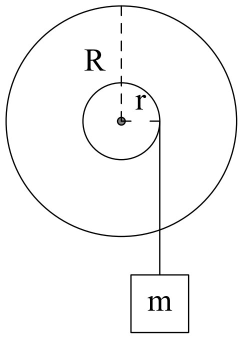
2. (30 pts.) A uniform disk of radius $R = 0.3$ m is pivoted so that it is free to rotate about a frictionless horizontal axis perpendicular to the disk and through the center. A string is wrapped around a small collar on the disk of radius $r = 0.1$ m, as shown in the figure. A small mass $m = 0.7$ kg is attached to the string. The mass is released from rest and takes 0.75s to fall a distance of 1.25 m before reaching the floor. The speed of the small mass at the bottom is 3.33 m/s. Find the moment of inertia of the disk.



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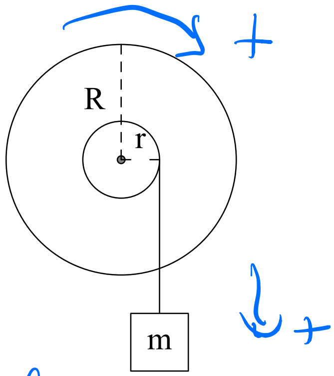
where to start?



$I = \frac{1}{2}MR^2$?

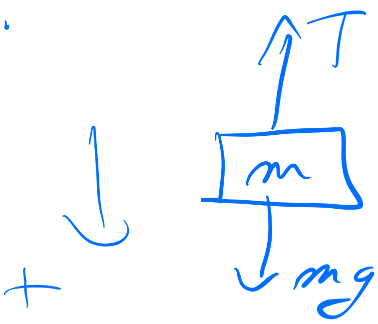
we don't Know Mass of disk.

$\Sigma \tau = I\alpha$

If we can find τ and α, then we can solve for I.

what is τ ? $\tau = T \cdot r$

what is T ?



$mg - T = ma$

$T = m(g-a)$

what is a ?

$y_f = y_i + v_i t + \frac{1}{2}at^2$

$1.25\text{m} = 0 + 0 + \frac{1}{2}a(0.75\text{s})^2$

$a = \dfrac{2(1.25\text{m})}{(0.75\text{s})^2} = 4.44\ \text{m/s}^2$

so $T = m(g-a) = (0.70\text{ kg})(9.8\text{ m/s}^2 - 4.44\text{ m/s}^2)$

$T = 3.76\text{N}$

Now look at wheel

$$\tau = I\alpha$$

$Tr = I\alpha$. What is α?

$$\alpha = \frac{a}{r} = \frac{4.44\,m/s^2}{0.1\,m} = 44.4\,\frac{rad}{s^2}$$

Lastly: $I = \frac{\tau}{\alpha} = \frac{Tr}{\alpha} =$

$$I = \frac{(3.76\,N)(0.1\,m)}{44.4\,rad/s^2} = 0.00846\,kg\,m^2$$

$$\boxed{I = 8.46 \times 10^{-3}\,kg\,m^2}$$

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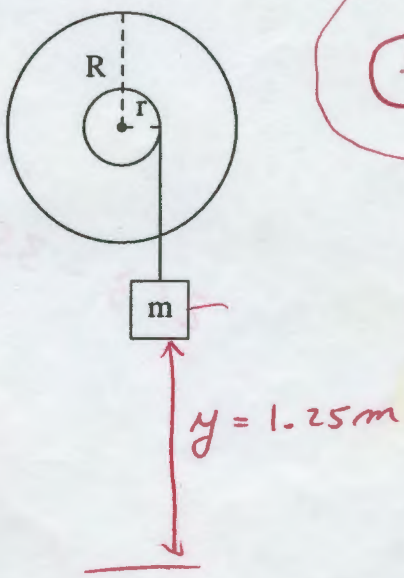

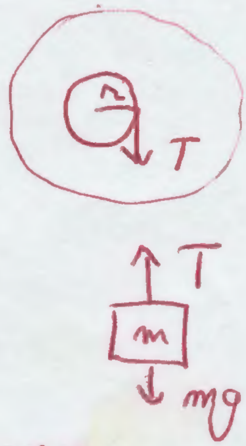

Two methods:

1. $E_i = E_f$

$mgy = \frac{1}{2} m v_f^2 + \frac{1}{2} I \omega^2$

use $\omega = v_f / r$

$mgy = \frac{1}{2} m v_f^2 + \frac{1}{2} \frac{I}{r^2} v_f^2$

$(.7)(9.81)(1.25) = \frac{1}{2}(.7)(3.33)^2 + \frac{1}{2} I \left(\frac{3.33}{.1}\right)^2$

$8.58\ \text{J} = 3.88 + I(554)$

$4.70\ \text{J} = 554\ I$

$0.00848\ \text{kg m}^2 = I$

$\boxed{8.48 \times 10^{-3}\ \text{kg m}^2 = I}$

2. Use $F = ma$ and $\tau = I\alpha$, as in lab.

acceleration of block: $mg - T = ma$

$T = m(g - a)$. $a = ?$

use $y = y_0 + v_0 t + \frac{1}{2} a t^2 = \frac{1}{2} a t^2 \Rightarrow a = \frac{2y}{t^2} = 4.44\ \text{m/s}^2$

So $T = .7(9.81 - 4.44) = 3.76$ N

Now $\tau = I\alpha$, $\tau = Tr$, $\alpha = a/r$

$Tr = I a / r \Rightarrow I = \frac{Tr^2}{a} = \boxed{8.48 \times 10^{-3}\ \text{kg m}^2}$