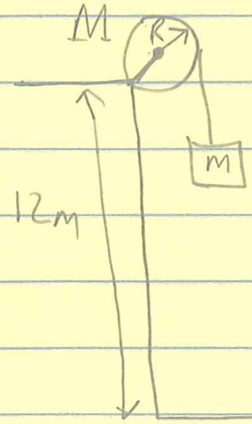
PHY 2048 HW due 4/3

9.72)



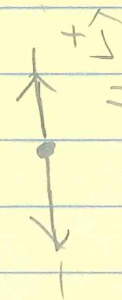
$R = 0.3\,m$
$I = 9.6\ kg\,m^2$
$m = 43\ kg$

Lots of information translates into this picture ☺

Asking for a time ("how long to reach ground"). Cons. of energy will not provide that information.

Using Newton

for m



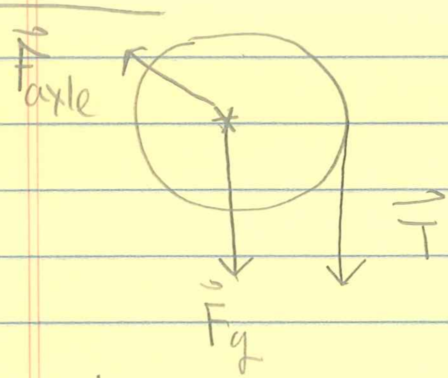
$\vec{T} = +T\hat{j}$

$\vec{F}_g = -mg\hat{j}$

2^{nd} $\boxed{\hat{j}}$ $\sum F_y = ma_y$

$\boxed{1}$ $\boxed{T - mg = ma_y}$

for M (motion is rotational)



$\vec{\tau}_{F_{axle}} = 0$

$\vec{\tau}_{\vec{F}_g} = 0$

$\vec{\tau}_{T} = \vec{R} \times \vec{T} = RT\sin(90)$ $\boxed{IN}$ or "−" $\boxed{CW}$

2^{nd} $\sum \vec{\tau} = I\vec{\alpha}$

$\boxed{2}$ $\boxed{-RT = I\alpha}$

NOTE: Signs for motion must be consistent. In coord. for 'm', expect motion to be $-\hat{j}$. ∴ Corresponding direction here must be "−".

use "cross-talk" relation $a_y = R\alpha$ in $\boxed{2}$ to get

$$\boxed{2} \Rightarrow \quad -RT = I\left(\frac{a_y}{R}\right)$$

$$\boxed{2A} \quad \boxed{-R^2 T = I a_y}$$

We now have two equations ($\boxed{1}$, $\boxed{2A}$) with two unknowns (T, a_y)

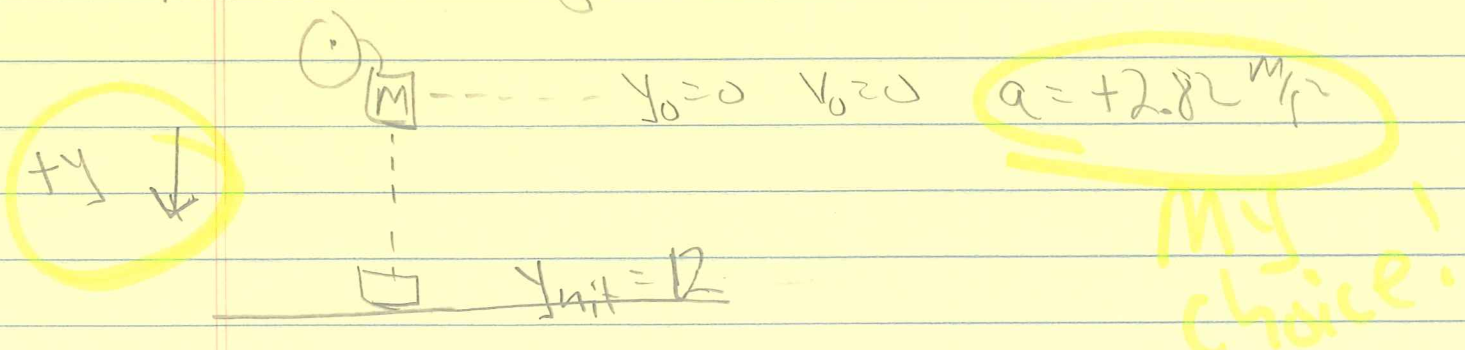
What we need is a_y so we can use eqtns. of motion. Substituting $\boxed{1}$ into $\boxed{2A}$ gives us

$$\Rightarrow -R^2(ma_y + mg) = I a_y$$

$$\therefore \quad a_y = \frac{-mgR^2}{(I + mR^2)} = -2.82 \text{ m/s}^2$$

makes sense w/ coordinates of that free body diagram.

Now use eqtns of motion w/ constant acceleration.



$$\left[\begin{array}{ll} y(t) = 1.41t^2 & \boxed{1} \\ v(t) = 2.82t & \boxed{2} \end{array}\right.$$

☺

@ $t = t_{hit}$, $y_{hit} = 12$, $v = v_{hit}$

$\boxed{1} \Rightarrow \quad 12 = 1.41 t_{hit}^2$

$t_{hit} = 2.92$ seconds

Answer ☆

$\boxed{2} \Rightarrow \quad v_{hit} = 2.82 * t_{hit} = 8.23\ m/s$

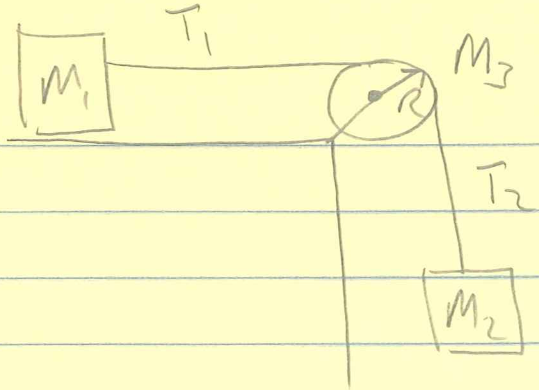
Answer ☆

10.2] Please ask if you have questions. ☺
10.4] " "

These are straight forward applications of the definition.

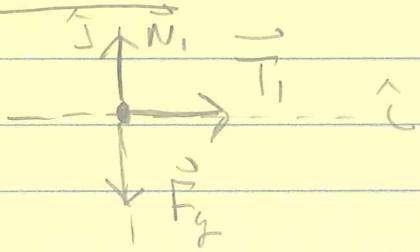
10.8] Solution was posted to discussion forum PLEASE TAKE A LOOK. There are some subtleties.

10.16)



$M_1 = 12\ kg$
$M_2 = 5\ kg$
$M_3 = 2\ kg$ (disk, solid)
$R = 0.025$

for m_1



$\vec{T}_1 = T_1 \hat{i}$
$\vec{N}_1 = N_1 \hat{j}$
$\vec{F}_g = -m_1 g \hat{j}$

2nd $\hat{i}$ $\sum F_x = m_1 a_x$

$$\boxed{T_1 = m_1 a_x} \quad \boxed{1}$$

This is all we will need, so I will move on :)

for m_2

$\vec{T}_2 = -T_2 \hat{i}$

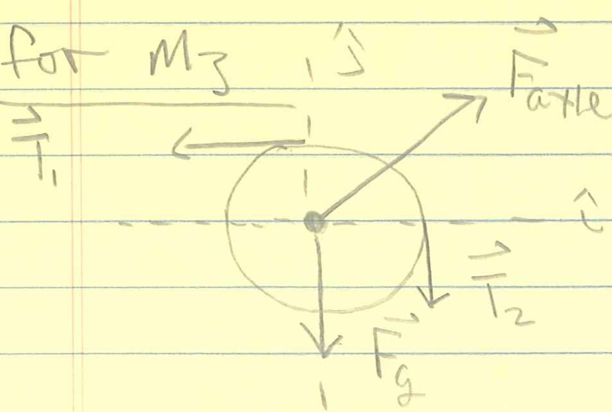
$\vec{F}_g = +m_2 g \hat{i}$

NOTE choice of coordinates!

2nd $\hat{i}$ $\sum F = m_2 a_x$

$$\boxed{2} \quad \boxed{m_2 g - T_2 = m_2 a_x}$$

for m_3



NOTE: We can find the tensions w\ $\sum \vec{\tau} = I \vec{\alpha}$. We will eventually need $\sum \vec{F} = m\vec{a}$ to find $\vec{F}_{axle}$.

I will go ahead and write out both forms of 2nd Law ☺

$$\vec{F}_{axle} = F_x\hat{i} + F_y\hat{j}$$
$$\vec{F}_g = -m_3 g\hat{j}$$
$$\vec{T}_2 = -T_2\hat{j}$$
$$\vec{T}_1 = -T_1\hat{i}$$

2nd $\sum\vec{F} = m_3\cancel{\vec{a}}$ → No translational Motion

$\boxed{\hat{i}}$ $\sum F_x = 0$

$$F_x - T_1 = 0$$
$$\boxed{F_x = T_1} \quad \boxed{A}$$

$\boxed{\hat{j}}$ $\sum F_y = 0$

$$F_y - m_3 g - T_2 = 0$$
$$\boxed{F_y = T_2 + m_3 g} \quad \boxed{B}$$

$$\vec{\tau}_{F_{axle}} = 0$$
$$\vec{\tau}_{\vec{F}_g} = 0$$
$$\vec{\tau}_{\vec{T}_2} = \vec{R}\times\vec{T}_2 = RT_2\sin(90) = RT_2 \quad \boxed{IN} \text{ or } \boxed{\text{Clockwise}}$$
$$\vec{\tau}_{T_1} = \vec{R}\times\vec{T}_1 = RT_1\sin(90) = RT_1 \quad \boxed{OUT} \text{ or } \boxed{\text{Counter Clockwise}}$$

2nd $\sum\vec{\tau} = I\vec{\alpha}$

So description of motion is consistent w/ other diagrams, choose $\boxed{\text{Clockwise}}$ as "+"

$$+RT_2 - RT_1 = I\alpha$$

$I = \frac{m_3R^2}{2}$

$a_x = R\alpha$

$\therefore \alpha = \frac{a_x}{R}$

$$\boxed{C} \quad \boxed{T_2 - T_1 = \frac{m_3 a_x}{2}}$$

This acceleration is NOT related to the one @ the top of this page!! Do you see why??

We now have 3 eqtns. and 3 unknowns:

$\boxed{1}$ $T_1 = m_1 a_x$

$\boxed{2}$ $m_2 g - T_2 = m_2 a_x \Rightarrow T_2 = m_2 g - m_2 a_x$

$\boxed{3}$ $T_2 - T_1 = \frac{m_3 a_x}{2}$

Use $\boxed{1}$ and $\boxed{2}$ in $\boxed{3}$ to get:

$$\Rightarrow m_2 g - m_2 a_x - m_1 a_x = \frac{m_3 a_x}{2}$$

$$m_2 g = a_x \left(m_1 + m_2 + \frac{m_3}{2}\right)$$

$$a_x = \frac{m_2 g}{\left(m_1 + m_2 + \frac{m_3}{2}\right)} = \underline{\underline{2.72\ m/s^2}}$$

So we have:

$$T_1 = m_1 a_x = \underline{32.6\ N}$$

$$T_2 = m_2 g - m_2 a_x = \underline{\underline{35.4\ N}}$$

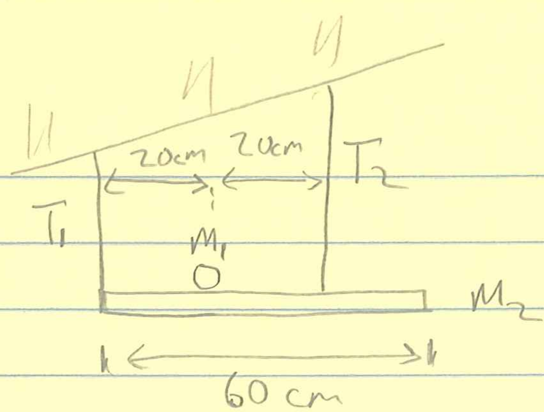
We can now go back to equations $\boxed{A}$ and $\boxed{B}$ on page $\boxed{5}$ to find the force of the axle on the pulley.

$\boxed{A}$ $F_x = T_1 = 32.6$

$\boxed{B}$ $F_y = T_2 + m_3 g = 55$

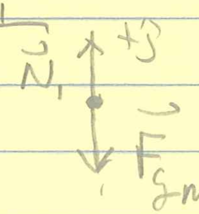
$$\therefore \vec{F}_{AXLE} = 32.6\hat{i} + 55\hat{j}$$ ☺

11.8)



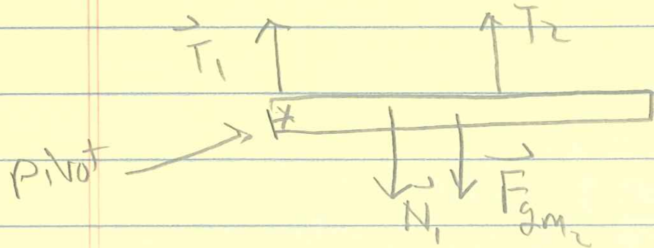
$F_{g m_2} = 50\ N$
$F_{g m_1} = 25\ N$

for m_1



2^{nd} law gives us $N_1 = F_{g m_1} = 25\ N$

for the shelf m_2



$\vec{\tau}_{T_1} = 0$

$\vec{\tau}_{N_1} = \vec{r}_1 \times \vec{N}_1 = (0.2)(25)$ $\boxed{\text{IN}}$ or $\boxed{\text{CW}}$

$\vec{\tau}_{F_{g m_2}} = \vec{r}_{F_g} \times \vec{F}_{g m_2} = (0.3)(50)$ $\boxed{\text{IN}}$ or $\boxed{\text{CW}}$

$\vec{\tau}_{T_2} = \vec{r}_2 \times \vec{T}_2 = (0.4)\, T_2$ $\boxed{\text{OUT}}$ or $\boxed{\text{CCW}}$

let $\boxed{\text{CCW}}$ be "+" (could let be "−") ☺

2^{nd} $\sum \vec{\tau} = I \cancel{\vec{\alpha}} \rightarrow 0$

$+0.4 T_2 - 0.3(50) - 0.2(25) = 0$

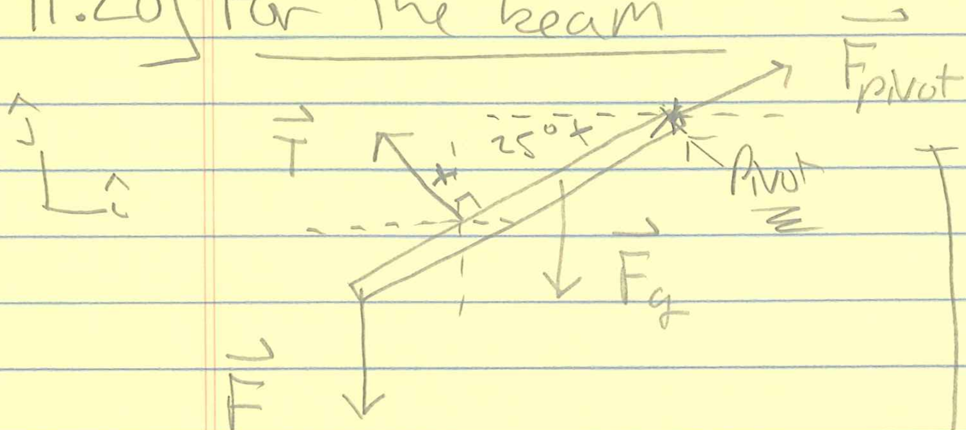
$T_2 = 50$ newtons ☺

Could apply $\sum \vec{\tau} = 0$ about a new pivot located where T_2 is applied to get T_1, OR

Could Apply $\sum \vec{F} = 0$ to the free body diagram for the shelf to get T_1.

Either way, $T_1 = 25$ newtons ☺

11.20 For the beam



$\vec F_{pivot} = F_x\hat i + F_y\hat j$

$\vec F_g = -1400\hat j$

$\vec F = -5000\hat j$

$\vec T = -T\sin(25)\hat i + T\cos(25)\hat j$

2nd $\sum \vec F = m\cancel{\vec a} \to 0$

$\boxed{\hat i}$ $\sum F_x = 0$

$F_x - T\sin(25) = 0$

$\boxed{F_x = T\sin(25)}$ $\boxed{1}$

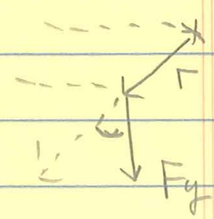
$\boxed{\hat j}$ $\sum F_y = 0$

$F_y - 1400 - 5000 + T\cos(25) = 0$

$\boxed{F_y = 6400 - T\cos(25)}$ $\boxed{2}$

For rotational form of 2nd law about axis shown:

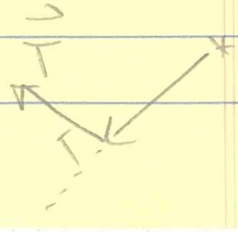
$\vec\tau_{F_{pivot}} = 0$



given

$\vec\tau_{\vec F_g} = \vec r_{F_g} \times \vec F_g = (2)(1400)\sin(90-25)$
$= 2537.66$ $\boxed{\text{OUT}}$ or $\boxed{\text{CW}}$

$\vec\tau_{\vec F} = \vec r_{\vec F} \times F = 4.5(5000)\sin(90-25)$
$= 20391.93$ $\boxed{\text{OUT}}$ or $\boxed{\text{CW}}$



$\vec\tau_{\vec T} = \vec r_T \times \vec T = 3T\sin(90)$ $\boxed{\text{IN}}$ or $\boxed{\text{CCW}}$

let $\boxed{CCW}$ be "+"

2nd $\sum \vec{\tau} = I\cancel{\vec{\alpha}} \rightarrow 0$

$+3T - 20391.93 - 2537.66 = 0$

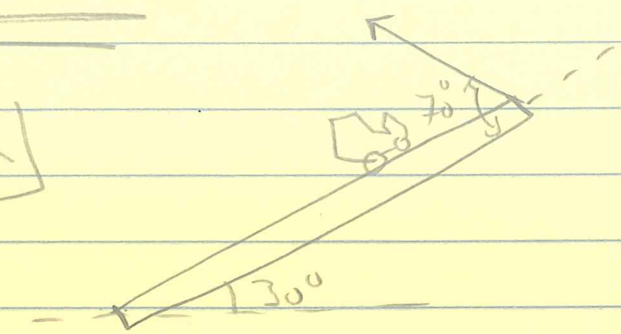
$T = 7643.2$ newtons

∴ From $\boxed{1}$ and $\boxed{2}$ we have:

$\vec{F}_{pivot} = T\sin(25)\hat{i} + (6400 - T\cos(25))\hat{j}$

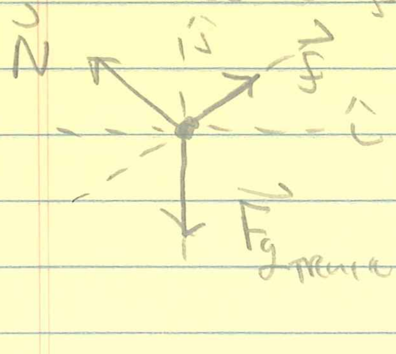
$= 3230\hat{i} - 527.1\hat{j}$

$\boxed{11.52}$

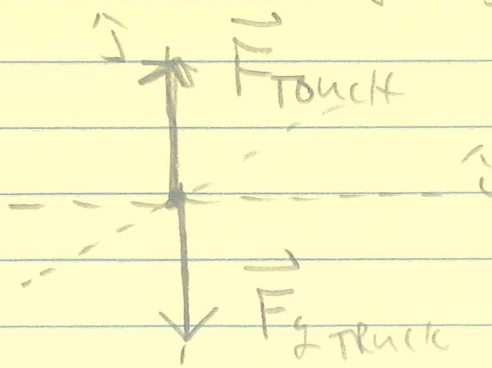


for the truck

two ways to consider this free body diagram.



$\boxed{OR}$

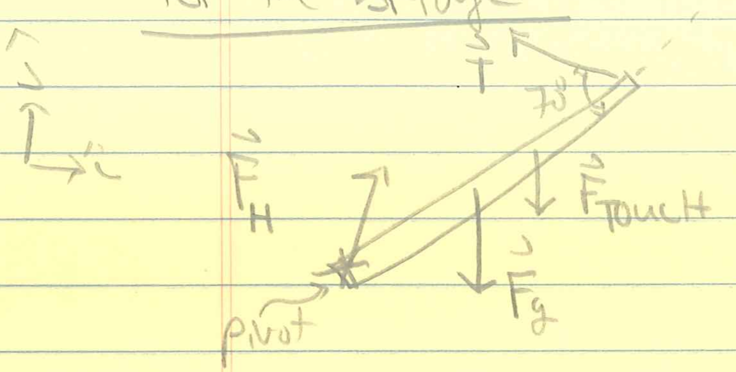


If we use $\vec{N}$ and $\vec{f}$, then both of these forces show up on a free body diagram for the bridge (in directions opposite those shown here).

If we use $\vec{F}_{Truck}$, then it shows up on diagram of bridge (in the direction opposite what is shown here). The second law applied to this diagram for the truck gives us $|\vec{F}_{Truck}| = |\vec{F}_{g_{Truck}}|$

EITHER WAY #'s for the bridge will work out to be the same!! ☺

for the bridge

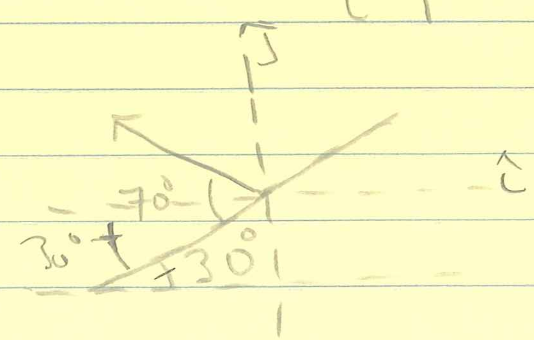


$\vec{F}_H = F_x\hat{i} + F_y\hat{j}$

$\vec{F}_g = -18000(9.8)\hat{j}$

$\vec{F}_{Touch} = -30000(9.8)\hat{j}$

$\vec{T} = -T\cos(70-30)\hat{i} + T\sin(70-30)\hat{j}$



2^{nd} $\sum \vec{F} = 0$

$\boxed{\hat{i}}$ $F_x - T\cos(70-30) = 0$

$\therefore \boxed{F_x = T\cos(40)}$ $\boxed{1}$

$\boxed{\hat{j}}$ $F_y - 18000(9.8) - 30000(9.8) + T\sin(70-30) = 0$

$\therefore \boxed{F_y = 470400 - T\sin(40)}$ $\boxed{2}$

Now use rotational form of 2^{nd} w/ pivot shown:

$\vec{\tau}_{\vec{F}_H} = 0$

$\vec{\tau}_{\vec{F}_g} = \vec{r}_{F_g} \times \vec{F}_g = 20(18000 * 9.8)\sin(90+30)$ $\boxed{IN}$ or $\boxed{CW}$

$\vec{\tau}_{\vec{F}_{Torch}} = \vec{r}_{F_{Torch}} \times \vec{F}_{Torch} = 30(30000 * 9.8)\sin(90+30)$ $\boxed{IN}$ or $\boxed{CW}$

$\vec{\tau}_{\vec{T}} = \vec{r}_T \times \vec{T} = 40T\sin(180-70)$ $\boxed{OUT}$ or $\boxed{CCW}$

letting $\boxed{CCW}$ be "+":

2^{nd} $\sum \tau = 0$

$$+40T\sin(180-70) - 30(30000 * 9.8)\sin(90+30) - 20(18000 * 9.8)\sin(90+30) = 0$$

$$T = 2.845 \times 10^5 \text{ newtons}$$

From eqtns $\boxed{1}$ and $\boxed{2}$ we can now write:

$$\vec{F}_H = T\cos(40)\,\hat{i} + \left(470400 - T\sin(40)\right)\hat{j}$$

$$\vec{F}_H = 2.179 \times 10^5\,\hat{i} + 2.875 \times 10^5\,\hat{j}$$

(4)