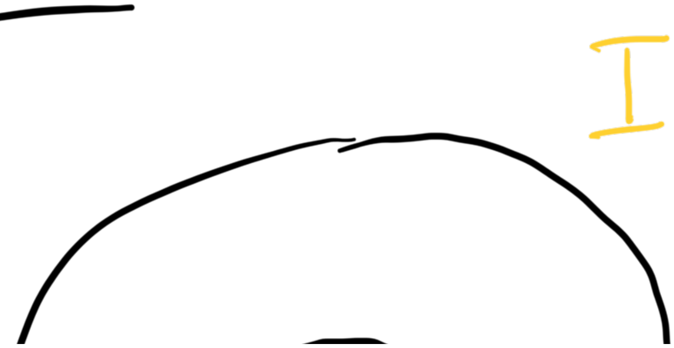
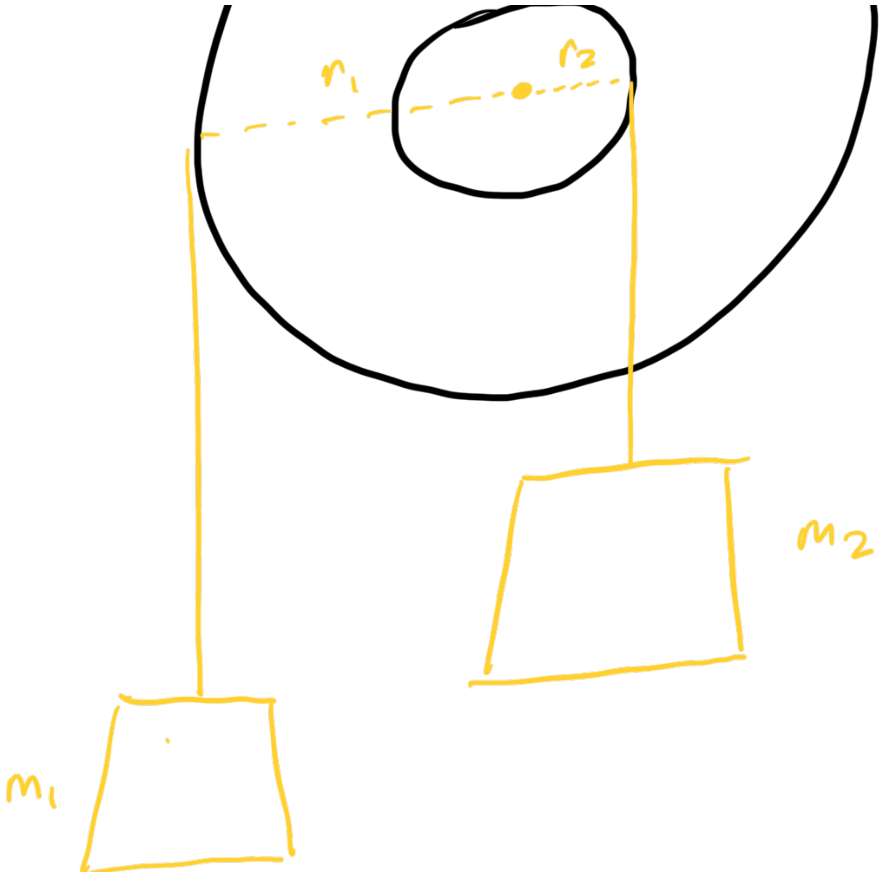
Physics 201 - Lecture 28

Let's try to bring together the ideas of calculating the acceleration of a <u>system</u> of objects, using $\vec{F}_{net} = m\vec{a}$ and free body diagrams and the things that we learned last lecture about $\tau_{net} = I\alpha$.

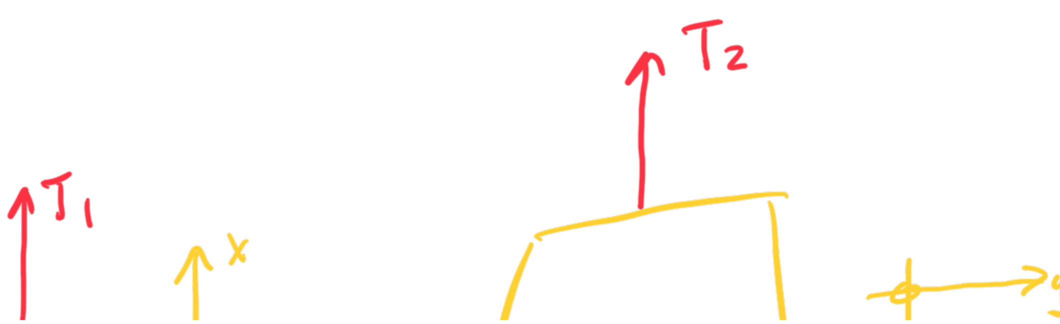
<u>Question 9:</u>

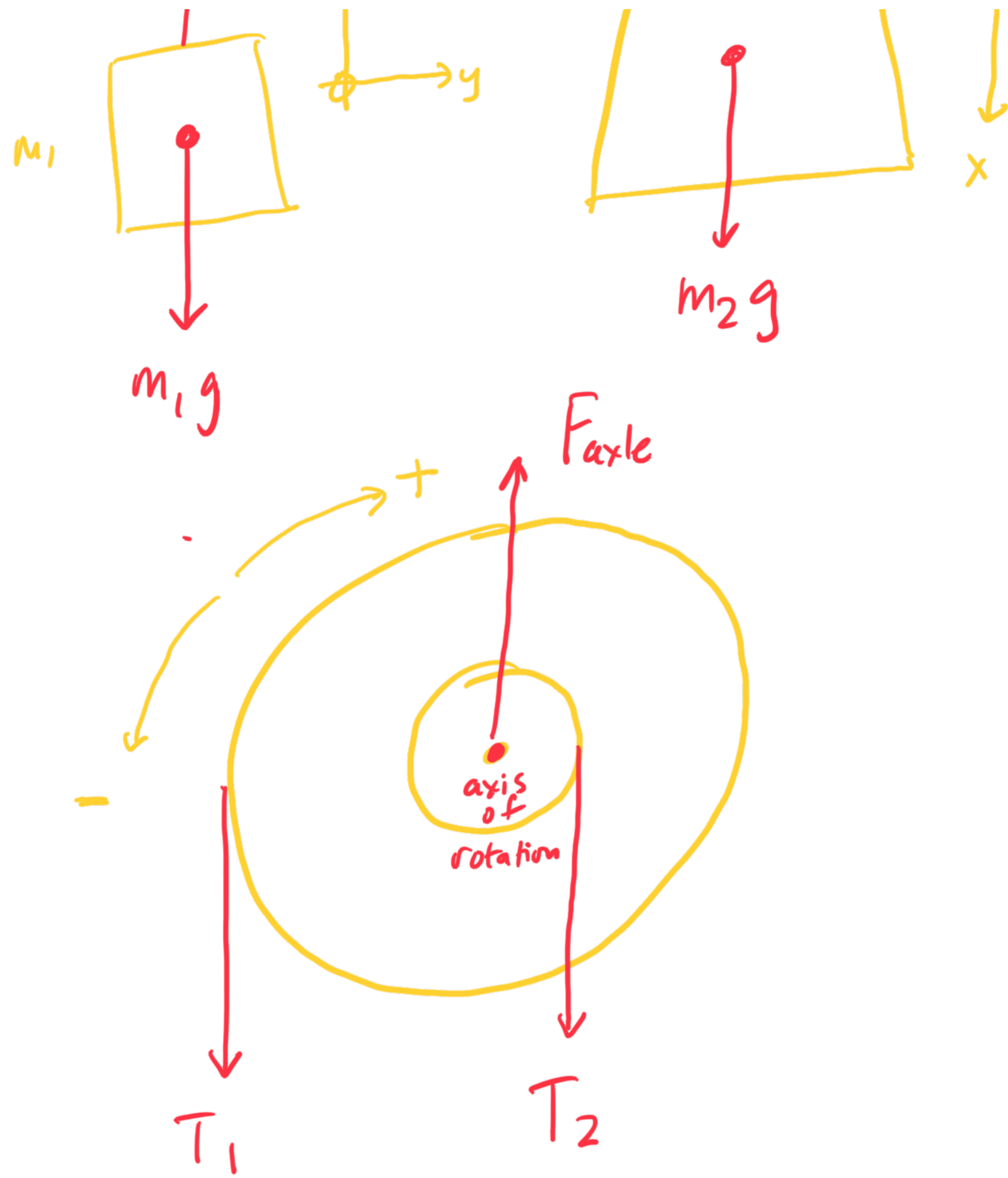




We need <u>three</u> FBD's ... one for each mass, plus an extra one for the pulley.

we know: m_1, m_2, r_1, r_2, I





Note the coordinate systems!

if m_1 moves in the $+x$ direction, so does m_2, and so does the pulley!

m_1: $$T_1 - m_1 g = m_1 a_{1x}$$

m_2: $$m_2 g - T_2 = m_2 a_{2x}$$

<u>Pulley</u> $$T_2 r_2 - T_1 r_1 = I\alpha$$

The big question is: How are a_{1x}, a_{2x}, and α related.

Recall the connection between linear/tang. quantities and angular quantities.

$$\boxed{\begin{aligned} a_{1x} &= r_1 \alpha \\ a_{2x} &= r_2 \alpha \end{aligned}}$$

$$\boxed{\begin{aligned} T_1 - m_1 g &= m_1 r_1 \alpha \\ m_2 g - T_2 &= m_2 r_2 \alpha \\ T_2 r_2 - T_1 r_1 &= I \alpha \end{aligned}}$$

These are three equations in three unknowns → T_1, T_2, α

let's substitute #'s →

$$\boxed{\begin{aligned} T_1 - 9.8 &= 0.53\alpha \\ 21.56 - T_2 &= 0.44\alpha \\ .20\,T_2 - 0.53\,T_1 &= 2.1\,\alpha \end{aligned}}$$

Solve using Wolfram Alpha:

$T_1 = 9.611$ N

$T_2 = 21.717$ N

a) $\alpha = -0.357 \, m/s$

it's rotating the other way!

I love physics!

b) $a_{1x} = r_1 \alpha = -0.189 \, m/s^2$

$a_{2x} = r_2 \alpha = -0.0714 \, m/s^2$

N.B. this is in our coordinate system!

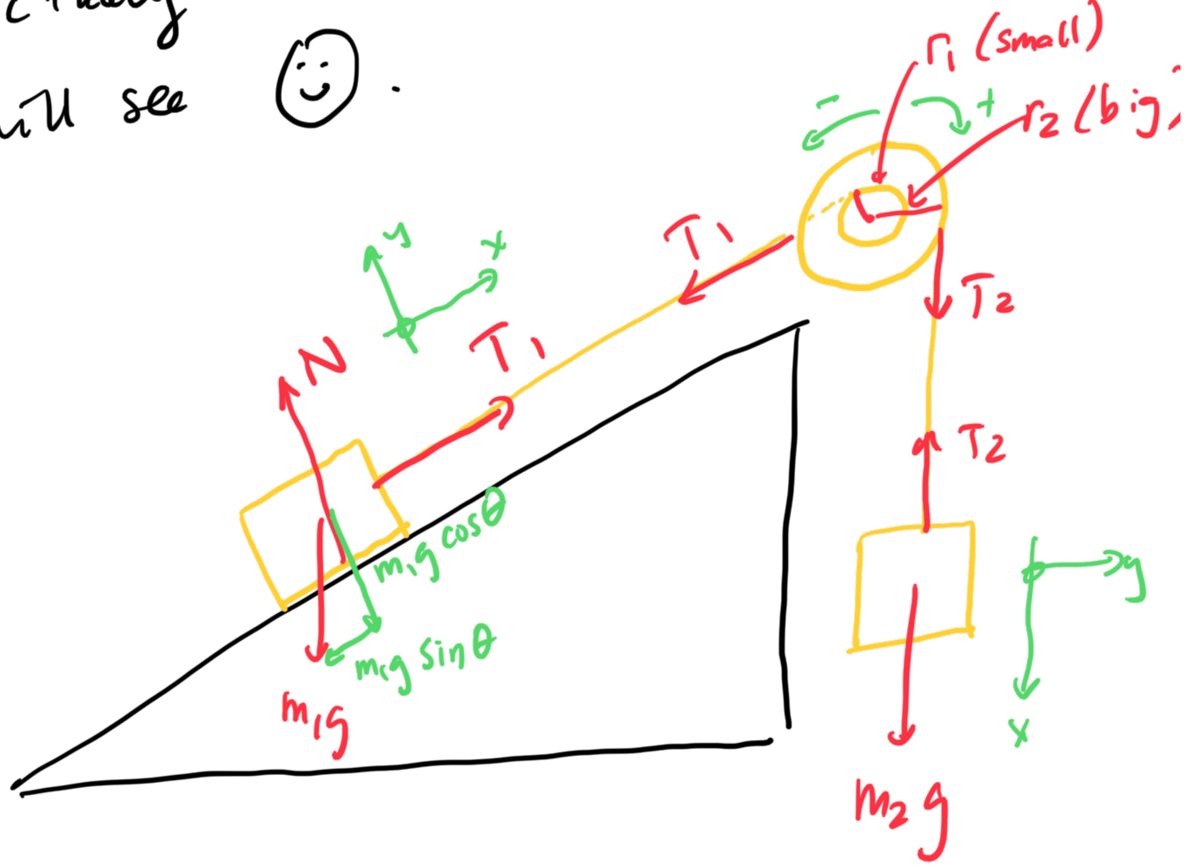
WebAssign choose (stupidly) the +ve axis going up for both masses, and so they expect

$a_{2x} = +0.0714 \, m/s^2$

Question 10:

... quite similar to

It is actually qu...
the last question! But, it is actually considerably easier, as we will see ☺.



$m_1 x$: $T_1 - m_1 g \sin\theta = 0$

~~$m_1 y$: $N - m_1 g \cos\theta = 0$~~ not relevant

$m_2 x$: $m_2 g - T_2 = 0$

pulley $T_2 r_2 - T_1 r_1 = 0$

$$\boxed{\begin{aligned} T_1 - 31.413 &= 0 \\ 9.8\,m_2 - T_2 &= 0 \\ .27\,T_2 - 0.20\,T_1 &= 0 \end{aligned}}$$

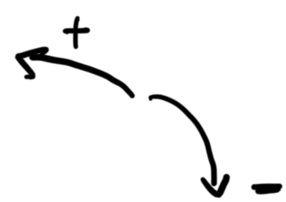
Solve using Wolfram Alpha!

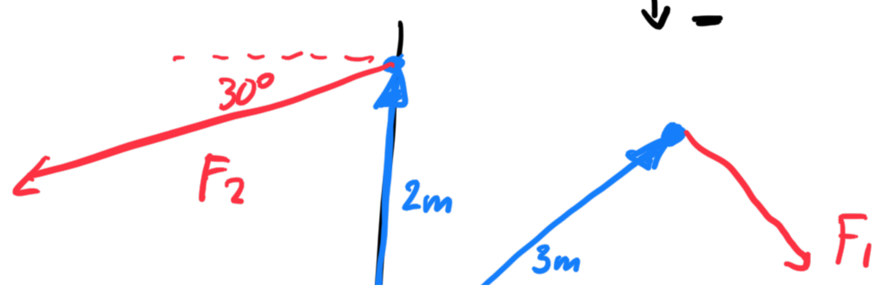
$T_1 = 31.41\ \text{N}$

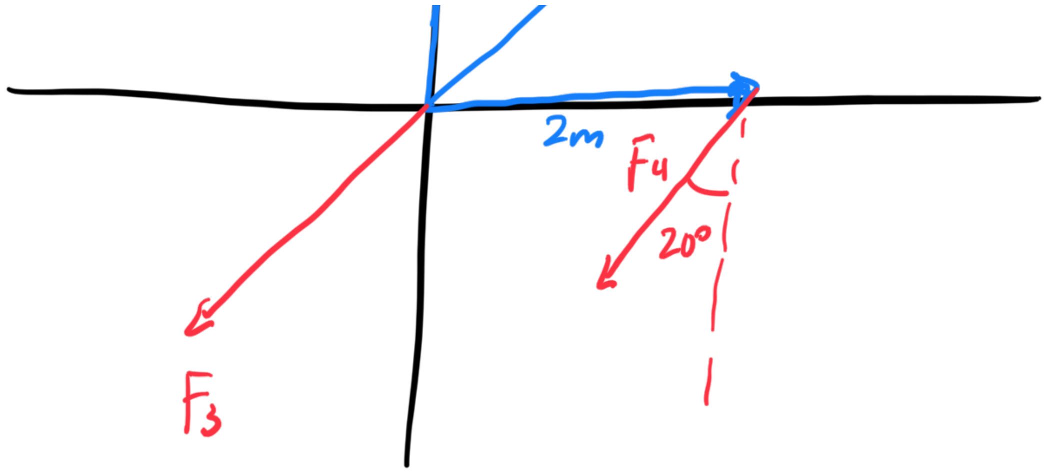
$T_2 = 23.27\ \text{N}$

$$\boxed{m_2 = 2.37\ \text{kg}}$$

Question 11:







$$\tau_{F_1} = -|\vec{F_1}||\vec{r_1}| \sin\theta_1$$

$$= -(5.0)(3.0)\sin(90°) = -15\ N\cdot m$$

$$\tau_{F_2} = |\vec{F_2}||\vec{r_2}| \sin\theta_2$$

$$= (3.1)(2)\sin(120°)$$

$$= 5.369\ N\cdot m$$

$$\tau_{F_3} = |\vec{F_3}||\vec{r_3}| \sin\theta_3$$

$$= (5.0)(0)\sin ? = 0\ !$$

$$\tau_{F_4} = -|\vec{F_4}||\vec{r_4}|\sin\theta_4$$

$$= -(2.2)(2)\sin(110°)$$

$$= -4.1346 \text{ N}$$

$$\tau_{net} = -15.0 + 5.369 - 4.1346$$

$$\boxed{\tau_{net} = -13.8 \text{ N·m}}$$