MT#2 PHYS141 Fall2015 Name________________________________ 85r

1) I spin a 2 kg rock over my head (David and Goliath style) on a string at constant speed such that it makes a circle around my hand of radius 3 m and makes an angle of 30 degrees below the horizon.

a) Find the Tension in the String.

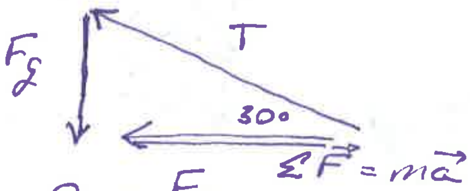
b) Find the acceleration of the rock.

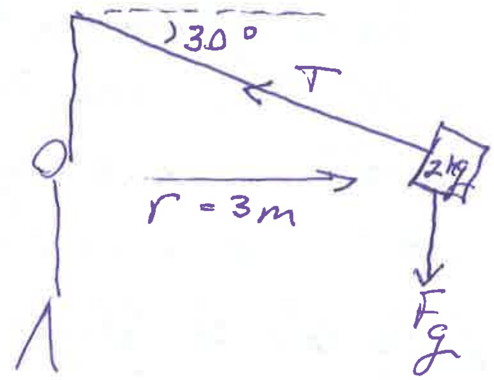
c) Find the speed of the rock.

a) Dynamics because $\sum \vec{F} = ma_{(c)}$

$\Leftarrow \vec{a}$ because a_c $\quad a = \frac{V^2}{r}$

$\sum \vec{F} \Leftarrow$





$\sin\theta = \sin 30° = \frac{O}{H} = \frac{F_g}{T}$

$T = \frac{F_g}{\sin 30°} = 2 \cdot F_g = 2mg = 40N$

b) $\sum \vec{F} = m\vec{a}$ we can see from the force diagram that $\sum \vec{F} = T_x$ or $T\cos\theta = T\frac{\sqrt{3}}{2} \approx 0.87T \approx 35N$

$a = \frac{F}{m} \approx \frac{35N}{2kg} = 17.5 \, m/s^2$ (plausible, $a = 1.75g$)

- Stright up kinematics -

c) $a = \frac{V^2}{r}$ $\quad V = \sqrt{ar} = (17.5 \, m/s^2 \cdot 3m)^{\frac{1}{2}}$

$(52.5)^{\frac{1}{2}} \left(\frac{m^2}{s^2}\right)^{\frac{1}{2}}$

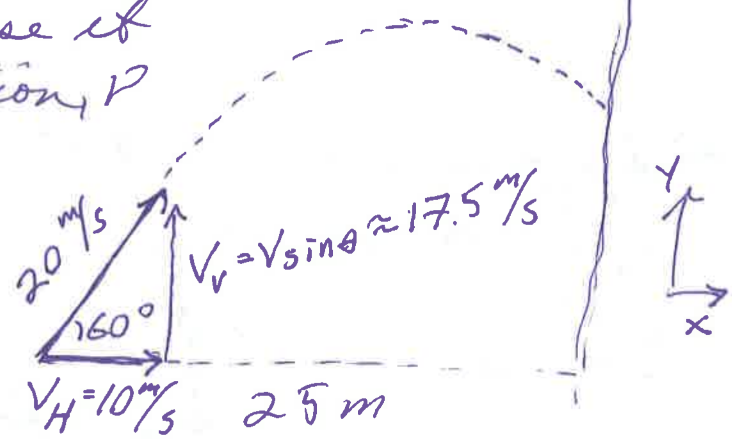
$\approx 7.2 \, m/s$

(about as fast as I can run)

2) From 25 meters away from a building, I shoot a water balloon up at it with a speed of 20 m/s, at an angle of 60° above the horizon.

a) How high do I hit the building?
b) What is the velocity of the water balloon when it hits? (please give angle and magnitude).

This is Kinematics because it deals explicitly w/ position, and time. The time the water is moving forward until it hits the building = time it's going up and down



Horizontal story!! ⇒ it's moving forward at 10 m/s a distance of 25 m ∴, it will take $2\frac{1}{2}$ s to hit the building! ($a_x = 0$)

b) Vertical: $V_0 = 17.5$ m/s ⇑ after $2\frac{1}{2}$ s, $a = -10$ m/s²

$V = V_0 + at = 17.5\,\text{m/s} - 10\,\text{m/s}^2 \cdot 2\frac{1}{2}\,\text{s} = 17.5\,\text{m/s} - 25\,\text{m/s}$

$= -7.5$ m/s

it's going down

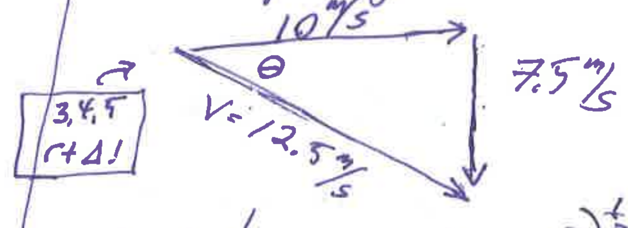
a) $Y_f = Y_0 + V_0 t + \frac{1}{2} a t^2$ ($V_0 \to V_Y$)

* or average $V_Y = \dfrac{17.5\,\text{m/s} + -7.5\,\text{m/s}}{2}$

$= 5$ m/s

$\Delta Y_{total} = V_{Y\,average}\,\Delta t = 5\,\text{m/s} \cdot 2.5\,\text{s}$

$= 12.5$ m



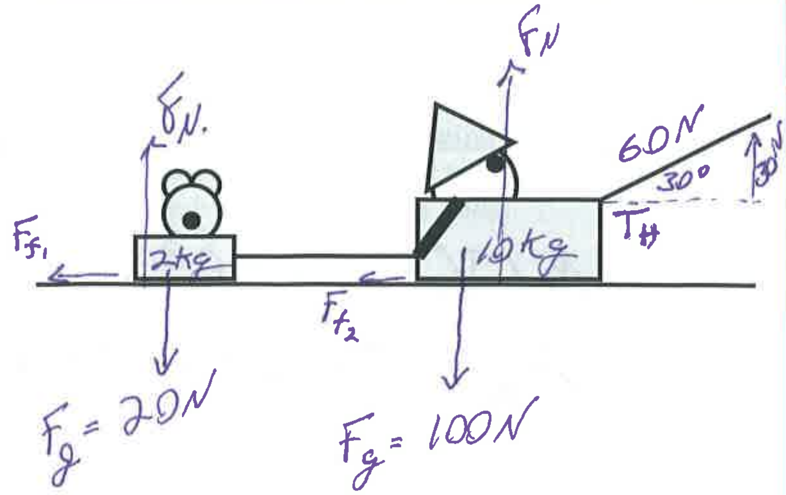
$|V| = \left((10\,\text{m/s})^2 + (7.5\,\text{m/s})^2\right)^{\frac{1}{2}}$

$= \left(100\,\frac{m^2}{s^2} + \tilde{5}5\,\frac{m^2}{s^2}\right)^{\frac{1}{2}}$

$\approx 12\frac{1}{2}$ m/s

$\theta = \tan^{-1}\left(\dfrac{7.5\,\text{m/s}}{10\,\text{m/s}}\right) = \tan^{-1} 0.75 \approx 37°$

3) I pull my little girl (10 kg) in her sled and she pulls Teddy (2 kg). I pull with a tension of 60 N at an angle of 30° above the horizon for 10 meters starting from rest. The coefficient of friction for both sleds on the snow is 0.2. Find the following: final speed, acceleration, tension in the string to Teddy…in any order showing all work.



I'm going to use work energy because I can see $W_{Pete} \Rightarrow KE + Heat$ ← $W_{friction}$

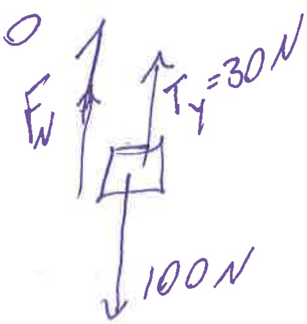
⇒ Then I do it again w/ dynamics

But first I have to use some dynamics in the y direction to find F_N to find F_f.

$W_p = F_p \cdot \Delta X = T_H \cdot 10m = 60N \cdot \cos 30° \cdot 10m$ N·m

$= 60N \cdot .87 \cdot 10m = 522\ J$

$F_f = ?$ $\sum_{girl} F_y = ma_y = 0$



60
522.0

F_N must $= 70N$

$F_{girl\ friction} = \mu F_N = 14N$ $F_{f_{Teddy}} = 4N$ $F_{f_{Total}} = 18N$

$W_F = Heat = 18N \cdot 10m = 180\ J$

$KE_{final} = W_p - W_f = 522J - 180J = 342\ J = \frac{1}{2} m_{total} v^2$

$V_f = \left(\frac{KE \cdot 2}{m}\right)^{\frac{1}{2}} = \left(\frac{342\ kg\frac{m^2}{s^2} \cdot 2}{12\ kg}\right)^{\frac{1}{2}} = \sqrt{57}\ m/s \sim 7.6\ m/s$

4) There are two planets made from the same substance. Planet B is three times as large as planet A, that is $r_B = 3r_A$. Imagine that I visit each planet.

an answer alone is worth zero points – please explain your logic:

a) What is the ratio of the masses of the two planets? $m_B = \_\_ m_A$. This question particularly doesn't really fall under one of the 4 lenses, but show your logic.

$m \propto \text{Volume} \propto r^3$

$m_B = 3^3 m_A = 27 m_A$

b) I visit the surface of each planet. Where do I weigh more, and what is the ratio of my weight on each planet? $F_B = \_\_ F_A$. This question particularly doesn't really fall under one of the 4 lenses, but show your logic.

$F_g = \frac{m_1 m_2}{r^2} G \propto \frac{m}{r^2}$ $F_B = \frac{27}{3^2} F_A$

$F_B = 3 F_{gA}$

c) If I need to escape from the planet into deep space, what is the ratio of my escape velocities from the planets: $v_B = \_\_ v_A$.

Energy! $\frac{1}{2} m v_e^2 = \frac{m_1 m_2 G}{r}$

$\propto r^3$

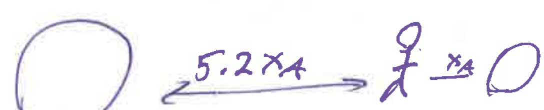
$V_B = 3 V_A$ $V \propto \left(\frac{m}{r}\right)^{\frac{1}{2}} \propto r^1$

d) If the planets were allowed to fall together from rest, what would be the ratio of the speeds of the planets right before they hit? $v_B = \_\_ v_A$ conserve $\vec{p}$ because

$F_{AB} = F_{BA}$ they have the same $|\vec{p}| = |m\vec{v}|$

so $V \propto \frac{1}{m}$ or $V_B = \frac{1}{27} V_A$

e) If I want to put myself between the two planets so that I am not attracted to either one more than the other, estimate the ratio of my distance from each planet: $x_B = \_\_ x_A$.



if $m_B = 27 m_A$

then $r_B = \sqrt{27}\, r_A$

~ 5.2

$F_g = \frac{m_1 m_2}{r^2} G$ $\propto r^3$

$V_{ave} = \frac{1}{2} V_f \approx 3.8\ m/s$ $\quad t = \frac{\Delta x}{V_{ave}} \approx 2.6\ s$

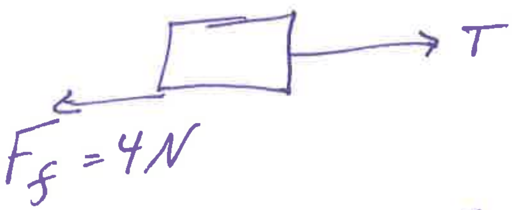
$$a = \frac{\Delta V}{\Delta t} = \frac{7.6\ m/s}{2.6\ s} \approx 2.9\ m/s^2$$

Now, we're just using kinematics

$T = ?$

This is dynamics because we know $\vec{a}$ and we want to find T force, so I look at the forces on Teddy

$a \Rightarrow 2.9\ m/s^2$



$$\Sigma F = m\vec{a}$$

$$-4N + T = ma$$

$$T = ma + 4N$$

$$= 2kg \cdot 2.9\ m/s^2 + 4N$$

$$= 9.8N$$

— <u>Really</u> — I should have just started the Problem w/ dynamics and <u>not</u> address work... look: $\Sigma F_x = m a_x$

$$F_{f\,girl} + F_{f\,Teddy} + T_H = m_{system} a_x$$

$$-14N - 4N + 52.2N = 12kg \cdot a_x \Rightarrow a_x = 2.85\ m/s^2$$

$\Rightarrow$ much easier.