Physics

Test 1

(November 2007)

Name:___________________

1) Calculate the following, expressing the answer in scientific notation with the correct number of significant figures: $(8.86 + 0.001) \div 3.610 \times 10^{-3}$

Solution

$$\frac{\left(8.86 + 1.0 \times 10^{-3}\right)}{\left(3.610 \times 10^{-3}\right)} = \frac{(8.86)}{\left(3.610 \times 10^{-3}\right)} = 2.45 \times 10^{3}$$

2) Convert $1.23 \times 10^{-3}\ {}^{g}\!/\!_{m^3}$ to ${}^{Kg}\!/\!_{dm^3}$

$$\frac{1.23 \times 10^{-3} \times 10^{-3}}{1 \times 10^{3}} = 1.23 \times 10^{-9}\ {}^{Kg}\!/\!_{dm^3}$$

3) A horse trots past a fencepost located 12 m to the left of point A. It then moves to the right and passes another fencepost located 24 m to the right of point A; if it takes the horse 11 seconds to do the above-mentioned, what is the average velocity of the horse?

Given

$x_i = -12$ m

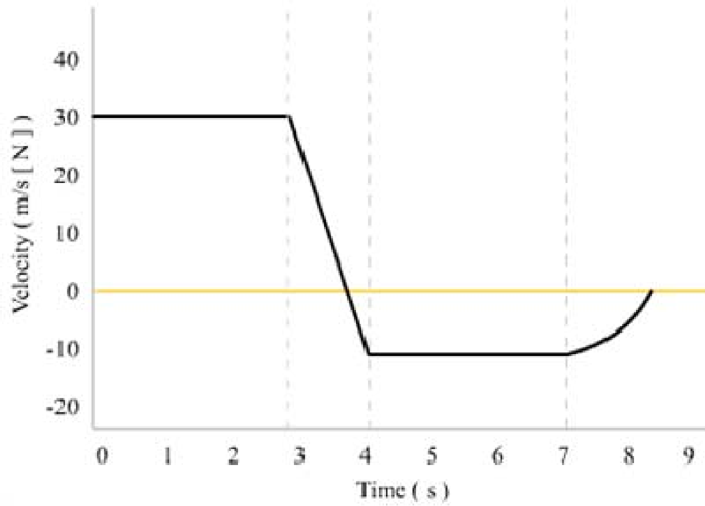
$x_f = 24$ m

$\Delta t = 11$ s

Solution

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{\Delta t} = \frac{(24\text{ m}) - (-12\text{ m})}{11\text{ s}} = 3.3\text{ m/s, to the right}$$

4) The graph above shows the motion of a car.
A) What is the acceleration between 3 and 4 seconds?
B) What is the displacement between 4 and 7 seconds?
C) In what time intervals do we have motion without acceleration?



Solution

A)

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} = \frac{-10.0\,\text{m/s} - 30.0\,\text{m/s}}{4.0\,\text{s} - 3\,\text{s}} = \frac{-40\,\text{m}}{1\,\text{s}} = -40\,\text{m/s}^2$$

B)

$$\Delta x = -10 \times 3 = -30m$$

This is the area under the graph of velocity vs time between 4 and 7 seconds.

C)

At intervals of 0 to 3 seconds and between 4 and 7 seconds.

5) A skater glides off a frozen pond onto a patch of ground at a speed of 1.8 m/s. Here she is slowed at a constant acceleration rate of 3.00 m/s^2. How fast is the skater moving when she has slid 0.37 m across the ground?

Given

v_i = 1.8 m/s

a = –3.00 m/s^2

Δx = 0.37 m

Solution

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$v_f = \sqrt{v_i^2 + 2a\Delta x} = \sqrt{(1.8\ \text{m/s})^2 + 2(-3.00\ \text{m/s}^2)(0.37\ \text{m})}$$

$$v_f = \sqrt{3.2\ \text{m}^2/\text{s}^2 - 2.2\ \text{m}^2/\text{s}^2} = \sqrt{1.0\ \text{m}^2/\text{s}^2}$$

$$v_f = 1.0\ \text{m/s}$$

6) Two cars pass each other traveling at the same speed. One car has a constant velocity of 15.0 m/s, east. The other car has a constant acceleration of 1.00 m/s^2, west. How much time will have elapsed until the cars are 164 m apart?

Given

$$v = |v_{i,1}| = |v_{i,2}| = 15.0 \text{ m/s}$$
$$a_2 = 1.00 \text{ m/s}^2$$
$$d = 164 \text{ m}$$

Solution

The total distance between the two cars is the sum of the distances that is traveled by each one of them. The first car has constant speed and the second one has acceleration:

$$d = |d_1| + |d_2| = |v_{i,1}\Delta t| + \left|v_{i,2}\Delta t + \frac{1}{2}a_2(\Delta t)^2\right|$$

$$but(v_{i,1} = v_{i,2} = v)$$

$$d = 2v\Delta t + \frac{1}{2}a_2(\Delta t)^2$$

$$\frac{1}{2}a_2(\Delta t)^2 + 2v\Delta t - d = 0$$

$$\Delta t = \frac{-(2v) \pm \sqrt{(2v)^2 - 4\left(\frac{a_2}{2}\right)(-d)}}{(2)\left(\frac{a_2}{2}\right)}$$

$$\Delta t = \frac{-(2)(15.0\text{ m/s}) \pm \sqrt{[(2)(15.0\text{ m/s})]^2 - 4\left(\frac{1.00\text{ m/s}^2}{2}\right)(-164\text{ m})}}{(2)\left(\frac{1.00\text{ m/s}^2}{2}\right)}$$

$$\Delta t = -30.0\text{ s} \pm 35.0\text{ s} = 5.0\text{ s}$$

7) A rock is thrown downward from the top of a cliff with an initial speed of 12 m/s. If the rock hits the ground after 2.0 s, what is the height of the cliff?(Disregard A.R. $a = -g = -9.81 \text{ m/s}^2$.)

Given

$a = -g = -9.81 \text{ m/s}^2$

$\Delta t = 2.0 \text{ s}$

$v_i = -12 \text{ m/s}$

Solution

$$\Delta x = v_i \Delta t + \frac{1}{2} a (\Delta t)^2$$

$$\Delta x = (-12 \text{ m/s})(2.0 \text{ s}) + \frac{1}{2}(-9.81 \text{ m/s}^2)(2.0 \text{ s})^2 = -44 \text{ m}$$

8) Vector **A** is 3.2 m in length and points along the positive *y*-axis. Vector **B** is 4.6 m in length and points along a direction 195° counterclockwise from the positive *x*-axis. What is the magnitude of the resultant when vectors **A** and **B** are added?

Given

$\mathbf{d}_1 = 3.2$ m along $+y$-axis

$\mathbf{d}_2 = 4.6$ m at 195° counterclockwise from $+x$-axis

$d_1 = 3.2 \text{ m} \qquad \theta_1 = 0.0°$

$d_2 = 4.6 \text{ m} \qquad \theta_2 = 195°$

Solution

$$\Delta x_1 = 0.0 \text{ m}$$

$$\Delta y_1 = 3.2 \text{ m}$$

$$\Delta x_2 = d_2 \cos \theta_2 = (4.6 \text{ m})(\cos 195°) = -4.4 \text{ m}$$

$$\Delta y_2 = d_2 \sin \theta_2 = (4.6 \text{ m})(\sin 195°) = -1.2 \text{ m}$$

$$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = (0 \text{ m}) + (-4.4 \text{ m}) = -4.4 \text{ m}$$

$$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = (3.2 \text{ m}) + (-1.2 \text{ m}) = 2.0 \text{ m}$$

$$d^2 = (\Delta x_{tot})^2 + (\Delta y_{tot})^2$$

$$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(-4.4 \text{ m})^2 + (2.0 \text{ m})^2} = 4.9 \text{ m}$$

9) A man runs at a velocity of 2 m/s before throwing a stone at an angle of 30.0° above the horizontal from the top edge of a cliff with an initial speed of 12 m/s. A person at the bottom of the cliff uses a stopwatch to measure the stone's trajectory time from the moment the stone is thrown from the top of the cliff to the bottom at 5.60 s. (Assume no air resistance and that $a_y = -g = -9.81\ \text{m/s}^2$.)

A) What is the height of the cliff?
B) What is the final vertical velocity of the stone?
C) What is the final horizontal velicity of the stone?
D) What is the total final speed of the stone?
E) At what angle does the stone hit the ground?

Given

$\mathbf{v}_i$ = 12 m/s at 30.0° above the horizontal

$\Delta t = 5.60$ s

$g = 9.81\ \text{m/s}^2$

Solution

A)

$$v_{i,y} = v_i \sin\theta = (12\ \text{m/s})(\sin 30.0°) = 6.0\ \text{m/s}$$

$$\Delta y = v_{i,y}\Delta t + \tfrac{1}{2}a_y(\Delta t)^2 = (6.0\ \text{m/s})(5.60\ \text{s}) + \tfrac{1}{2}(-9.81\ \text{m/s}^2)(5.60\ \text{s})^2$$

$$\Delta y = 34\ \text{m} - 154\ \text{m} = -120\ \text{m}$$

$$h = 120\ \text{m}$$

B)

$$v_{i,y} = 6.0\ \text{m/s}$$

$$(v_f)^2 - (v_i)^2 = 2a_y(\Delta x)$$

$$(v_f)^2 - (6.0 m/s)^2 = 2 \times (-9.8) \times (-120)$$

$$(v_f)^2 = 2388$$

$$v_f = 48.9 m/s$$

C) $v_{i,x} = v_i \cos\theta + 2m/s = (12\ \text{m/s})(\cos 30.0°) + 2m/s = 12.4\ \text{m/s}$

D) $s^2 = (v_x)^2 + (v_y)^2$

$$s^2 = (12.4)^2 + (48.9)^2$$

$$s^2 = 2544.97$$

$$s = 50.4 m/s$$

E) $\tan^{-1}(\frac{v_y}{v_x}) = \tan^{-1}(\frac{48.9}{12.4}) = 75.8^0$ *above the horizontal.*

10) A firefighter 50.0 m away from a burning building directs a stream of water from a fire hose at an angle of 30.0° above the horizontal. Suppose the velocity of the stream is 40.0 m/s. ($a_y = -g = -9.81\ \text{m/s}^2$)

A) How long will it take the stream of water to strike the building?

B) At what height will the stream of water strike the building?

C) What is the final vertical velocity of water as it strikes the building?

Given

$v_i = 40.0$ m/s $\theta = 30.0°$

$\Delta x = 50.0$ m

Solution

A)

$$v_{i,y} = v_i \sin\theta = (40.0\ \text{m/s})(\sin 30.0°) = 20.0\ \text{m/s}$$

$$v_{i,x} = v_i \cos\theta = (40.0\ \text{m/s})(\cos 30.0°) = 34.6\ \text{m/s}$$

$$\Delta x = v_x \Delta t$$

$$\Delta t = \frac{\Delta x}{v_x} = \frac{50.0\ \text{m}}{34.6\ \text{m/s}} = 1.45\ \text{s}$$

B)

$$\Delta y = v_{i,y}\Delta t + \tfrac{1}{2} a_y (\Delta t)^2$$

$$\Delta y = (20.0\ \text{m/s})(1.45\ \text{s}) + \tfrac{1}{2}(-9.81\ \text{m/s}^2)(1.45\ \text{s})^2$$

$$\Delta y = 29.0\ \text{m} - 10.3\ \text{m}$$

$$\Delta y = 18.7\ \text{m}$$

C)

$$(v_f)^2 - (v_i)^2 = 2a_y(\Delta x)$$

$$(v_f)^2 - (20.0 m/s)^2 = 2 \times -9.8 \times 18.7 m$$

$$(v_f)^2 = 33.5$$

$$v_f = 5.79 m/s$$

11) A fox sees a piece of carrion being thrown from a hawk's nest and rushes to snatch it. The nest is 14.0 m high, and the carrion is thrown with a horizontal velocity of 1.5 m/s. The fox is 7.0 m from the base of the tree. (Assume no air resistance and that $a_y = -g = -9.81\ \text{m/s}^2$.)

A) How long does it take for the carrion to land on the ground?
B) How far from the base of the tree will the carrion land?
C) What is the magnitude of the fox's average velocity if it grabs the carrion in its mouth just as it touches the ground?

Given

$v_{carrion} = v_c = 1.5$ m/s horizontally

$\Delta y = -14.0$ m

$d = 7.0$ m

Solution

A)

$$\Delta y_c = \frac{1}{2} a_y (\Delta t)^2 + 0$$

$$(\Delta t)^2 = \frac{2\Delta y_c}{a_y}$$

$$\Delta t = \sqrt{\frac{2\Delta y_c}{a_y}} = \sqrt{\frac{2(-14.0\ \text{m})}{(-9.81\ \text{m/s}^2)}} = 1.69\ \text{s}$$

B)

$$\Delta x = v_x(\Delta t)$$

$$\Delta x = 1.50m/s \times 1.69s = 2.53m$$

C)

The distance between the fox and the place where carrion lands is found to be:

$$d = 7.00 - 2.53 = 4.47m$$

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{4.47m}{1.69s} = 2.64m/s$$