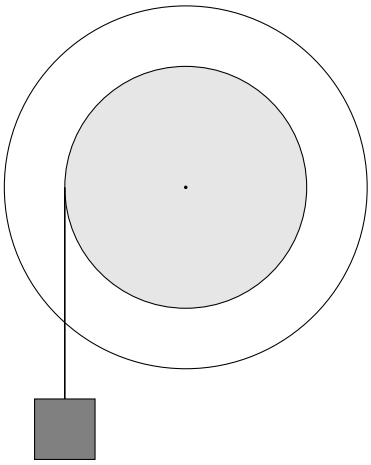
Problem 3: (30 pts.) A uniform disk of mass 4.00 kg and radius 0.300 m is pivoted so that it is free to rotate about a frictionless horizontal axis perpendicular to the disk and through the center. A string is wrapped around a hub on the disk of radius 0.200 m as shown in the figure. A 0.800 kg mass is attached to the string and released from rest.

a. (20 pts.) What is the angular acceleration of the disk?

b. (5 pts.) What is the angular speed of the disk after 1.5 s?

c. (5 pts.) What is the total linear distance (in meters) that a point *on the rim* of the disk travels in 1.5 s?



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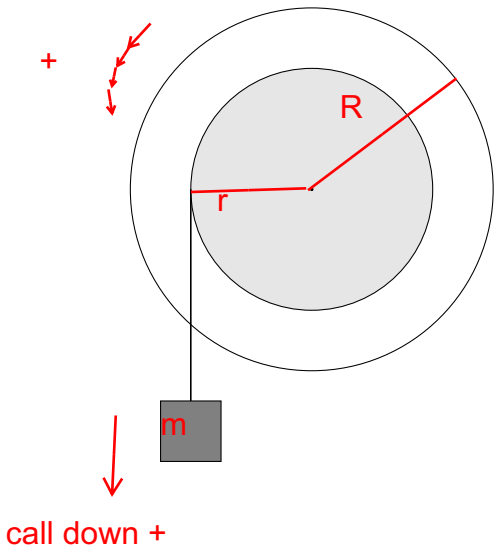

R = 0.300 m (full disk)
r = 0.200 m (hub)
M = 4.00 kg (full disk)
m = 0.800 kg (hanging

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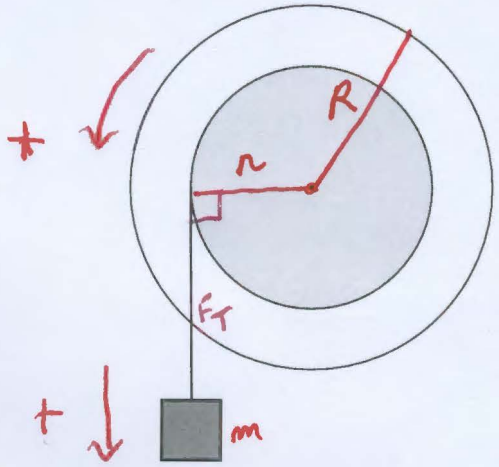
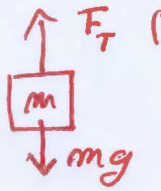
c. (5 pts.) What is the total angular distance (in radians) that a point *on the rim* of the disk travels in 1.5 s?



$M = 4.00\ kg$ $\quad m = 0.800\ kg$

$R = 0.300\ m$ $\quad r = 0.200\ m$

hanging mass:



$$mg - F_T = ma$$

$$F_T = mg - ma$$

Disk:

$$\Sigma \tau = I\alpha$$

$$F_T \cdot r = I\alpha$$

$$(mg - ma)r = \tfrac{1}{2}MR^2\alpha$$

To solve for α, use $\boxed{a = \alpha r}$

$$mgr - m\alpha r^2 = \tfrac{1}{2}MR^2\alpha$$

$$mgr = \left(\tfrac{1}{2}MR^2 + mr^2\right)\alpha$$

$$\alpha = \frac{mgr}{\frac{1}{2}MR^2 + mr^2} = \frac{(0.800\,kg)\left(9.8\frac{m}{s^2}\right)(0.200\,m)}{\frac{1}{2}(4.00\,kg)(0.300\,m)^2 + (0.8\,kg)(.2\,m)^2}$$

(a) $\boxed{\alpha = 7.396\ rad/s^2}$

(b) $\omega = \omega_i + \alpha(\Delta t) = 0 + (7.396\,rad/s^2)(1.5\,s) = \boxed{11.09\ rad/s}$

(c) $\Delta\theta = \omega_i(\Delta t) + \frac{1}{2}\alpha(\Delta t)^2 = 8.32\ rad.$

$\Delta s = R\,\Delta\theta = (0.300\,m)(8.32\,rad) = \boxed{2.50\,m}$

↖ note: radius of rim!