Quiz 2 Study Guide: *1-D Motion* Name: ***Solution Key***

Two runners, A and B, run along a straight track. Runner A runs 100 m forward, then returns to the starting position. Runner B runs 100 m forward, then stops.

1) What is the distance traveled for Runner A and Runner B?
   Runner A: 200 m **Runner B: 100 m**

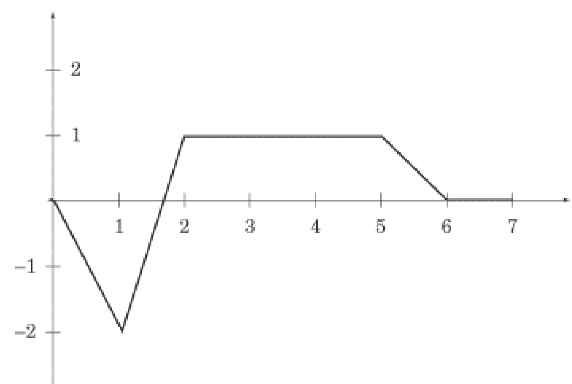
2) What is the displacement of Runner A and Runner B? (*displacement* = $x - x_0$)
   Runner A: 0 m **Runner B: 100 m**

3) If each runner completes his described run in 25 seconds, what their average speed? $\left(\begin{matrix}average \\ speed\end{matrix} = \frac{distance\ traveled}{time}\right)$
   Runner A: 8 m/s **Runner B: 4 m/s**

4) What is each runner's average velocity? $\left(\begin{matrix}average \\ velocity\end{matrix} = \bar{v} = \frac{displacement}{time}\right)$
   Runner A: 0 m/s **Runner B: 4 m/s**

5) What is the difference between instantaneous and average quantities? Are they ever the same?
   Instantaneous quantities are taken at a single instant (over an infinitesimally small amount of time), while average quantities are taken over a time interval. They are the same when the quantity is constant over the entire time interval being considered.

The following graph is a *position versus time* graph for an object that starts from the origin.



6) During what time intervals is the object…

   a) moving in the positive direction? **1 s – 2 s**

   b) moving in the negative direction? **0 s – 1 s**
   5 s – 6 s

   c) not moving? **2 s – 5 s**
   6 s – 7 s

7) During what time intervals is the object…

   a) located on the positive side of the origin? **Approximately 1.8 s – 6 s**

   b) located on the negative side of the origin? **0 s – Approximately 1.8 s**

   c) located at the origin? **0 s, Approximately 1.8 s, 6 s – 7 s**

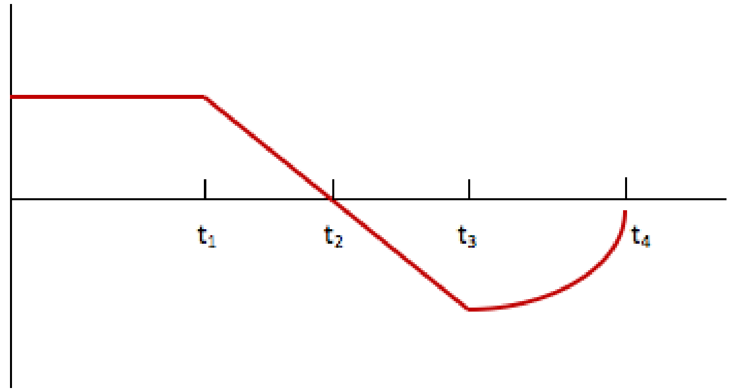
8) When is the object…

   a) moving the fastest? **1 s – 2 s (largest magnitude of slope)**

   b) moving the slowest? **2 s – 5 s, 6 s – 7 s (not moving at all during these time intervals)**

   c) accelerating? **Each time interval has a constant slope, and therefore has a constant velocity. However, we could say that the object must accelerate at 1 s, 2 s, 5 s, and 6 s because it does change its velocity at those times.**

The following graph is a *velocity versus time* graph for an object that starts from the origin.



9) In which direction does the object initially move?

Positive

10) When is the object…

a) moving at a constant, non-zero velocity? **0 – t_1**

b) not moving? **t_2**

c) accelerating at a constant rate? **$t_1 – t_3$**

d) accelerating at a changing rate? **$t_3 – t_4$**

11) When is the object…

a) moving in the positive direction? **0 – t_2**

b) moving in the negative direction? **$t_2 – t_4$**

c) not moving? **t_2**

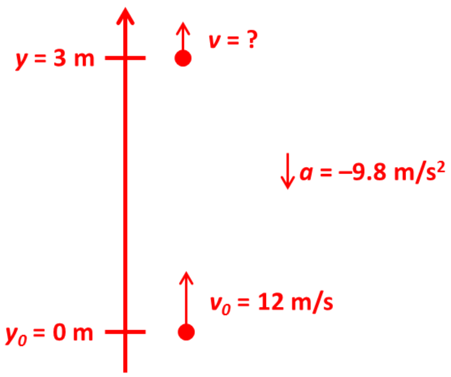
12) Does the object return to the origin during the time interval shown? How do you know? **No; the area above the *x*-axis (positive displacement) is larger than the area below the *x*-axis (negative displacement). Therefore, its total displacement is positive, meaning it is still on the positive side of the origin at t_4.**

13) A ball is thrown straight upward with an initial velocity of 12 m/s.

a) How fast is the ball traveling when it reaches a height of 3 m above its original position?
b) What is the ball's maximum height above its original position?
c) How long does it take for the ball to return to its original position?

a) Given: v_0 = 12 m/s, y = 3 m; Want: v

Figure:



Calculations:

Equation for Uniform Acceleration

$$v^2 = v_0^2 + 2a(y - y_0)$$

$$v^2 = v_0^2 + 2ay$$

$$v^2 = (12)^2 + 2(-9.8)(3)$$

$$v^2 = 85.2$$

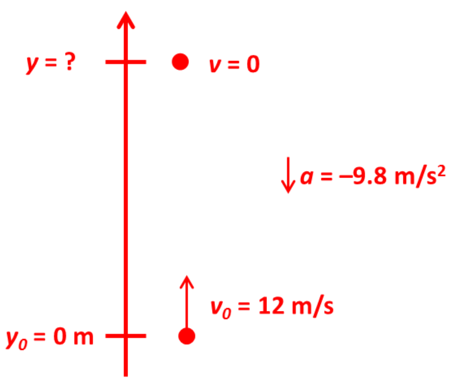
$$v = \pm\sqrt{85.2}$$

$$v = \pm 9.2303 \text{ m/s}$$

$$\boxed{v = \pm 9.2 \text{ m/s}}$$

b & c) Given: v_0 = 12 m/s, v = 0; Want: y, t

Figure:



Calculations:

Equation for Uniform Acceleration

$$v^2 = v_0^2 + 2a(y - y_0)$$

$$0 = v_0^2 + 2ay$$

$$y = \frac{-v_0^2}{2a}$$

$$y = \frac{-(12)^2}{2(-9.8)}$$

$$y = 7.3469 \text{ m}$$

$$\boxed{y = 7.3 \text{ m}}$$

Equation for Uniform Acceleration

$$v = v_0 + at$$

$$t = \frac{-v_0}{a}$$

$$t = \frac{-12}{-9.8}$$

$$t = 1.2244 \text{ s}$$

This is the time it takes to reach the highest point. Since the path is symmetric, the total time it takes to return to its original position is 2*t*:

$$2t = 2(1.2244 \text{ s}) = 2.4488 \text{ s}$$

$$\boxed{t = 2.4 \text{ s}}$$

Conclusion: a) The ball is traveling at a speed of <u>9.2 m/s</u> when it reaches a height of 3 m. (The ± in the solution indicates that it will travel at this speed both times it is 3 m above its starting position—once on the way up, and once on the way back down.)

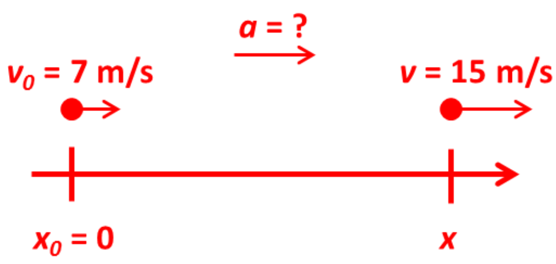
b) The ball will reach a maximum height of <u>7.3 m</u> above its original position.

c) It will take <u>2.4 s</u> to return to its original position after it is released.

14) An object is traveling at a speed of 7 m/s. How fast will it need to accelerate to reach a speed of 15 m/s in 2.5 s?

Given: v_0 = 7 m/s, v = 15 m/s, t = 2.5 s; Want: a

Figure:



Calculations:

Equation for Uniform Acceleration

$$v = v_0 + at$$

$$a = \frac{v - v_0}{t}$$

$$a = \frac{15 - 7}{2.5}$$

$$\boxed{a = 3.2\ \text{m/s}^2}$$

Conclusion: The object must accelerate at a rate of <u>3.2 m/s²</u> in order to reach a speed of 15 m/s in 2.5 s.

15) A runner begins from rest and accelerates at a constant rate of 2.5 m/s^2 until reaching his maximum speed of 10 m/s. He runs at this speed for 5 s, then begins to slow down, returning to rest at a constant deceleration in 5 s. He then turns around and runs back toward his starting position with a non-constant acceleration until reaching a speed of 8 m/s after 3 s. Sketch the velocity versus time graph of the runner's motion on the grid below.