Physics 160

Extra Credit #4

Motion of Two Rockets

a) At what time Do they have SAME velocity?

Have to look at spacing Between each picture since that gives you an estimate of V_{AV}.

Initially A's Drawings Are closer together than B's ⇒ Slower

Later A's are farther apart ⇒ Faster

So At some time Between 1s And 4s, they must have had the SAME velocity.

b) SAME x-position? this is places where there is the A picture Both Above AND Below the line ⇒ t=1s And t=4s

c) SAME Acceleration? Never! B has SAME spacing throughout ⇒ ZERO ACCELERATION. A is getting farther apart ⇒ NON-ZERO Acceleration.

d) As just stated, A has non-zero acceleration

e) B has zero acceleration ⇒ constant velocity

f) A ahead of B?

have to compare positions at a given time

Before 1s, A is ahead of B, but also after 4s

Clear the Runway

From rest $\Rightarrow V_{0,x} = 0$

$a_x = 5\,m/s^2$

reaches takeoff velocity at end of runway.

$\Rightarrow X = 1800\,m$

a) How long to take off?

$\Rightarrow$ Know: $x_0 = 0$, $X = 1800\,m$

$V_{0,x} = 0$, $a_x = 5\,m/s^2$

Unknown: V_x, t_{TO}

$\hookrightarrow V_{TO}$

$X = x_0 + V_{0,x}t + \frac{1}{2}a_x t^2$ will work $\Rightarrow 1800\,m = 0 + 0 + \frac{1}{2}(5\,m/s^2)t_{TO}^2$

$$\Rightarrow t_{TO} = \sqrt{\frac{2(1800\,m)}{5\,m/s^2}} = 26.8\,s$$

Unit: $\frac{m}{m/s^2} = \frac{m \cdot s^2}{m} = s^2$, $\sqrt{s^2} = s$

b) what is takeoff speed?

$V_x = V_{0,x} + a_x t \Rightarrow V_{TO} = 0 + 5\,m/s^2(26.8\,s) = 134\,m/s$

Unit: $\frac{m}{s^2} \cdot s = m/s$

c) What is distance traveled in first second

$\Rightarrow$ KNOWN: $x_0 = 0$, $v_{x,0} = 0$, $a_x = 5\,m/s^2$; $t = 1s$

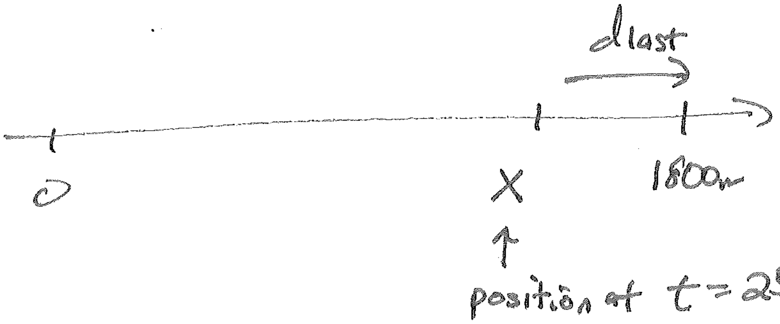
UNKNOWN: v_x, x

$x = x_0 + v_{x,0}t + \frac{1}{2}a_x t^2$ works $\Rightarrow x = 0 + 0 + \frac{1}{2}(5\,m/s^2)(1s)^2$

$\Rightarrow x = 2.5m$ Unit: $\frac{m}{s^2} \cdot s^2 = m$

d) distance traveled in last second?

this one's kind of tricky, we know at $t = 26.8s$ plane's at $x = 1800m$, so we should find x at $t = 25.8s$



$d_{last} = 1800m - X$

KNOWN: $x_0 = 0$, $v_{0,x} = 0$, $a_x = 5\,m/s^2$, $t = 25.8s$, UNKNOWN: x, v_x

$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2 \Rightarrow x = 0 + 0 + \frac{1}{2}(5\,m/s^2)(25.8s)^2 = 1664.1m$

$\therefore \Rightarrow d_{last} = 1800m - 1664.1m = 135.9m \approx 136m$

e) what percentage of $V_{takeoff}$ at midpoint?

i.e, $\frac{V_x}{V_{TO}} = ?$ where V_x is velocity at $x = 900m$

KNOWN: $x_0 = 0$, $V_{x,0} = 0$, $a_x = 5 m/s^2$, $x = 900m$

UNKNOWN: t, V_x

Use $V_x^2 = V_{x,0}^2 + 2a_x(x - x_0)$ to avoid finding t

$V_x^2 = 0^2 + 2(5 m/s^2)(900m) = 9000 m^2/s^2$

$\Rightarrow V_x = \sqrt{9000 m^2/s^2} = 94.868 m/s$

$\Rightarrow \frac{94.868 m/s}{134 m/s} \times 100 = 70.8\% \simeq 71\%$

↑ Mastering wants 70%, whatever

2.23 Human Body can survive $|a_x| = 250 m/s^2$

What distance to survive crash with $V_{0,x} = 106 km/h$

Known: $V_{0,x} = 106 \frac{km}{h} \times \frac{1000m}{1km} \times \frac{h}{3600s} = 29.444 m/s$

$V_x = 0$ (stopped)

Slowing down $\Rightarrow$ a_x opposite to $V_{0,x}$ $\Rightarrow$ $a_x = -250 m/s^2$

Set $x_0 = 0$

Unknown: t, x

Use $V_x^2 = V_{0x}^2 + 2a_x (x - x_0)$

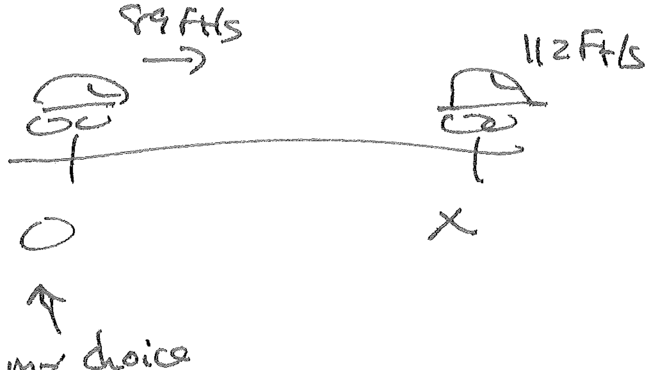
$\Rightarrow 0 = (29.444 m/s)^2 + 2(-250 m/s^2)(x - 0)$

$\Rightarrow x = \frac{-(29.444 m/s)^2}{2(-250 m/s^2)} = 1.73 m$

Unit: $\frac{\left(\frac{m}{s}\right)^2}{m/s^2} = \frac{m^2}{s^2} \cdot \frac{s^2}{m} = m$

2.27 A car driving down turnpike

Known: $v_{x,0} = 89\,ft/s$, $v_x = 112\,ft/s$, $t = 3.5\,s$, $x_0 = 0$



unknown: a_x, X

a) what is acceleration in ft/s^2?

We can use any units in kinematics

$$v_x = v_{x,0} + a_x t \Rightarrow 112\,ft/s = 89\,ft/s + a_x\,(3.5\,s)$$

$$\Rightarrow a_x = \frac{112\,ft/s - 89\,ft/s}{3.5\,s} = \frac{23\,ft/s}{3.5\,s} = 6.57\,ft/s^2$$

Unit: $\frac{ft}{s} \cdot \frac{1}{s} = ft/s^2$

b) $X = ?$ $\quad X = x_0 + v_{x,0}t + \frac{1}{2}a_x t^2$

$$\Rightarrow X = 0 + (89\,ft/s)(3.5\,s) + \frac{1}{2}(6.57\,ft/s^2)(3.5\,s)^2$$

$$= 311.5\,ft + 40.25\,ft = 351.75\,ft$$

$$= 352\,ft$$