PROBLEM SET 7

CHAPTER 9: 8, 32, 56
CHAPTER 10: 10, 36

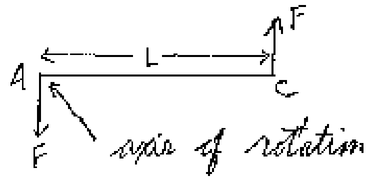
CHAPTER 9 #8 [4 MARKS]

In each case $\vec{\tau} = \vec{\tau}_A + \vec{\tau}_C$

Each torque causes counterclockwise rotation

$\therefore \tau = \tau_A + \tau_C$

(A)

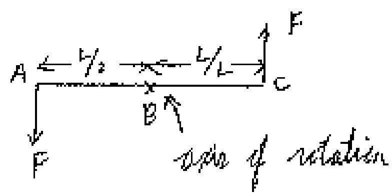


$\tau_A = 0$ (no lever arm)

$\tau_B = FL$

$\therefore \underline{\underline{\tau = FL}}$

(B)

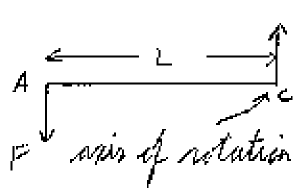


$\tau_A = F(L/2)$

$\tau_B = F(L/2)$

$\therefore \tau = F(L/2 + L/2) = \underline{\underline{FL}}$

(C)



$\tau_A = FL$

$\tau_B = 0$ (no lever arm)

$\therefore \underline{\underline{\tau = FL}}$

CHAPTER 9 #32 [4 MARKS]

$M = 85\,kg$ $\quad L = 1.2\,m$

$F = 68\,N$

$\alpha = ?$

For each pane $I_p = \frac{1}{3} ML^2$

For the entire door $I = 4 I_p = \frac{4}{3} ML^2$

The torque is $\tau = FL$

Newton's 2'nd law gives $\tau = I\alpha$

$$\alpha = \frac{\tau}{I} = \frac{FL}{\frac{4}{3}ML^2} = \frac{3F}{4ML} = \frac{3 \times 68}{4 \times 85 \times 1.2}$$

$$\boxed{\alpha = 0.5\ rad/s^2}$$

CHAPTER 9 #56 [5 MARKS]

$R = 2.00\,m$ $\quad$ $m = 40.0\,kg$

$M = 1.00 \times 10^2\,kg$ $\quad$ $r = 1.25\,m$

$v = 2.00\,m/s$

$\omega = ?$

The direction of rotation of the dish is opposite the runner's direction because of conservation of angular momentum.

Angular momentum of runner is

$L_R = I_R \omega_R$, but $I_R = mr^2$ and $v = \omega_R r$

$\therefore L_R = mr^2 \frac{v}{r} = mrv$

Angular momentum of dish is

$L_D = I_D \omega_D$, but $I_D = \frac{1}{2} M R^2$ and $\omega \equiv \omega_D$

$\therefore L_D = \frac{1}{2} M R^2 \omega$.

Using conservation of angular momentum.

$L_R + L_D = 0 \Rightarrow mrv + \frac{1}{2} M R^2 \omega$

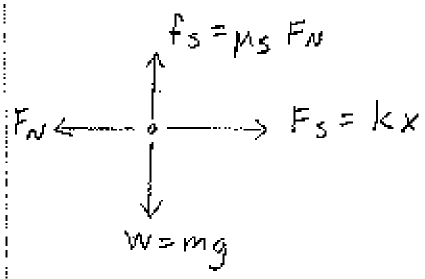
$\omega = -\frac{2mrv}{MR^2} = \frac{-2 \times 40 \times 1.25 \times 2}{100 \times 2^2}$

angular rotation of disk opposite of runner.

$\boxed{\omega = -0.5\ rad/s}$

CHAPTER 10 #10 [4 MARKS]

$m = 2.3$ kg
$k = 480$ N/m
$x = 0.051$
$\mu_s = ?$



For equilibrium : $F_N = kx$ and $f_s = W$

$\mu_s F_N = mg \Rightarrow F_N = \frac{mg}{\mu_s}$

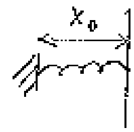
$\therefore \frac{mg}{\mu_s} = kx$

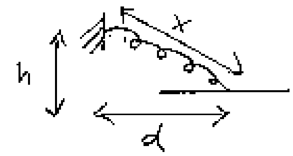
$\mu_s = \frac{mg}{kx} = \frac{2.3 \times 9.8}{480 \times 0.051}$

$\boxed{\mu_s = 0.92}$

CHAPTER 10 #36 [8 MARKS]

$L = 0.200\ m$
$M = 0.750\ kg$
$k = 25.0\ N/m$





Lets first calculate how much the spring stretched

$$\Delta x = x - x_0 = (h^2+d^2)^{1/2} - x_0$$

$x_0 = 0.100\ m$
$h = 0.100\ m$
$d = 0.100 + 0.100 = 0.200\ m$

The energy when the bar is vertical is
$E_i = MgH$, where H is the center of gravity
$H = L/2$

$\therefore\ E_i = Mg\cdot L/2$

The energy when the bar strikes A is
$E_f = \frac{1}{2} I\omega^2 + \frac{1}{2} k(\Delta x)^2$, where $I = \frac{1}{3}ML^2$

The tangential speed is given by $v = \omega r = \omega L$

$$\therefore\ E_f = \frac{1}{6} ML^2 \left(\frac{v}{L}\right)^2 + \frac{1}{2} k(\Delta x)^2$$

Conservation of energy gives $E_i = E_f$

$$\therefore\ v^2 = \frac{\frac{1}{2}MgL - \frac{1}{2}k(\Delta x)^2}{\frac{1}{6}M}$$

$$v = \left\{3\left[gL - \frac{k}{M}\left(\sqrt{h^2+d^2} - x_0\right)^2\right]\right\}^{1/2}$$

$$= \left\{3\left[9.8 \times 0.2 - \frac{25}{0.75}\left(\sqrt{0.1^2+0.2^2} - 0.1\right)^2\right]\right\}^{1/2}$$

$\underline{v = 2.09\ m/s}$