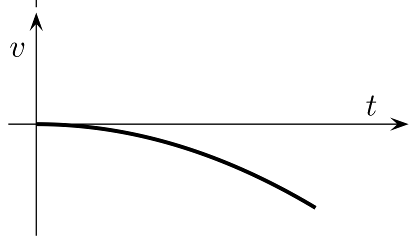

**5.**



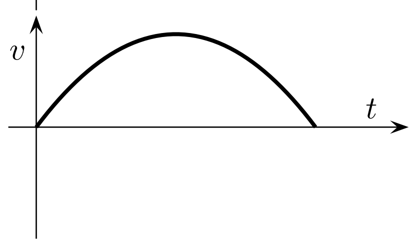

**6.**



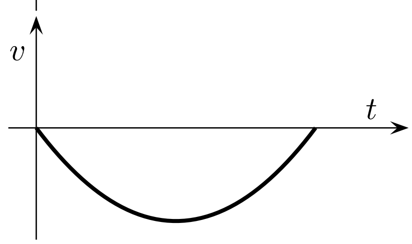

**7.**




**8.**



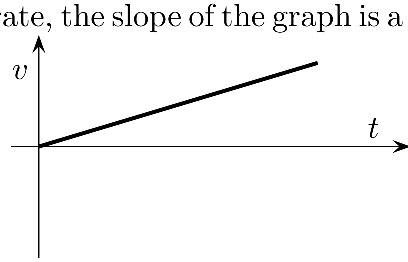

**9.**




**10.** None of these graphs are correct.

**Explanation:**

Since the car's speed is increasing at a constant rate, the slope of the graph is a constant.

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keywords:

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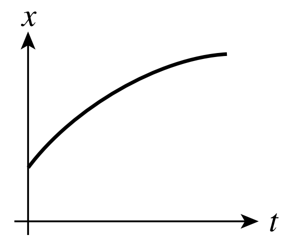
**X vs T**

02:02, trigonometry, multiple choice, > 1 min, fixed.

**008**

A train car moves along a long straight track. The graph shows the position as a function of time for this train.




The graph shows that the train

**1.** speeds up all the time.

**2.** slows down all the time. **correct**

**3.** speeds up part of the time and slows down part of the time.

**4.** moves at a constant velocity.

**Explanation:**

The slope of the curve diminishes as time increases, hence the train slows down all the time.

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keywords:

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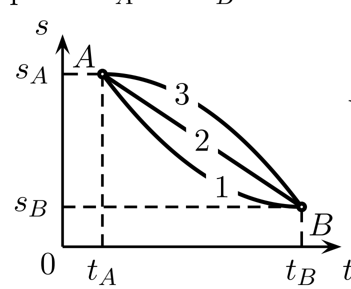
**Velocity Relationships 01**

02:03, trigonometry, multiple choice, > 1 min, fixed.

**009**

Consider three position curves between time points $t_A$ and $t_B$.




$$\overline{v} = \frac{v_A + v_B}{2},$$

when $a$ is constant.

Choose the correct relationship among quantities $\overline{v}_1$, $\overline{v}_2$, and $\overline{v}_3$.

**1.** $\overline{v}_1 = \overline{v}_2 = \overline{v}_3$ **correct**

**2.** $\overline{v}_1 < \overline{v}_2 < \overline{v}_3$

**3.** $\overline{v}_1 > \overline{v}_2 > \overline{v}_3$

**Explanation:**

**Basic Concepts:**

The average velocity of an object is defined as follows

$$\overline{v} = \frac{\text{displacement}}{\text{time}} = \frac{s_B - s_A}{t_B - t_A}.$$

**Solution:** All three curves have exactly the same change in position $\Delta s = s_B - s_A$ in exactly the same time interval $\Delta t = t_B - t_A$. Hence all three average velocities are equal

$$\overline{v}_1 = \overline{v}_2 = \overline{v}_3 .$$

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keywords:

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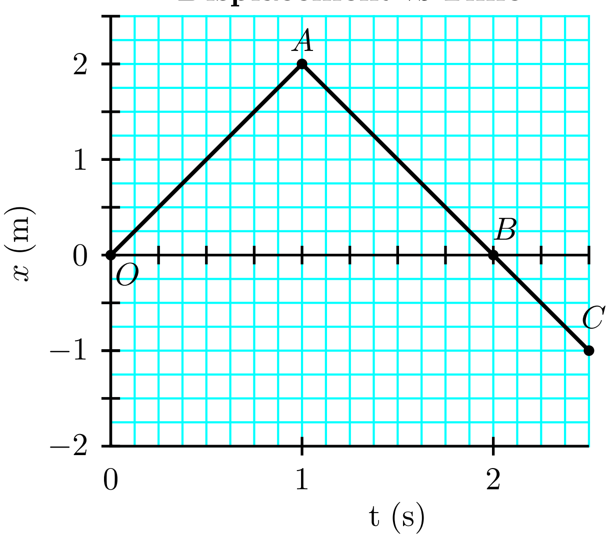
**Displacement vs Time 02**

02:04, trigonometry, multiple choice, < 1 min, fixed.

**010**

Consider the displacement curve: $OABC$

**Displacement** *vs* **Time**




Choose the appropriate quantity for the average velocity $\overline{v}_{OA}$ from point $O$ to $A$.

**1.** $\overline{v}_{OA} = +2$ m/s **correct**

**2.** $\overline{v}_{OA} = 0$ m/s

**3.** $\overline{v}_{OA} = +\sqrt{3}$ m/s

**4.** $\overline{v}_{OA} = -\sqrt{3}$ m/s

**5.** $\overline{v}_{OA} = -2$ m/s

**Explanation:**

**Definitions:**

Average velocity: $\overline{v} = \dfrac{\text{displacement}}{\text{time}}$

Average speed: $\overline{s} = \dfrac{\text{distance}}{\text{time}}$

Instantaneous velocity: $v = \dfrac{d\,x}{dt}$

Instantaneous speed: $s = |v|$

**Solution:**

Note that the displacement $x$ is on the vertical axis and that time $t$ is on the horizontal axis. The key here is to know that velocity uses net displacement in its equation while speed uses total distance traveled.

$$\overline{v}_{OA} = \frac{x_A - x_O}{t_A - t_O} = \frac{2-0}{1-0} = +2 \text{ m/s}.$$

The values for the average velocity come directly from evaluating the definitions.

---

**011**

Choose the appropriate quantity for the average velocity $\overline{v}_{OB}$ for the motion from point $O$ to point $B$.

**1.** $\overline{v}_{OB} = 0$ m/s **correct**

**2.** $\overline{v}_{OB} = +2$ m/s

**3.** $\overline{v}_{OB} = +\sqrt{3}$ m/s

**4.** $\overline{v}_{OB} = -\sqrt{3}$ m/s

**5.** $\overline{v}_{OB} = -2$ m/s

**Explanation:**

$$\overline{v}_{OB} = \frac{x_B - x_O}{t_B - t_O} = \frac{0-0}{2-0} = 0 \text{ m/s}.$$

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**012**

Choose the appropriate quantity for the average speed $\overline{s}_{OB}$ for the motion from point $O$ to point $B$.

**1.** $\overline{s}_{OB} = +2$ m/s **correct**

**2.** $\overline{s}_{OB} = 0$ m/s

**3.** $\overline{s}_{OB} = +\sqrt{3}$ m/s

**4.** $\overline{s}_{OB} = -\sqrt{3}$ m/s

**5.** $\overline{s}_{OB} = -2$ m/s

**Explanation:**

$$\overline{s}_{OB} = \frac{|x_A - x_O| + |x_B - x_A|}{t_B - t_O} = \frac{2+2}{2-0} = +2 \text{ m/s}.$$

The values for the average speed come directly from evaluating the definitions.

---

**013**

Choose the appropriate quantity for the instantaneous velocity $v_B$ at point $B$.

**1.** $v_B = -2$ m/s **correct**

**2.** $v_B = +2$ m/s

**3.** $v_B = 0$ m/s

**4.** $v_B = +\sqrt{3}$ m/s

**5.** $v_B = -\sqrt{3}$ m/s

**Explanation:**

The instantaneous velocity at point $B$ can be obtained by first finding an expression for the graph describing the position of the moving object and taking its derivative evaluated at time $t_B$.

However, since the graph near $B$ is linear, it is simpler to calculate the slope of the line over the interval from $A$ to $B$. The result correctly describes the instantaneous velocity at $B$ because the derivative of a straight line is constant at all points on the line and can be obtained for our case by

$$v_B = \frac{x_B - x_A}{t_B - t_A} = \frac{0-2}{2-1} = -2 \text{ m/s}.$$

---

**014**

Choose the appropriate quantity for the instantaneous speed $s_B$ at point $B$.

**1.** $s_B = +2$ m/s **correct**

**2.** $s_B = -2$ m/s

**3.** $s_B = 0$

**4.** $s_B = +\sqrt{3}$ m/s

**5.** $s_B = -\sqrt{3}$ m/s

**Explanation:**

Instantaneous speed, is simply the absolute value of instantaneous velocity because speed has magnitude but no direction.

$$s_B = |v_B| = |-2| = +2 \text{ m/s}.$$

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keywords:

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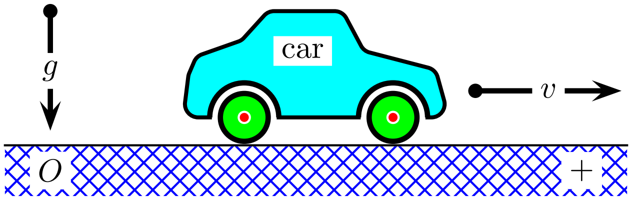
**Acceleration Time Graph 01**

02:05, trigonometry, multiple choice, < 1 min, wording-variable.

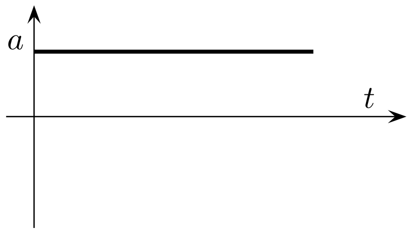
**015**

The following 5 questions refer to a toy car which can move to the right or left on a horizontal surface along a straight line (the + distance axis).

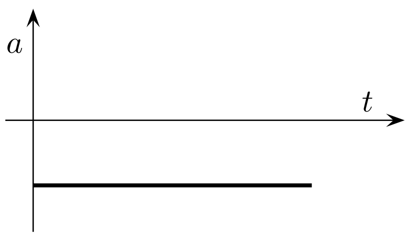
The positive direction is to the right. Different motions of the car are described below. Choose the acceleration-time graph which corresponds to the motion of the car described in each statement.

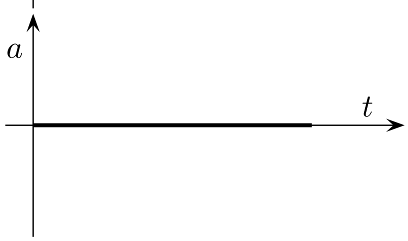


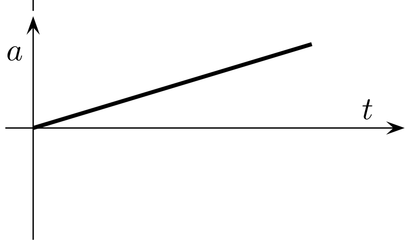

The car moves toward the right (away from the origin), speeding up at a steady rate.

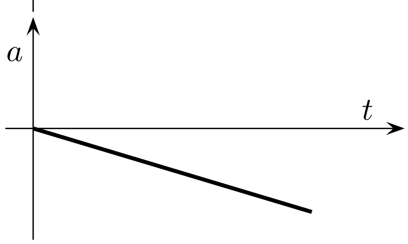
**1.** 

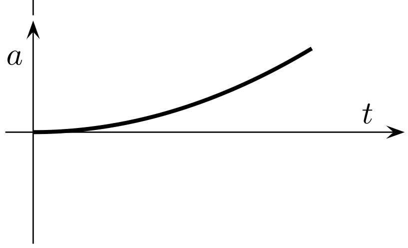

**correct**

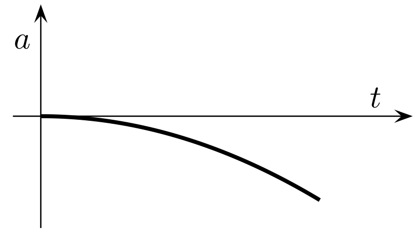
**2.** 


**3.** 


**4.** 


**5.** 


**6.** 


**7.** 


**8.** None of these graphs are correct.

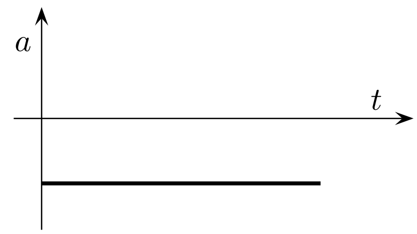
**Explanation:**

Since the car speeds up at a steady rate, the acceleration is a constant.

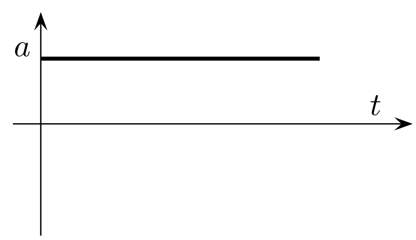
---

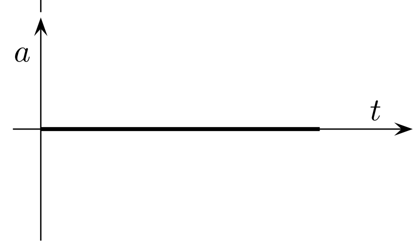
**016**

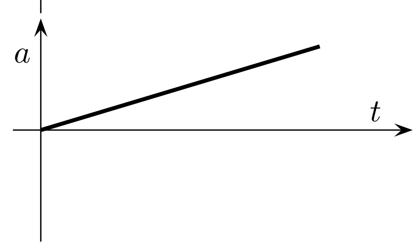
The car moves toward the right, slowing down at a steady rate.

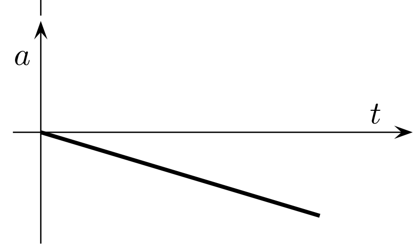
**1.** 

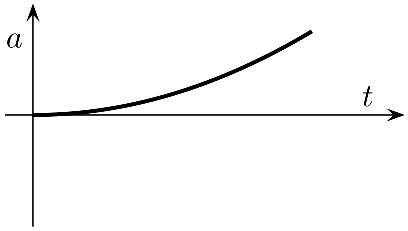

**correct**

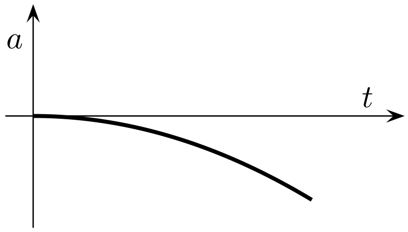
**2.** 


**3.** 


**4.** 


**5.** 

**6.** 


**7.** 


**8.** None of these graphs are correct.

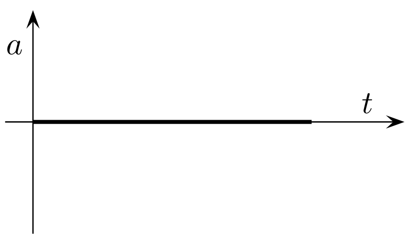
**Explanation:**

Since the car slows down, the acceleration is in the opposite direction.

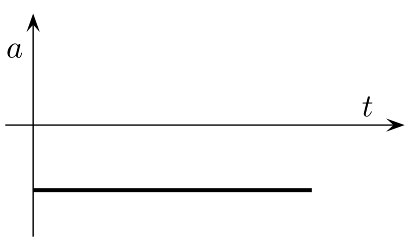
---

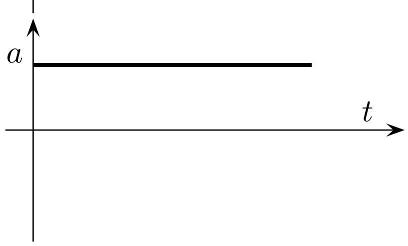
**017**

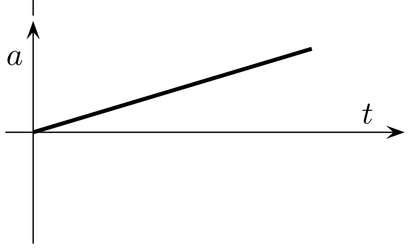
The car moves towards the left (toward the origin) at a constant velocity.

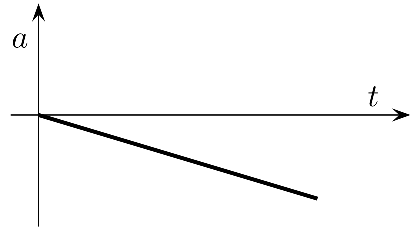
**1.** 

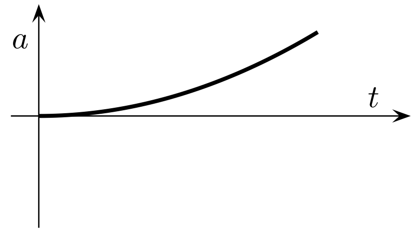

**correct**

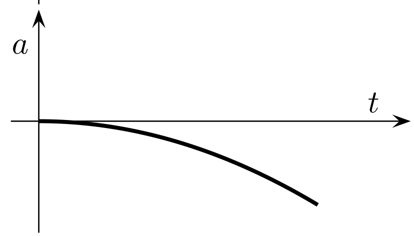
**2.** 


**3.** 


**4.** 


**5.** 


**6.** 


**7.** 


**8.** None of these graphs are correct.

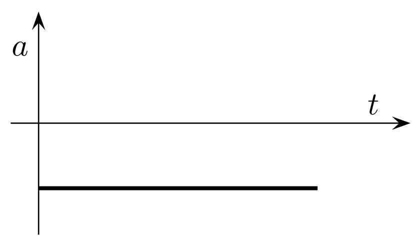
**Explanation:**

Since the car moves at a constant velocity, the acceleration is zero.

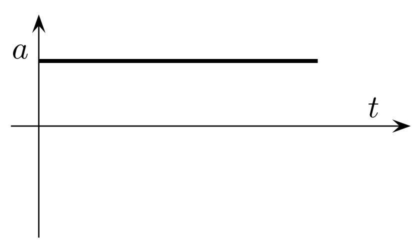
---

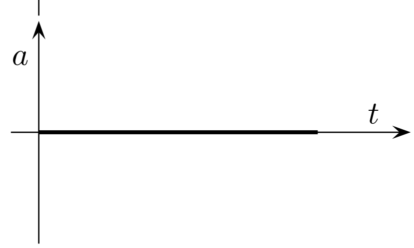
**018**

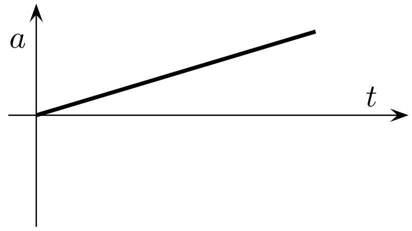
The car moves toward the left, speeding up at a steady rate.

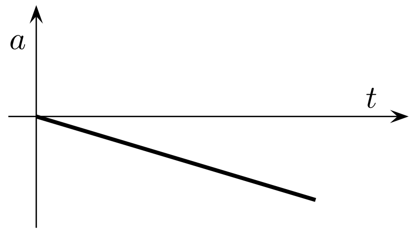
**1.** 

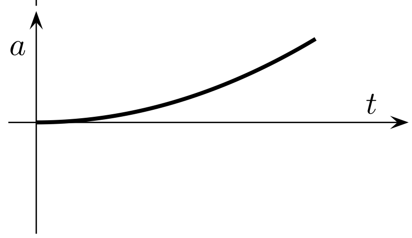

**correct**

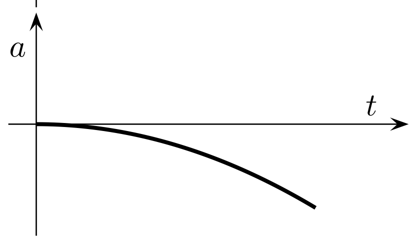
**2.** 


**3.** 

**4.** 


**5.** 


**6.** 


**7.** 


**8.** None of these graphs are correct.

**Explanation:**
The same reason as Part 1.

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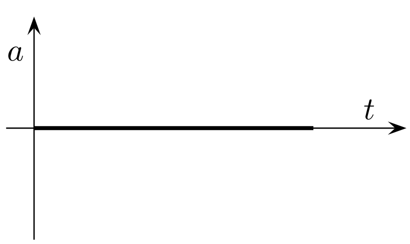
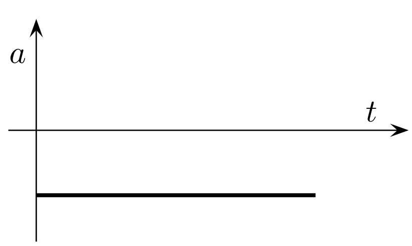
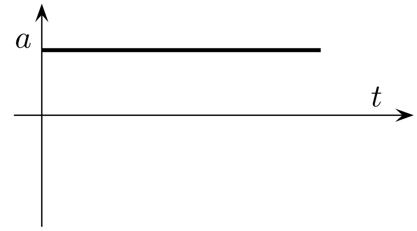
**019**

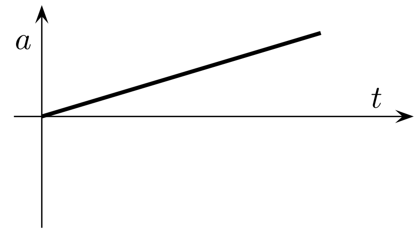
The car moves toward the right at a constant velocity.

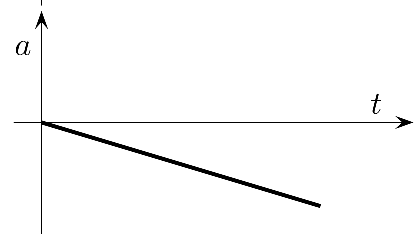
**1.** 

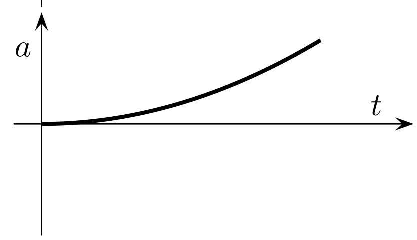

**correct**

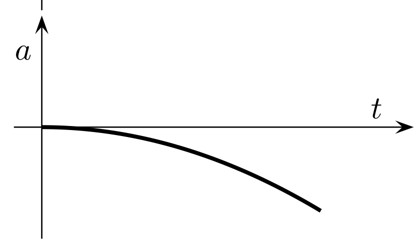
**2.** 


**3.** 


**4.** 


**5.** 


**6.** 


**7.** 


**8.** None of these graphs are correct.

**Explanation:**
The same reason as Part 3.

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keywords:

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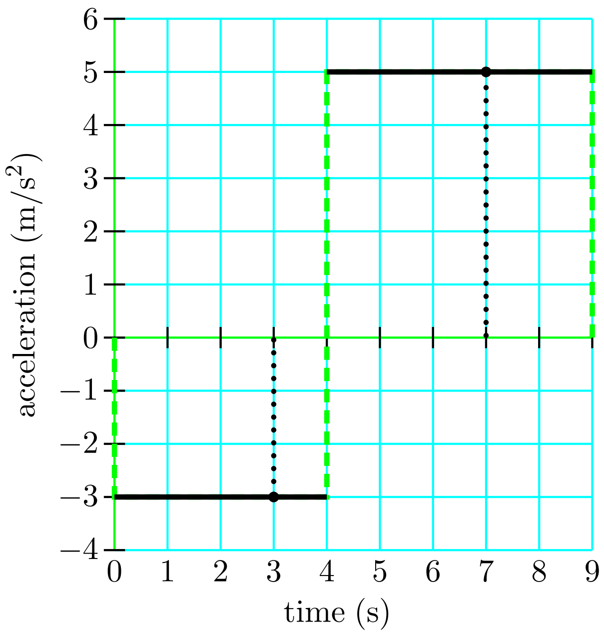
**Acceleration vs Time 01**

02:05, trigonometry, numeric, $>$ 1 min, normal.

**020**

Consider the plot below describing the acceleration of a particle along a straight line with an initial position of $-30$ m and an initial velocity of 4 m/s.




What is the velocity at 3 s?
Correct answer: $-5$ m/s.
**Explanation:**
In order to use the above graph, let

$$\begin{aligned}
x_0 = x_{0,1} &= -30\text{ m}\,,\\
v_0 = v_{0,1} &= 4\text{ m/s}\,,\\
(t_0, a_0) = (t_{0,1}, a_0) &= (0\text{ s}, 0\text{ m/s}^2)\,,\\
(t_1, a_1) = (t_{0,1}, a_{1,2}) &= (0\text{ s}, -3\text{ m/s}^2)\,,\\
(t_2, a_2) = (t_{2,3}, a_{1,2}) &= (4\text{ s}, -3\text{ m/s}^2)\,,\\
(t_3, a_3) = (t_{2,3}, a_{3,4}) &= (4\text{ s}, 5\text{ m/s}^2)\,,\\
(t_4, a_4) = (t_{4,5}, a_{3,4}) &= (9\text{ s}, 5\text{ m/s}^2)\,, \quad \text{and}\\
(t_5, a_5) = (t_{4,5}, a_5) &= (9\text{ s}, 0\text{ m/s}^2)\,.
\end{aligned}$$

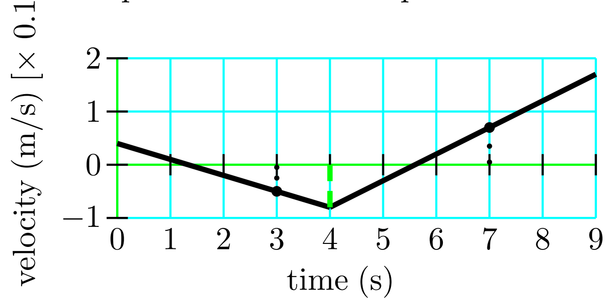
**Basic Concepts:** The plot shows a curve of **acceleration** *versus* **time**.
The change in velocity is the area $(a_{1,2}\, t)$ between the acceleration curve and the time axis

$$v = v_{0,1} + a_{1,2}\, t\,,$$

where the acceleration is constant.
**Solution:** With constant acceleration ($a_{1,2} = -3$ m/s$^2$),

$$\begin{aligned}
v &= v_{0,1} + a_{1,2}\, t \qquad (1)\\
&= (4\text{ m/s}) + (-3\text{ m/s}^2)\,(3\text{ s})\\
&= -5\text{ m/s}\,.
\end{aligned}$$

Equations 1 and 3 are plotted below.



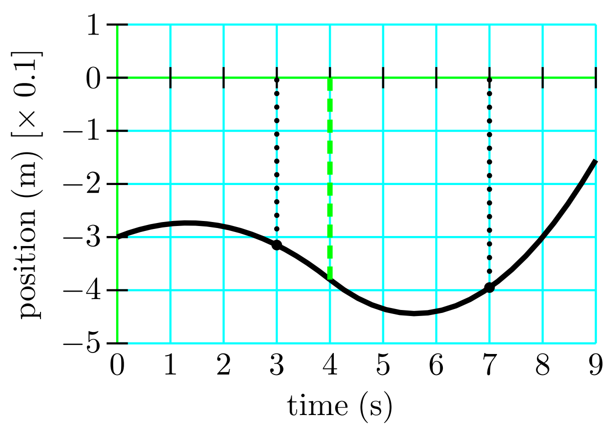

**021**
What is the position at 3 s?
Correct answer: $-31.5$ m.
**Explanation:**
**Basic Concepts:** The change in position is the area $(v_{0,1}\, t + \frac{1}{2}\, a\, t^2)$ between the velocity curve and the time axis

$$x = x_{0,1} + v_{0,1}\, t + \frac{1}{2}\, a\, t^2\,.$$

**Solution:** With constant acceleration ($a_{1,2} = -3$ m/s$^2$),

$$\begin{aligned}
x &= x_{0,1} + v_{0,1}\, t + \frac{1}{2}\, a_{1,2}\, t^2 \qquad (2)\\
&= (-30\text{ m}) + (4\text{ m/s})\,(3\text{ s})\\
&\quad + \frac{1}{2}\,(-3\text{ m/s}^2)\,(3\text{ s})^2\\
&= -31.5\text{ m}\,.
\end{aligned}$$

Equations 2 and 4 are plotted below.




**022**
What is the velocity at 7 s?
Correct answer: 7 m/s.
**Explanation:**

The calculation is done in two parts, each with constant acceleration ($a_{1,2} = -3\ \text{m/s}^2$) and ($a_{3,4} = 5\ \text{m/s}^2$).

$$\begin{aligned} v &= v_{0,1} + a_{1,2}\, t_{2,3} + a_{3,4}\, [t - t_{2,3}] \qquad (3)\\ &= (4\ \text{m/s}) + (-3\ \text{m/s}^2)\,(4\ \text{s}) \\ &\quad + (5\ \text{m/s}^2)\,[(7\ \text{s}) - (4\ \text{s})] \\ &= 7\ \text{m/s}\,, \end{aligned}$$

where

$$\begin{aligned} v_{2,3} &= v_{0,1} + a_{1,2}\, t_{2,3} \\ &= (4\ \text{m/s}) + (-3\ \text{m/s}^2)\,(4\ \text{s}) \\ &= -8\ \text{m/s}\,. \end{aligned}$$

---

**023**

What is the position at 7 s?

Correct answer: $-39.5$ m.

**Explanation:**

The calculation is done in two parts, each with constant acceleration ($a_{1,2} = -3\ \text{m/s}^2$) and ($a_{3,4} = 5\ \text{m/s}^2$).

$$\begin{aligned} x &= x_{0,1} + v_{0,1}\, t_{2,3} + \frac{1}{2}\, a_{1,2}\, t_{2,3}^2 \qquad (4)\\ &\quad + v_{2,3}\,[t - t_{2,3}] + \frac{1}{2}\, a_{3,4}\,[t - t_{2,3}]^2 \\ &= (-30\ \text{m}) + (4\ \text{m/s})\,(4\ \text{s}) \\ &\quad + \frac{1}{2}\,(-3\ \text{m/s}^2)\,(4\ \text{s})^2 \\ &\quad + (-8\ \text{m/s})\,[(7\ \text{s}) - (4\ \text{s})] \\ &\quad + \frac{1}{2}\,(5\ \text{m/s}^2)\,[(7\ \text{s}) - (4\ \text{s})]^2 \\ &= -39.5\ \text{m}\,, \end{aligned}$$

where

$$\begin{aligned} x_{2,3} &= x_{0,1} + v_{0,1}\, t_{2,3} + \frac{1}{2}\, a_{1,2}\, t_{2,3}^2 \\ &= (-30\ \text{m}) + (4\ \text{m/s})\,(4\ \text{s}) \\ &\quad + \frac{1}{2}\,(-3\ \text{m/s}^2)\,(4\ \text{s})^2 \\ &= -38\ \text{m}\,. \end{aligned}$$

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keywords:

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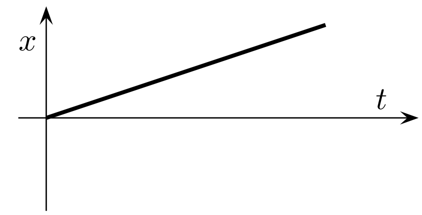
**Graphical Analysis**

02:05, trigonometry, multiple choice, < 1 min, fixed.

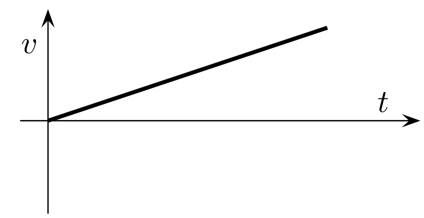
**024**

Identify all of those graphs that represent motion at constant speed (note the axes carefully).

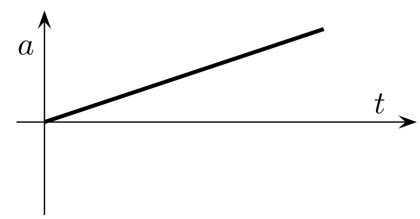
a)



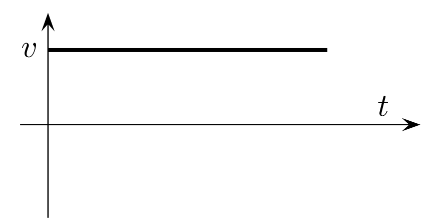

b)



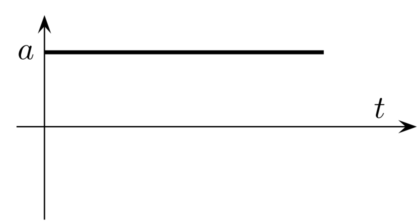

c)




d)




e)




**1.** (a) and (d) **correct**

**2.** (a), (b), and (c)

**3.** (a) and (c)

**4.** (a), (b), and (d)

**5.** (d) only

**6.** (a), (b), and (e)

**7.** (a) only

**8.** (c) only

**9.** (e) only

**10.** None of these

**Explanation:**

**Basic Concepts:** $v = v_o$ and $a = 0$.

**Solution:**

a) $x = k\,t,\ k > 0$ is a linear function of $t$, so it is **correct**.

b) $v = k\,t,\ k > 0$ increases at a constant rate, so it is incorrect.

c) $a = k\,t,\ k > 0$, so it is incorrect.

d) $v = k,\ k > 0$, so it is **correct**.

e) $a = k,\ k > 0$, so it is incorrect.

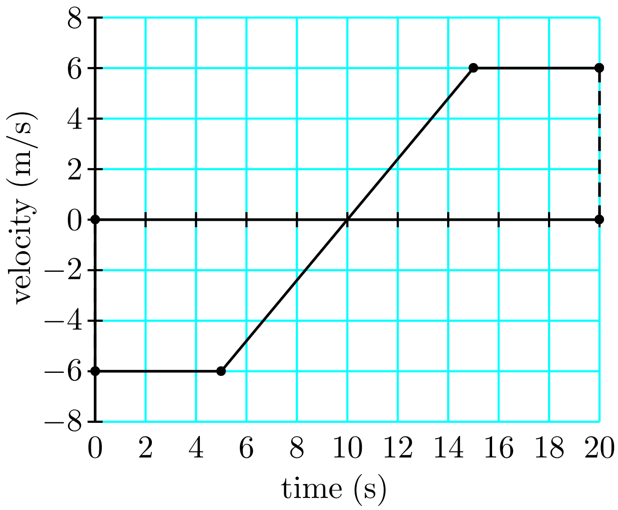
keywords:

**Serway CP 02 22**

02:05, trigonometry, numeric, > 1 min, normal.

**025**

Consider the plot below describing motion of an object along a straight path as shown in the figure below.




Find the average acceleration during the time interval 0 s to 5 s.

Correct answer: 0 $\text{m/s}^2$.

**Explanation:**

$$\text{Given}: \quad v_i = -6 \text{ m/s}\,, \quad v_f = -6 \text{ m/s}\,, \quad t_i = 0 \text{ s} \quad \text{and} \quad t_f = 5 \text{ s}\,.$$

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{(-6 \text{ m/s}) - (-6 \text{ m/s})}{(5 \text{ s}) - (0 \text{ s})} = \boxed{0 \text{ m/s}^2}\,.$$

**026**

Find the average acceleration during the time interval 5 s to 15 s.

Correct answer: 1.2 $\text{m/s}^2$.

**Explanation:**

$$\text{Given}: \quad v_i = -6 \text{ m/s}\,, \quad v_f = 6 \text{ m/s}\,, \quad t_i = 5 \text{ s} \quad \text{and} \quad t_f = 15 \text{ s}\,.$$

$$a_{avg} = \frac{(6 \text{ m/s}) - (-6 \text{ m/s})}{(15 \text{ s}) - (5 \text{ s})} = \boxed{1.2 \text{ m/s}^2}\,.$$

**027**

Find the average acceleration during the time interval 0 s to 20 s.

Correct answer: 0.6 $\text{m/s}^2$.

**Explanation:**

$$\text{Given}: \quad v_i = -6 \text{ m/s}\,, \quad v_f = 6 \text{ m/s}\,, \quad t_i = 0 \text{ s} \quad \text{and} \quad t_f = 20 \text{ s}\,.$$

$$a_{avg} = \frac{(6 \text{ m/s}) - (-6 \text{ m/s})}{(20 \text{ s}) - (0 \text{ s})} = \boxed{0.6 \text{ m/s}^2}\,.$$

---

**028**

Find the instantaneous acceleration at 2 s.
Correct answer: 0 $\mathrm{m/s^2}$.

**Explanation:**

At $t = 2$ s, the slope of the tangent line is zero; therefore the acceleration is $\boxed{\text{zero}}$.

---

**029**

Find the instantaneous acceleration at 10 s.
Correct answer: 1.2 $\mathrm{m/s^2}$.

**Explanation:**

At $t = 10$ s, the slope of the tangent line is the same as in Part 2.

$$a_{avg} = \frac{(6\ \mathrm{m/s}) - (-6\ \mathrm{m/s})}{(15\ \mathrm{s}) - (5\ \mathrm{s})} = \boxed{1.2\ \mathrm{m/s^2}}.$$

---

**030**

Find the instantaneous acceleration at 18 s.
Correct answer: 0 $\mathrm{m/s^2}$.

**Explanation:**

At $t = 18$ s, the slope of the tangent line is zero; therefore the acceleration is $\boxed{\text{zero}}$.

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keywords: