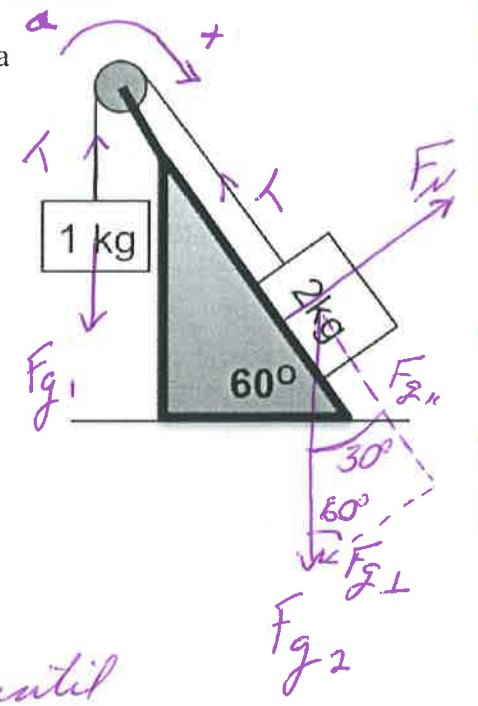
MT2 May 12, 2016 Name Pete You are graded on your ***communication*** of Physics

9.14

1) See the system of masses at right. The masses are attached by a string over a low mass, low friction pulley. The system is released from rest and the coefficient of friction between the 2 kg mass and the incline is 0.2.

a) Please find the acceleration of the system.

b) Please find the tension in the string



$\mu = 0.2$

a) Forces + a ..... I'll try dynamics.

FBD

I will find a using a system's approach $\sum \vec{F}_s = m_s \vec{a}_s$

$\sum F_{\parallel} = m_s a_{\parallel} \Rightarrow -F_{g_1} + F_{g_{\parallel}} \mp F_f = m_s a_s$ (?)

but we don't know the direction of F_f until we know the direction of v.... $F_{g_1} = mg = 10N$

so $F_{g_{\parallel}} > F_{g_1}$ & the system will accelerate (if it does move) in the "+" direction. Now I have $-F_{g_1} + F_{g_{\parallel}} - F_f = m_s a_s$

$F_{g_{\parallel}} = m_2 g \cos 30 = 20N(.87) \approx 17.4N$

$$a_s = \frac{F_{g_{\parallel}} - F_{g_1} - F_f}{m_s} = \frac{17.4N - 10N - 2N}{3kg} \approx {}^{+}1.8\,m/s^2$$

Oh no... what's F_f? $F_f = \mu F_N$ $\sum F_{\perp} = ma_{\perp} = 0$

$F_N = F_{g_\perp} = F_{g_2} \sin 30° = 20N(\tfrac{1}{2}) = 10N$

$F_f = (.2)10N = 2N$

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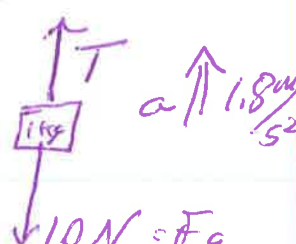
b) Forces + a ⇒ Dynamics. T is an internal force, so I can't use a system's approach

T acts on the 1kg mass + the 2kg mass.

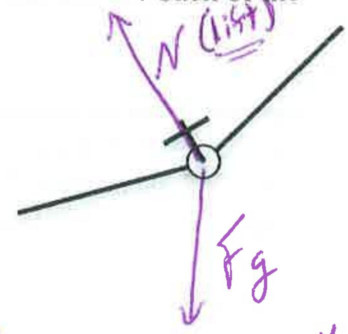
I choose the 1kg mass. $T > F_{g_1}$ because $a \Uparrow$

$\sum \vec{F} = ma$, $T - F_g = ma$

$T = F_g + ma = 10N + 1kg \cdot 1.8\,m/s^2 = \boxed{11.8N}$



2) You are sitting on a mountain top watching an airplane at the same elevation. You see the back of the airplane as it executes a horizontal turn.



   a) What is the direction of the plane's acceleration? *Make clear you know why this is correct.*
   b) Estimate the acceleration of the airplane as best you can from the picture, *making clear why you know this is correct.*
   c) The 50 kg pilot is sitting on a scale. Estimate what this scale reads, *making clear why you know this is correct.*

Dynamics because of $\vec{F}, \vec{a}$

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

$a_y = 0$, so $\Sigma\vec{F}_y = 0$

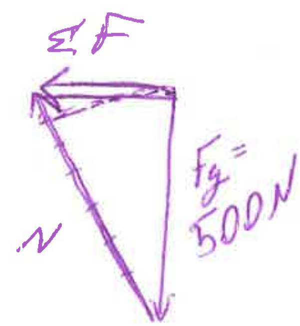
it is accelerating to the left. This is centripetal acceleration $= \frac{V^2}{r}$ because it is turning to the left.

b) $\Sigma\vec{F}$ appears to be $\sim \frac{1}{2} F_g$; so (or a little more)

$ma \sim \frac{1}{2} mg$ $\quad a \sim \frac{1}{2} g \approx 5\ m/s^2$, or $6\ m/s^2$

c) looking at the $\Sigma\vec{F}$ diagram

$N \approx 1.15\ F_g \approx 57N$



3) You are looking to drop two satellites into orbit around two planets made of the same substance, except that planet A has twice the diameter as planet B. The satellites will be close to the surface of each planet, which we can do because neither planet has atmosphere. How does the speed of satellite B (orbiting planet B in low orbit) compare to the speed of satellite A? That is:

$v_A =$ __2__ v_B

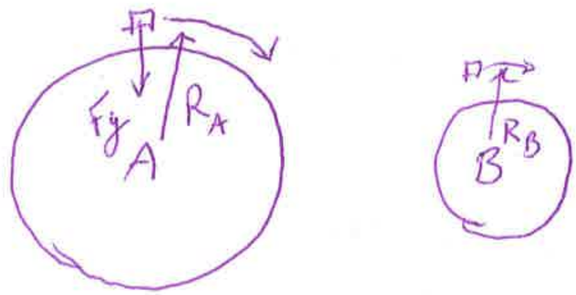
A correct answer with no explanation will earn you an F. Please explain what is going on.

Along the way, it might be a good idea to explain what is the ratio of the masses of the planets:

$m_A =$ __8__ m_B

As well as the ratio of the accelerations of the two satellites:

$a_A =$ __2__ a_B



$m \propto$ Volume $\propto r^3$

$m_A = 2^3 m_B = 8 m_B$

Dynamics because

$\Sigma \vec{F} = m\vec{a}$ .... $= m\frac{v^2}{r}$ There is only 1 force

.... ~~Centripetal Force~~ OMG... I didn't say that...

The gravitational force $= m a_c$

$\propto \frac{m_{(planet)}}{r^2}$, so $a_A = \frac{(8)}{2^2} a_B = 2 a_B$

$a_c = \frac{v^2}{r}$ $\quad v = \sqrt{a_c r}$

$v_A = \sqrt{(2)(2)}\, v_B = 2 v_B$

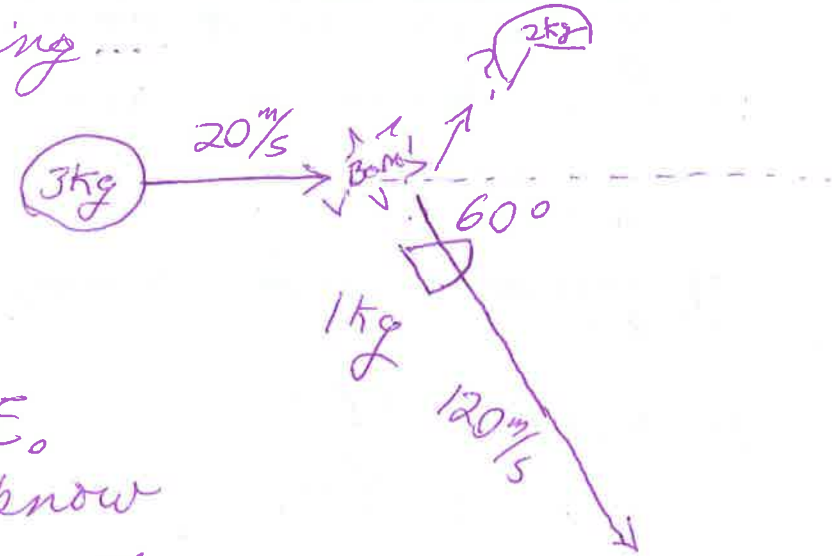
or = all together: $\quad F_g = m a_c \Rightarrow \frac{m_s M_{planet}}{r^2} G = \frac{m_s v_s^2}{r}$

$M_{planet} = \text{Density} \cdot \frac{4}{3}\pi r^3$ $\quad \frac{\text{Density} \cdot \frac{4}{3}\pi r^3}{r^2} G = \frac{v_s^2}{r}$

$v_s = (\text{Density} \frac{4}{3}\pi)^{\frac{1}{2}} r \propto r$

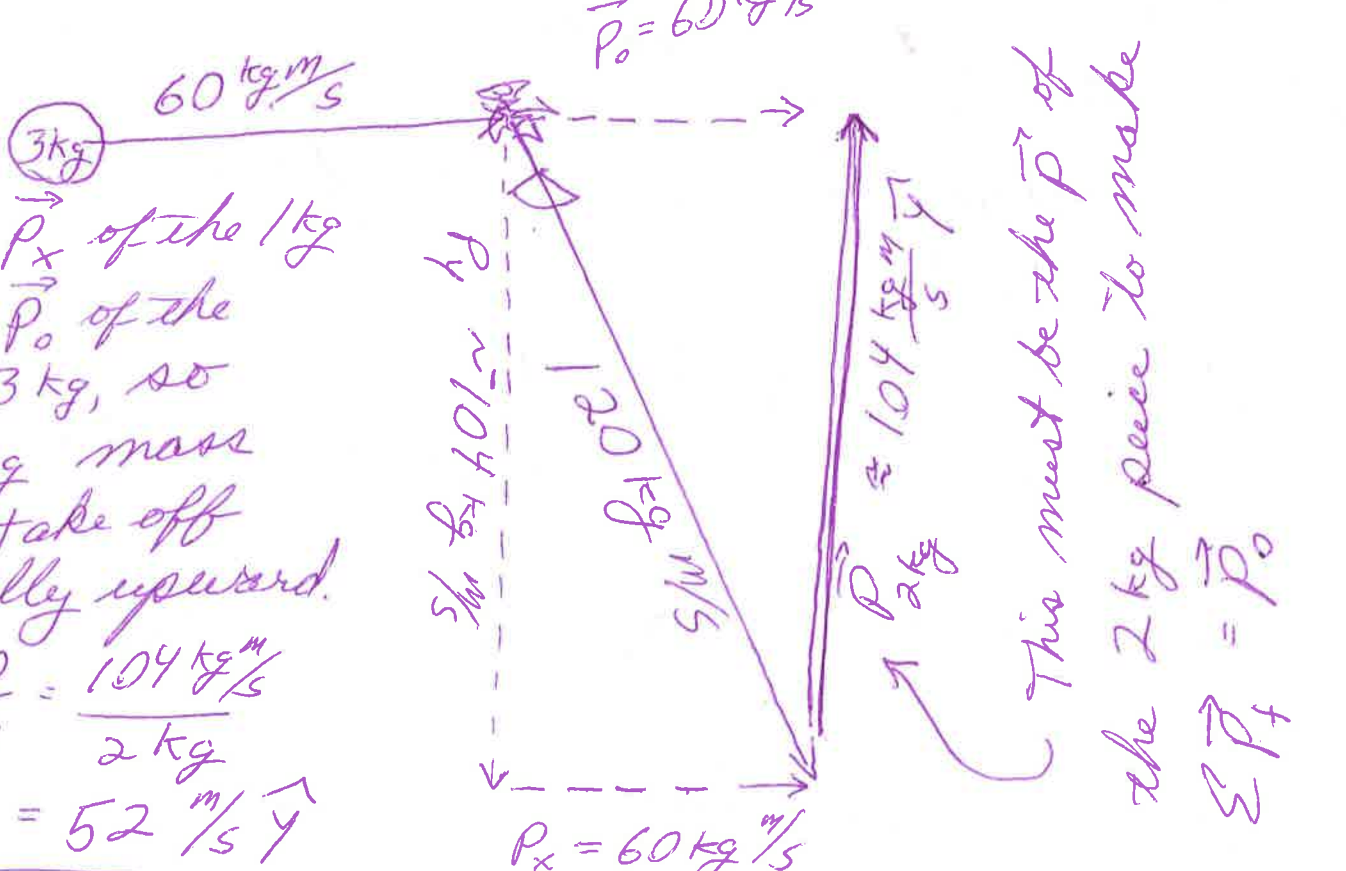
4) A 3 kg chocolate love bomb has a velocity of 20 m/s $\underline{x}$, when it explodes into two pieces and a 1 kg piece takes off downward at 120 m/s, its trajectory making a 60° angle with the x axis and a 30° angle with the $-y$ axis. What is the velocity of the remaining 2 kg piece of chocolate? (include direction).

I just start drawing...



Energy doesn't work because energy was given off in the explosion, so $KE_f > KE_o$ and I don't even know the difference. I know to conserve $\vec{p}$ + make sure I remember that $\vec{p}$ is a <u>vector</u> $\Sigma\vec{p}_o = \Sigma\vec{p}_f$ I choose to make a $\vec{p}$ diagram + be careful of ∡s.

$\vec{P}_o = 60\ kg\,m/s\ \vec{x}$



we see $\vec{P}_x$ of the 1kg mass = $\vec{P}_o$ of the whole 3 kg, so the 2 kg mass must take off vertically upward.

@ $V = \frac{P}{m} = \frac{104\ kg\,m/s}{2\ kg}$

$\vec{V}_{2kg} = 52\ m/s\ \vec{y}$