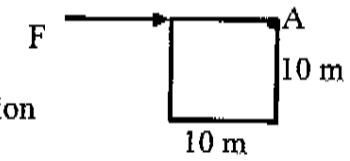
TEST 2
ME 230 Spring 2009
Open textbook (no other books) & open notes.

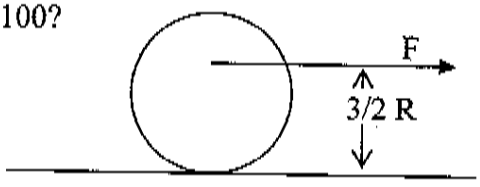
1a) *(10)* What is the frictional force that is acting on the 100 kg mass if $\mu = 0.25$ and i) F= 125 N, ii) F=300 N?

1 b) *(20)* Determine the acceleration of point A if M = 6 kg and F=60 N as the system is released from rest. The block does not rest on any surface. Assume that the motion is in the plane of the paper only and that there is no gravity.

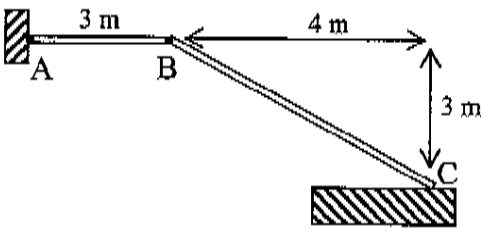


2 a). *(15)* Determine the angular momentum of the rod about i) its center of mass and ii) point o when its angular velocity is 10 rad/sec counter clockwise and it rotates about pivot point p. The length of the rod is 2 m and its mass is 3 kg. Point o is 3m below point p.

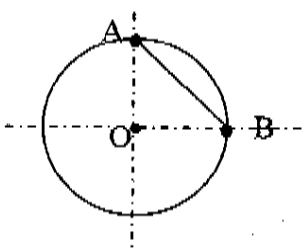
2 b) *(20)* What is the frictional force acting on the disk of radius R= 2 and mass 10 kg if it rolls without slip and F = 100?



3 a) *(15)* Bar AB is pinned to bar BC. End C is sliding on the ground without friction. Determine the angular velocity of the bar BC when bar AB is rotating clockwise with 2 rad/sec..

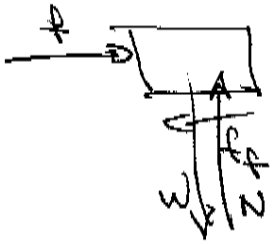


3b) *(20)* A person walks on a rotating 10 m radius platform with a speed of 1m/s in a straight line from point A to B as indicated. If the angular velocity of the platform is constant at 0.1 rad/sec (clockwise) what is the acceleration of the person when she/he is at point A? The platform rotates about a fixed axis at O.



1a/ Max frictional force $= \mu \cdot N = 245.25\ N \Rightarrow f_{max}$

FBD:



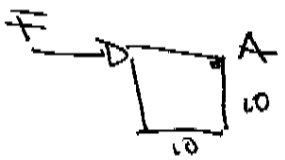
i) $f = 125\ N$ this is less than f_{max} so no slip

$f - f_f = 0 \Rightarrow \boxed{f_f = 125\ N}$

ii) $f = 300\ N$ this is more than f_{max} so slip

$\Rightarrow \boxed{f_f = f_{max} = 245.25\ N}$

1b/



$m = 6\ kg$
$F = 60\ N$

1) $F = m \cdot a_{cm} \Rightarrow 60 = 6 \cdot a_{cm} \Rightarrow a_{cm} = 10\ m/s^2$

2) $M = I_{cm} \alpha \Rightarrow 60 \cdot 5 = \frac{6}{12}(10^2 + 10^2) \cdot \alpha \Rightarrow \alpha = 3\ rad/s^2$

$\underset{\sim}{a}_A = \underset{\sim}{a}_{cm} + \underset{\sim}{\alpha} \times \underset{\sim}{r}_{A/cm} - \omega^2 \cdot r_{A/cm} =$

$\underset{\sim}{a}_A = 10 \cdot \underset{\sim}{i} + (-3\underset{\sim}{k})(5\underset{\sim}{i} + 5\underset{\sim}{j}) \Rightarrow a_A = 10\underset{\sim}{i} - 15\underset{\sim}{j} + 15\underset{\sim}{i}$

$\underset{\sim}{a}_A = (25\underset{\sim}{i} - 15\underset{\sim}{j})\ m/s^2$

2 a/

i $\quad \underset{\sim}{H}_{cm} = \underset{\sim}{I}_{cm} \cdot \underset{\sim}{\omega} = \frac{1}{12} m L^2 \cdot \underset{\sim}{\omega}$

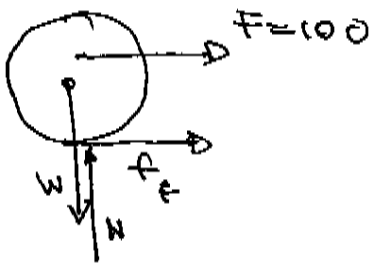
$= \frac{1}{12} 3 \cdot 4 \cdot 10 \underset{\sim}{k} = \boxed{10 \underset{\sim}{k} \text{ kg m}^2/\text{s}}$

ii/ $\quad \underset{\sim}{H}_0 = \underset{\sim}{I}_{cm} \cdot \underset{\sim}{\omega} + \underset{\sim}{r}_{cm/0} \times m \underset{\sim}{V}_{cm}$

$\underset{\sim}{H}_0 = 10 \underset{\sim}{k} + 2 \underset{\sim}{j} \times m (10 \cdot 1) \underset{\sim}{i}$

$\underset{\sim}{H}_0 = 10 \underset{\sim}{k} + -60 \underset{\sim}{k} = \boxed{-50 \underset{\sim}{k} \text{ kg m}^2/\text{s}}$

2b/



$m = 10 \text{ kg}$

$R = 2 \text{ m}$

$\Sigma F_x = 100 + f_f = m \cdot a_{cm}$ (1)

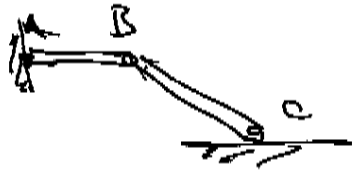
$\Sigma M_0 = -100 \cdot 3 = I_0 \cdot \omega = \left(\frac{1}{2} m R^2 + m \cdot R^2\right) \omega = \left(\frac{3}{2} m R^2\right) \omega$

$\Rightarrow \omega = \frac{-300}{|3/2| \cdot 10 \cdot 4} = -5$ (2)

Then into (1) $\rightarrow \quad 100 + f_f = m(-2 \cdot \omega)$

$100 + f_f = 10(+2.5) \Rightarrow \boxed{f_f = 0}$

3/



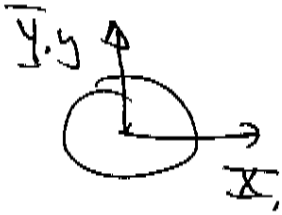
$\underset{\sim}{V}_B = -2\underset{\sim}{k} \times 3\underset{\sim}{i} = -6\underset{\sim}{j}$

$\underset{\sim}{V}_C = \underset{\sim}{V}_B + \underset{\sim}{\omega}_{BC} \times \underset{\sim}{r}_{C/B}$

$V_C \underset{\sim}{i} = -6\underset{\sim}{j} + \omega_{BC}\underset{\sim}{k} \times (4\underset{\sim}{i} - 3\underset{\sim}{j})$

$V_C \underset{\sim}{i} = -6\underset{\sim}{j} + 4\omega_{BC}\underset{\sim}{j} + 3\omega_{BC}\underset{\sim}{i} \Rightarrow 4\omega_{BC} - 6 = 0 \Rightarrow \boxed{\underset{\sim}{\omega}_{BC} = 1.5\underset{\sim}{k}}$

3b/



$\underset{\sim}{a}_A = \underset{\sim}{a}_O + \cancel{\underset{\sim}{\alpha} \times \underset{\sim}{r}_{A/O}}^{\,0} + \underset{\sim}{\omega} \times (\underset{\sim}{\omega} \times \underset{\sim}{r}_{A/O}) + 2\underset{\sim}{\omega} \times (\underset{\sim}{V}_{A/O})_{xy} + \cancel{(\underset{\sim}{a}_{A/O})_{xy}}^{\,0}$

$\underset{\sim}{a}_A = 0 + -0.1\underset{\sim}{k} \times (-0.1\underset{\sim}{k} \times 10\underset{\sim}{j}) + 2 \cdot 0.1\underset{\sim}{k} \times \left(\frac{1}{\sqrt{2}}\underset{\sim}{i} - \frac{1}{\sqrt{2}}\underset{\sim}{j}\right)$

$\underset{\sim}{a}_A = -0.1\underset{\sim}{j} + \frac{0.2}{\sqrt{2}}\underset{\sim}{j} + \frac{0.2}{\sqrt{2}}\underset{\sim}{i} = \boxed{\frac{0.2}{\sqrt{2}}\underset{\sim}{i} + \left(\frac{0.2}{\sqrt{2}} - 0.1\right)\underset{\sim}{j}}$