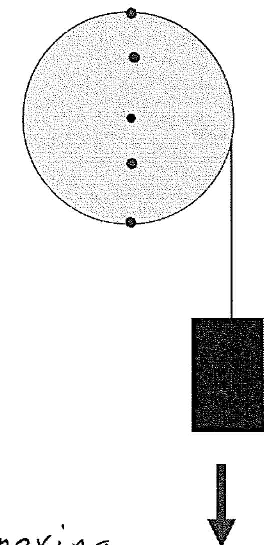
Discussion 9b : Rotation

Name: Epicurus



A) A thin, light disk of radius 0.50 m has four, small 1.0 kg masses (M) affixed to it initially at positions of (0,0.50 m), (0,0.25 m), (0,-0.25 m) & (0,-0.50 m). It is mounted with a frictionless horizontal pivot which passes through the center of the disk. Wrapped around (and tied to) the disk's circumference is a massless string which can unwind smoothly. The string is tied to a hanging mass of 2.0 kg. Gravity acts downwards with g = 10 m/s^2.

1. If you hold the disk and keep it from rotating, then what is the tension in the string about the hanging mass?

If you hold the disk, nothing is moving, or $a=0$ so

$\Rightarrow \quad T = mg = 2 \cdot 10 = \boxed{20N}$

2. If the hanging mass were moving down at 2.0 m/s then what would be the tangential velocity of the string as it leaves the disk?

The ~~spin~~ string will come off the disk at the same speed at the edge of the disk, so

$$\boxed{V = 2\ m/s}$$

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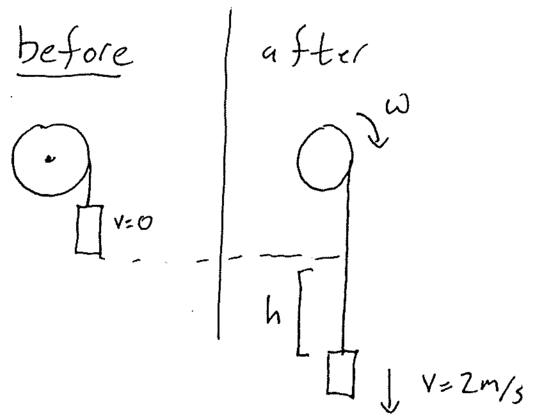
3. With respect to #2, what would be the angular velocity of the disk?

$$\omega = \frac{v}{r} = \frac{2}{0.5} = \boxed{4\,\text{rad/s}}$$

4. With respect to #2, what would be the total mechanical kinetic energy of the masses?



Once the blocks are moving, all the energy is Kinetic. The block has just linear Kinetic, the disk rotational

$$I = 1(0.5)^2 + 1(0.5)^2 + 1(0.25)^2 + 1(0.25)^2$$
$$= \frac{1}{4} + \frac{1}{4} + \frac{1}{16} + \frac{1}{16} = \frac{5}{8}$$

$$E_{tot} = KE_r + KE_L = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 = \frac{1}{2}\left(\frac{5}{8}\right)4^2 + \frac{1}{2}2\cdot 2^2$$
$$= 5 + 4 = \boxed{9\,J}$$

5. Starting from rest, how far would the hanging mass have to drop to have a velocity of 2.0 m/s?

Where did the energy come from?
Gravitational Potential, (only from hanging mass)

$$E_{tot} = PE \Rightarrow 9 = mgh \Rightarrow \frac{9}{mg} = \boxed{\frac{9}{20}\,m = h}$$

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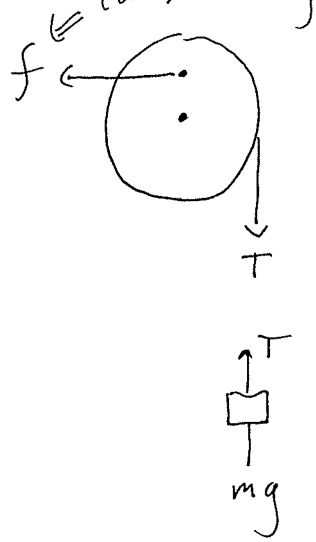
6. If the angular acceleration were somehow limited to -1.0 rad/s^2 what would be the tension in the string (e.g., from some frictional force) ?

(or something like this to cause the torque)



we know $\alpha = 1 = \frac{a}{r}$ ~~so~~

We don't know about the frictional force, so we can't use the disk, but we have the hanging mass!

$$mg - T = ma = m\alpha r$$

$$20 - T = 2 \cdot 1 \cdot \frac{1}{2} = 1$$

so $\boxed{T = 19N}$