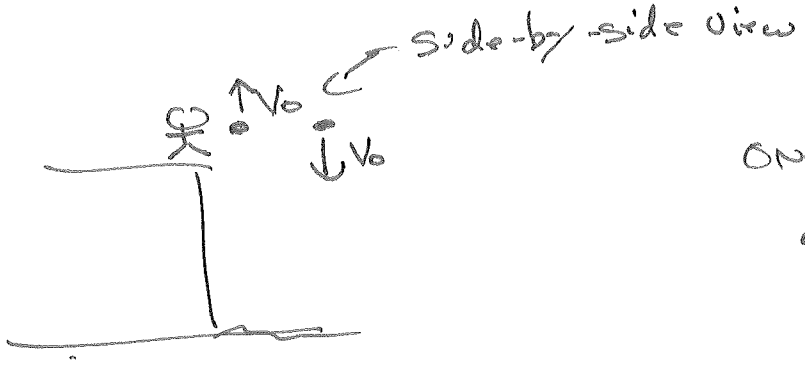
Physics 160

Extra Credit #5

Tossing Balls off Cliff



ONE Ball up, the other down.

Parts a & b)

After being released, only thing making Both Balls move is gravity ⇒ Both have Acceleration g

Part c: the speeds are the SAME Because Speed is just How fast, i.e, $|v_0|$

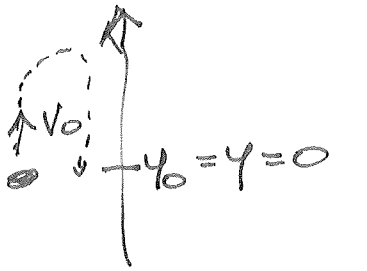
Part d: which has greater Average Speed? Now things are different! For upwards BALL: Velocity AND Acceleration have opposite sign ⇒ decreasing speed.

For DOWNWARD BALL: velocity AND Acceleration have SAME sign ⇒ increasing speed.

So DOWNWARD BALL HAS greater Average Speed.

Part e: which hits ground with greater speed?

This one is kind of tricky until you learn one fact: A ball thrown upwards returns to its starting point with the same speed (No Air Resistance)



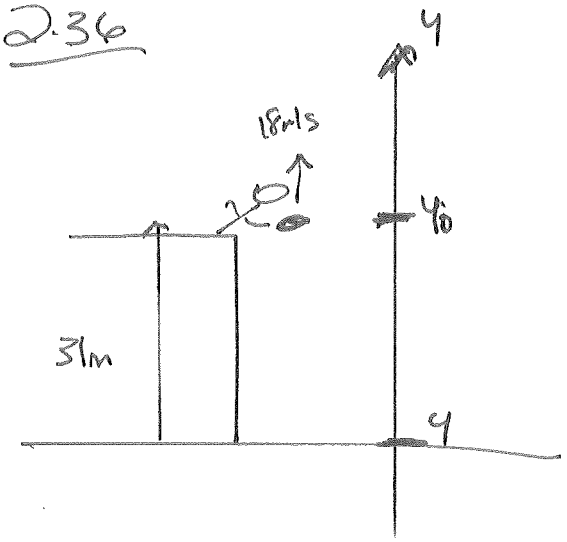
Since $y_0 = y = 0$

$$V^2 = V_{y0}^2 + 2a_y(y - y_0) \Rightarrow V^2 = V_{y0}^2 + 2a_y(0)$$

$$\Rightarrow V = \pm V_{y0} \Rightarrow |V| = V_{y0}$$

So ball thrown upwards returns to its throwing height with same V_0 but going downward. So while it will take longer for it to reach the ground, its motion is now the same as the downwards ball. So both hit ground with same speed.

2.36



How fast and how long to hit street

KNOWN:

Set ground level at street $\Rightarrow y = 0$

$y_0 = 31\text{m}$

(Notice that we don't have to worry about the up-then-down motion)

$V_0 = +18\text{m/s}$ (up is positive)

$\Rightarrow a_y = -g = -9.8\text{m/s}^2$

UNKNOWN: V_y, t

Since we don't know t: $V_y^2 = V_{0y}^2 + 2a_y(y - y_0)$

$\Rightarrow V_y^2 = (18\text{m/s})^2 + 2(-9.8\text{m/s}^2)(0 - 31\text{m})$

$\Rightarrow V_y^2 = 324\text{m}^2/\text{s}^2 + 607.6\text{m}^2/\text{s}^2 = 931.6\text{m}^2/\text{s}^2$

$\Rightarrow V_y = \pm\sqrt{931.6\text{m}^2/\text{s}^2} = \pm 30.5\text{m/s}$. If we wanted velocity, we'd choose -30.5m/s because it was moving downward the instant before it hit the ground.

Mastering doesn't know about your sign choices, so it asks for the speed $\Rightarrow +30.5\text{m/s}$

b) How much time? Since we have v_y now

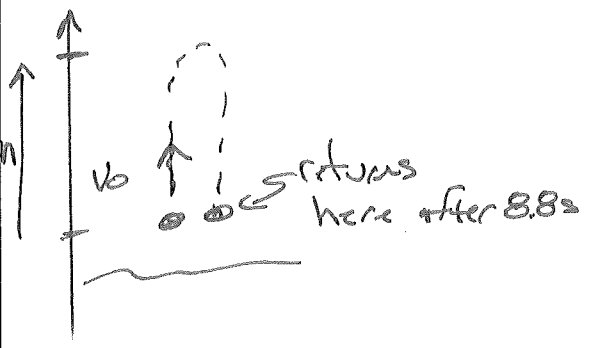
$v_y = v_{0y} + a_y t$ is simplest. But we have to use negative value

$$\Rightarrow -30.5\,m/s = 18\,m/s - 9.8\,m/s^2 t$$

$$\Rightarrow t = \frac{-30.5\,m/s - 18\,m/s}{-9.8\,m/s^2} = \frac{-48.5\,m/s}{-9.8\,m/s^2} = 4.95\,s$$

2.39 tennis ball on Mars : $g_{Mars} = 0.379 g_{earth} = 0.379(9.8 m/s^2)$

$= 3.7142 m/s^2$



What is MAX height AND V_0

I'll solve for V_0 first since we know: $y_0 = y = 0$

for $t = 8.8s$

$a_y = -g_{Mars} = -3.7142 m/s^2$

UNKNOWN: V_0, V

$y = y_0 + V_{0y}t + \frac{1}{2}a_y t^2$ will work $\Rightarrow 0 = 0 + V_{0y}(8.8s) + \frac{1}{2}(-3.7142 m/s^2)(8.8s)^2$

$\Rightarrow 0 = V_{0y}(8.8s) - 143.8m \Rightarrow V_{0y} = \frac{143.8m}{8.8s} = 16.34248 m/s$

NOW: To find MAX height : KNOWN $V_{0y} = 16.34248 m/s$

$y_0 = 0$

$a_y = -3.7142 m/s$

$V_y = 0$ ← at MAX

UNKNOWN: y, t

↖ Different elapsed time to reach top

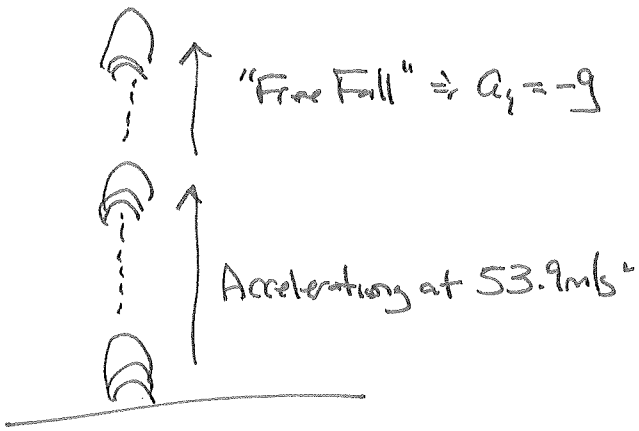
$$V_y^2 = V_{oy}^2 + 2a_y(y - y_0) \text{ there}$$

$$\Rightarrow 0 = (16.34248\,m/s)^2 + 2(-3.7142\,m/s^2)(y - 0)$$

$$\Rightarrow y = -\frac{(16.34248\,m/s)^2}{2(-3.7142\,m/s^2)} = 35.953\,m = 36.0\,m$$

Note: the "other" way to do this problem is to use the fact that on any planet, (AND NO AIR RESISTANCE), AN object takes AN equal AMOUNT of time to go up as to go down. So use that info to get V_{oy}.

Rocket height



Two Motions:

1st Motion: Known:

$y_{0,1} = 0$, $a_1 = 53.9 m/s^2$

$V_{0,1} = 0$, $t_1 = 10s$

Unknown: $V_{f,1}$, y_1

2nd Motion: Known: $a_2 = -9.8 m/s^2$

$V_{f,2} = 0$ for max height

Unknown: y_2, ~~t_2~~ $y_{0,2}$, $V_{0,2}$, t_2

Also know that $y_{0,2} = y_1$ and $V_{0,2} = V_1$ since 1st Motion leads directly into 2nd Motion.

So Start by Finding y_1 and V_1

$V_1 = V_{0,1} + a_1 t_1 \Rightarrow V_1 = 0 + (53.9 m/s^2)(10s) = 539 m/s$

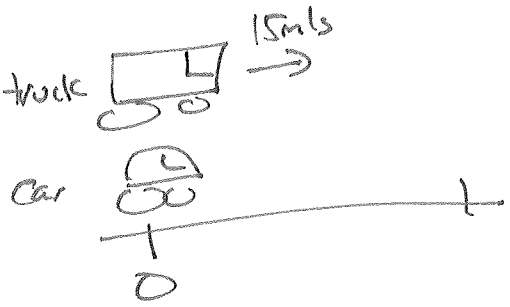
$y_1 = y_{0,1} + V_{0,1} t_1 + \frac{1}{2} a_1 t_1^2 \Rightarrow y_1 = 0 + 0 + \frac{1}{2}(53.9 m/s^2)(10s)^2 = 2695m$

So finish by $V_2^2 = V_{0,2}^2 + 2a_2(y_2 - y_{0,2}) \Rightarrow 0 = (539 m/s)^2 + 2(-9.8 m/s^2)(y_2 - 2695m)$

$$\Rightarrow y_2 = 2695m + \frac{+(539 m/s)^2}{2(+9.8 m/s^2)} = 2695m + 14822.5m$$

$$= 17517.5m = 17500m$$

2.34



truck: $V_{oT} = 15 m/s$, $a_T = 0$ (constant speed) $x_{oT}=0$

Car: $V_{oc} = 0$, $a_c = 3.35 m/s^2$; $x_{oc}=0$

⇒ where does car catch truck?

So Problem ends when $x_T = x_c$

$x = x_o + V_o t + \frac{1}{2} a t^2$ ⇒ Solve for t first

$x_T = 0 + 15 m/s\, t + 0 = (15 m/s) t$

$x_c = 0 + 0 + \frac{1}{2}(3.35 m/s^2) t^2$

⇒ $x_T = x_c$ ⇒ $(15 m/s) t = \frac{1}{2}(3.35 m/s^2) t^2$

⇒ $\frac{1}{2}(3.35 m/s^2) t^2 - (15 m/s) t = 0$ ⇒ $t\left[\frac{1}{2}(3.35 m/s^2) t - 15 m/s\right] = 0$

⇒ $t = 0$ (just telling us what we already know, they were at the same point at the start of the problem)

or $\frac{1}{2}(3.35 m/s^2) t - 15 m/s = 0$ ⇒ $t = \frac{2(15 m/s)}{3.35 m/s^2} = 8.955 s$

So $X_T = (15 m/s)(8.955) = 134.328 m = 134 m$

As A Check: $X_c = \frac{1}{2}(3.35 m/s^2)(8.955)^2 = 134 m$

b) How fast is car going?

$V_c = V_{oc} + a_c t \Rightarrow V_c = 0 + (3.35 m/s)(8.955) = 30 m/s$

I think this is to stress the point that the car AND truck DO not have SAME Velocity when they PASS, so if you tried $V_c = V_T$, that's why you got the wrong Answer.