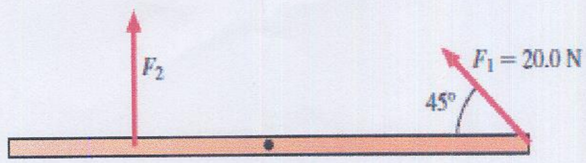
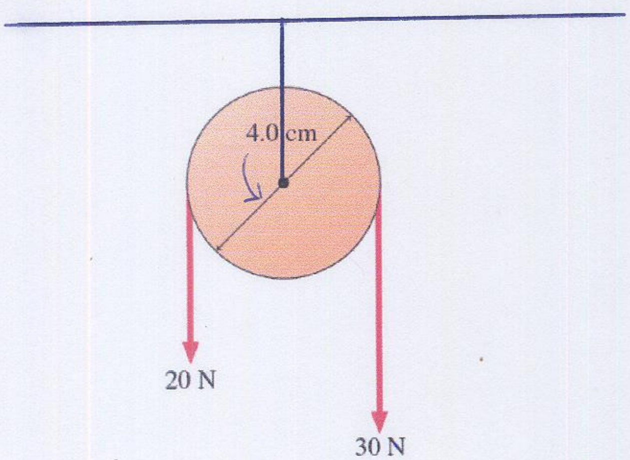
Torque: class group problems

Method: a. draw the situation and the forces acting on your object of interest.
b. mark the pivot.
c. if asked, draw the line of force and lever arm for each force. (This is often helpful in concept problems.)
d. note that counterclockwise rotation is the positive direction for torque.
e. reason about what is happening. You will then do some combination of summing torques, finding a moment of inertia, and applying $\Sigma\tau = I\alpha$

1. (Prob. 22) Force F2 acts half as far from the pivot as F1. What magnitude of F2 causes the net torque on the rod to be zero?



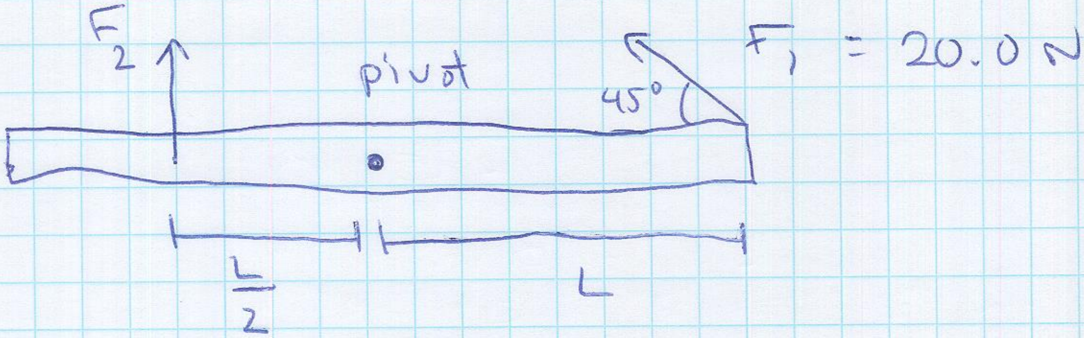
2. (Prob. 19 with additions). The pulley shown has a mass of 3.0 kg. It hangs from the ceiling by a support, as shown. There is no friction between pulley and support. Find the angular acceleration (magnitude and direction) of the pulley.



3. (Prob. 21) A professor's door is 0.91 m wide, 2.0 m high, and 4.0 cm thick. If has a mass of 25 kg and pivots on frictionless hinges. A "door closer" is attached to the door and the top of the door frame. When the door is open and at rest, the door closer exerts a torque of 5.2 Nm. What is the least amount of force that you need to apply to the door to hold it open?

4. (Prob. 42) If you let go of the door in the previous problem, what is its angular acceleration (magnitude and direction) immediately afterward?

7-22



$$\Sigma\tau = {}^{+}\tau_1 + {}^{-}\tau_2$$

$$\Sigma\tau = F_1 r_1 \sin\varphi_1 - F_2 r_2 \sin\varphi_2$$

$$\Sigma\tau = (20)(L)\sin 45^\circ - F_2\left(\frac{L}{2}\right)\sin 90^\circ$$

and

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

$$\alpha = 0.$$

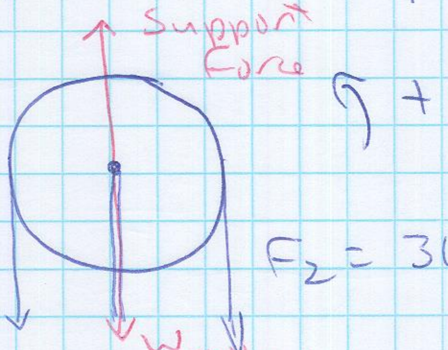
$$20\,L\sin 45 = F_2\left(\frac{L}{2}\right)\sin 90^\circ$$

$$F_2 = 28.3\ \text{N}$$

7-19 + I, α

$m_{pulley} = 3.0$ kg

$r = 0.020$ m



Solid Disk:

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

$I = \frac{1}{2}(3.0)(0.02)^2$

$I = 0.0006$ kg m^2

$\tau_1 = F_1 r_1 \sin\theta_1$
$= (20\text{ N})(0.020\text{ m})\sin 90°$
$= 0.40$ N m

$\tau_2 = F_2 r_2 \sin\theta_2$
$= (30\text{ N})(0.02\text{ m})\sin 90°$
$= 0.60$ N m

$\Sigma\tau = + \tau_1 + - \tau_2$

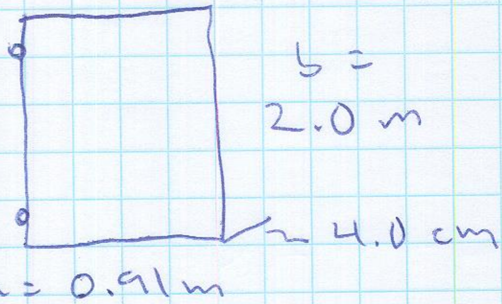
$\Sigma\tau = -0.20$ N m

and $\Sigma\tau = I\alpha$

$-0.20\text{ N m} = (0.0006\text{ kg m}^2)\alpha$

$\alpha = -333\text{ rad/s}^2$

7-21.

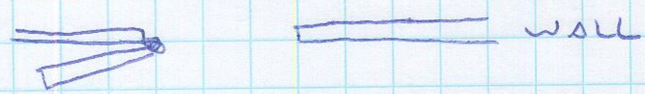


m = 25 kg

I ?

$$I = \frac{1}{3} M a^2$$
$$= \frac{1}{3}(25)(0.91)^2$$
$$= 6.9 \text{ kg m}^2$$

Top View:



At rest.

Closer is exerting a τ of 5.2 Nm, trying to close door.

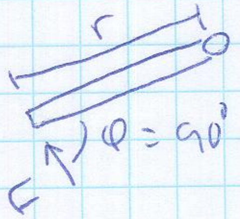
You must be exertin $\tau = 5.2$ Nm in opposite direction.

Your Force ?

Your $\tau = F r \sin\varphi$

To get smallest F, make r as large as possible & $\sin\varphi = 1$

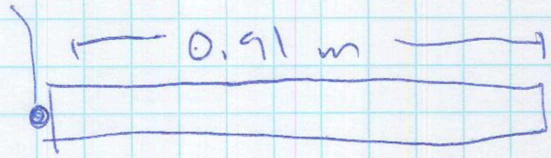
Top View:



r = 0.91 m

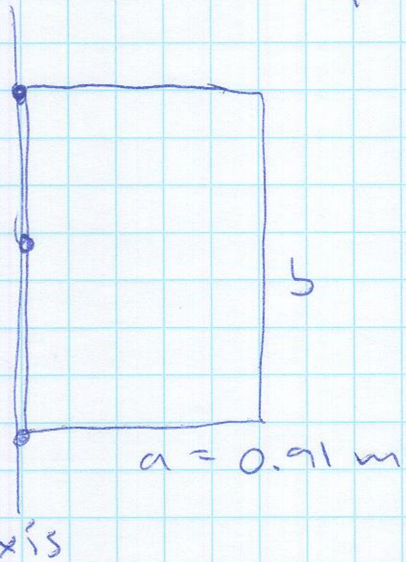
$$\tau = F r \sin\varphi$$
$$5.2 = F(0.91)\sin 90°$$
$$F = 5.7 \text{ N}$$

7-42   Seen from top: 4.0 cm I



height = 2.0 m

$m = 25$ kg



Rectangle, about edge:

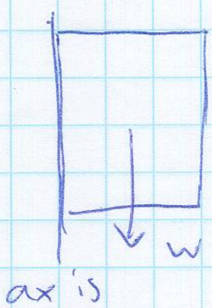
$$I = \frac{1}{3} M a^2$$

$$I = \frac{1}{3}(25\ \text{kg})(0.91\ \text{m})^2$$

$$I = 6.90\ \text{kg m}^2$$

b. You have let go, so your force is not acting.

Note that door's weight does not exert a τ:



Force line does have a lever arm, but $\varphi = 0°$

$$\tau_w = 0$$

$$\therefore \Sigma\tau = \tau_{\text{DOOR CLOSER}} = 5.2\ \text{N m}\quad \text{(stated!)}$$

$$\alpha = \frac{\Sigma\tau}{I} = \frac{5.2\ \text{Nm}}{6.9\ \text{kg m}^2} = 0.75\ \text{rad/s}^2$$