Acceleration & Displacement

Guided Practice

A car is initially traveling 20 m/s [E]. It then accelerates to 32 m/s [E] in 3.5 seconds.

a) Calculate the average acceleration.

$v_o = 20\,m/s$

$v_f = 32\,m/s$

$t = 3.5\,s$

$a = ?$

$$a = \frac{v_f - v_o}{t}$$

$$a = \frac{32-20}{3.5} = \frac{12}{3.5} = \boxed{3.4\,m/s^2}$$

b) Calculate the position of the car at the end of the acceleration.

Reread question and set up the frame of reference and coordinate system

W,- E,+

Frame of reference is relative to the road or a stationary observer outside of the car - this will most often be the case.

Reread question and list known/wanted quantities - include any previously calculate values but only use them if necessary

$v_o = 20\,m/s$ $\quad d_f = ?$

$v_f = 32\,m/s$ $\quad d_o = 0\,m$ * Always the case if not given.

$t = 3.5\,s$

$a = 3.4\,m/s^2$

Check for a formula using only the known and wanted quantities

Two choices! Which one is more mathematically simple to use?

Think about what we are solving for, then decide.

$$* \quad \vec{d}_f = \vec{d}_o + \vec{v}_o t + \frac{1}{2}\vec{a}t^2 \quad \Big| \quad \vec{v}_f^{\,2} = \vec{v}_o^{\,2} + 2\vec{a}(\vec{d}_f - \vec{d}_o)$$

Substitute values and solve for the unknown

$$d_f = 0 + (20)(3.5) + \underbrace{\frac{1}{2}(3.4)(3.5)^2}_{(0.5)(3.4)(3.5)^2 \to (1.7)(12.25) \to 20.8}$$

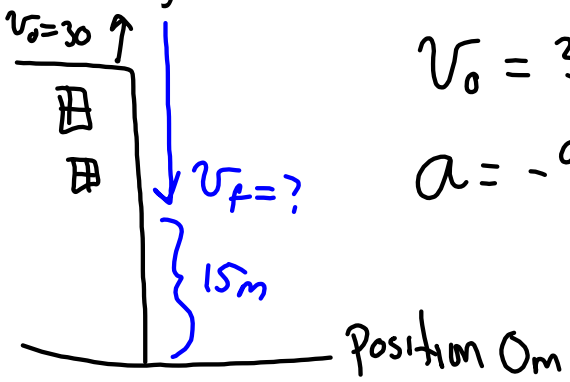
$$= 70 + 20.8$$

$$\boxed{d_f = 90.8\,m}$$

Check answer conceptually - does its value and direction make sense?

Extra Practice: Objects Thrown on Earth

A person stands near the edge of a 75 m high building and throws a quarter upwards with an initial velocity of 30 m/s. Calculate the velocity when it is 15 m above the ground.



$v_0 = 30\,m/s$ $\quad d_0 = 75\,m$

$a = -9.81\,m/s^2$ $\quad d_f = 15\,m$

$v_f = ?$

$$v_f^2 = v_0^2 + 2a(d_f - d_0)$$

$$= (30)^2 + 2(-9.81)(15 - 75)$$

$$v_f^2 = 900 - 19.62(-60)$$

$$v_f^2 = 900 + 1177$$

$$v_f^2 = 2077$$

$$v_f = \pm\sqrt{2077}$$

$$v_f = -45.6\,m/s$$

because object traveling down.

3. A person is standing atop a cliff that is 250 m high cliff overlooking the water below. Not happy with the new iPhone 5S she drops the phone. Hints: use the acceleration of gravity for the Earth; and when an object is dropped the initial velocity is zero.
   a. Calculate the time it takes for the iPhone to hit the water below. {t = 7.1 s}
   b. Calculate the velocity as it enters the water. {$\vec{v}_f$ = -70.0 m/s}
   c. Calculate the velocity of the iPhone 75 m above the water. {$\vec{v}_f$ = -58.6 m/s}

a) $d_o = 250m$ $\quad d_f = 0m/s$

$v_o = 0m/s$ $\quad t = ?$

$a = -9.81 m/s^2$

$$\cancel{d_f}^{0} = d_o + \cancel{v_o t}^{0} + \tfrac{1}{2}at^2$$

$$0 = 250 + \tfrac{1}{2}(-9.81)t^2$$

$$0 = 250 - 4.9t^2 \quad -250$$

$$\frac{-250}{-4.9} = \frac{-4.9t^2}{-4.9}$$

$$51 = t^2$$

$$\pm\sqrt{51} = t$$

$$\boxed{7.1s = t}$$

* -7.1s is rejected as time can never be negative

b) $v_f = ?$

$$a = \frac{v_f - v_o}{t} \quad \text{or} \quad v_f^2 = v_o^2 + 2a(d_f - d_o)$$

$$v_f^2 = (0)^2 + 2(-9.81)(0 - 250)$$

$$v_f^2 = -19.62(-250)$$

$$v_f^2 = 4905$$

$$v_f = \pm\sqrt{4905}$$

$$\boxed{v_f = -70 m/s}$$

downward motion

c) $v_f = ?$

$d_f = 75m$

$d_o = 250m$

$v_o = 0m/s$

$a = -9.81 m/s^2$

$$v_f^2 = v_o^2 + 2a(d_f - d_o)$$

$$v_f^2 = 0^2 + 2(-9.81)(75 - 250)$$

$$v_f^2 = -19.62(-175)$$

$$v_f^2 = 3433$$

$$v_f = \pm\sqrt{3433}$$

$$v_f = -58.6 m/s$$

down.

Attachments

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