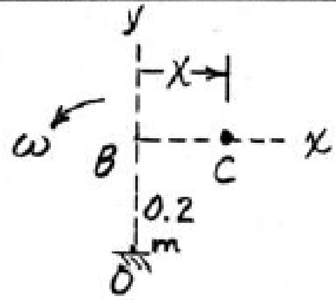
	(a) $t=3$ s	(b) $t=0.5$ s
$x = 0.04\sin\pi t =$	0	0.04
$\dot{x} = 0.04\pi\cos\pi t =$	-0.04π	0
$\ddot{x} = -0.04\pi^2\sin\pi t =$	0	$-0.04\pi^2$
$\omega = 2\sin\frac{\pi}{2}t =$	-2	$\sqrt{2}$
$\dot{\omega} = \pi\cos\frac{\pi}{2}t =$	0	$\pi/\sqrt{2}$



$$\underline{a}_C = \underline{a}_B + \dot{\underline{\omega}}\times\underline{r} + \underline{\omega}\times(\underline{\omega}\times\underline{r}) + 2\underline{\omega}\times\underline{v}_{rel} + \underline{a}_{rel}$$

(a) $\underline{a}_B = 0.2(-2)^2(-\underline{j}) + 0\underline{i} = -0.8\underline{j}\ m/s^2$

$\dot{\underline{\omega}}\times\underline{r} = \underline{0}$, $\underline{\omega}\times(\underline{\omega}\times\underline{r}) = -2\underline{k}\times(-2\underline{k}\times\underline{0}) = \underline{0}$

$2\underline{\omega}\times\underline{v}_{rel} = 2(-2\underline{k})\times(-0.04\pi\underline{i}) = 0.503\underline{j}\ m/s^2$, $\underline{a}_{rel} = \underline{0}$

Substitute & get $\underline{\underline{a}_C = -0.297\underline{j}\ m/s^2}$

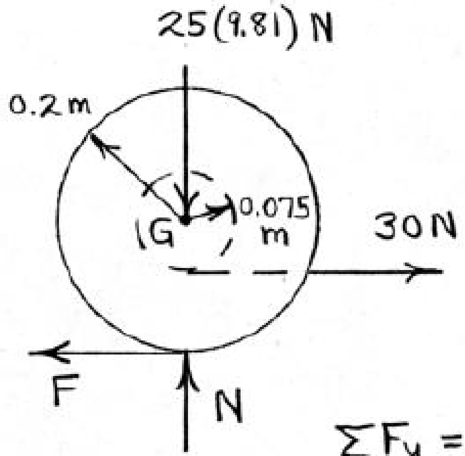
(b) $\underline{a}_B = -0.2\sqrt{2}^2\underline{j} - 0.2\frac{\pi}{2}\underline{i} = -0.444\underline{i} - 0.4\underline{j}\ m/s^2$

$\dot{\underline{\omega}}\times\underline{r} = \pi/\sqrt{2}\ \underline{k}\times 0.04\underline{i} = 0.0889\underline{j}\ m/s^2$

$\underline{\omega}\times(\underline{\omega}\times\underline{r}) = \sqrt{2}\underline{k}\times(\sqrt{2}\underline{k}\times 0.04\underline{i}) = -0.08\underline{i}\ m/s^2$

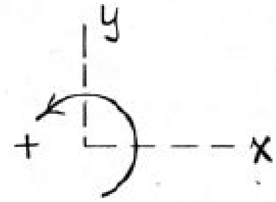
$2\underline{\omega}\times\underline{v}_{rel} = 2\sqrt{2}\underline{k}\times\underline{0} = \underline{0}$, $\underline{a}_{rel} = -0.04\pi^2\underline{i} = -0.395\underline{i}\ \frac{m}{s^2}$

Substitute & get $\underline{\underline{a}_C = -0.919\underline{i} - 0.311\underline{j}}\ m/s^2$



$\bar{k} = 0.175$ m

$\mu_s = 0.1, \quad \mu_k = 0.08$



$\Sigma F_y = 0 \Rightarrow N = 25(9.81) = 245$ N

$\Sigma F_x = m\bar{a}_x : \quad 30 - F = 25a \qquad (1)$

$\Sigma M_G = \bar{I}\alpha : \quad 30(0.075) - F(0.2) = 25(0.175)^2\alpha \quad (2)$

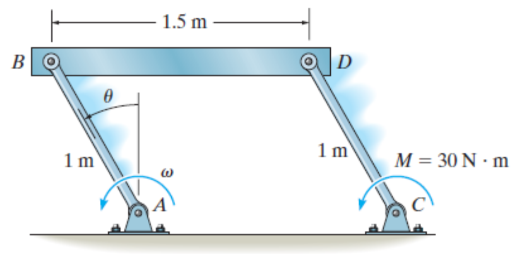
Assume rolling with no slip: $\quad a = -r\alpha \qquad (3)$

Solution of Eqs. (1)-(3): $\begin{cases} a = 0.425 \text{ m/s}^2 \\ \alpha = -2.12 \text{ rad/s}^2 \\ F = 19.38 \text{ N} \end{cases}$

$F_{max} = \mu_s N = 0.1(245) = 24.5 \text{ N} > F$ (assumption OK)

18–31.

The linkage consists of two 6-kg rods AB and CD and a 20-kg bar BD. When $\theta = 0°$, rod AB is rotating with an angular velocity $\omega = 2$ rad/s. If rod CD is subjected to a couple moment of $M = 30$ N · m, determine ω_{AB} at the instant $\theta = 90°$.



SOLUTION

Kinetic Energy. The mass moment of inertia of each link about the axis of rotation is $I_A = \frac{1}{12}(6)(1^2) + 6(0.5^2) = 2.00$ kg · m. The velocity of the center of mass of the bar is $v_G = \omega r = \omega(1)$. Thus,

$$T = 2\left(\frac{1}{2}I_A\omega^2\right) + \frac{1}{2}M_b v_G^2$$

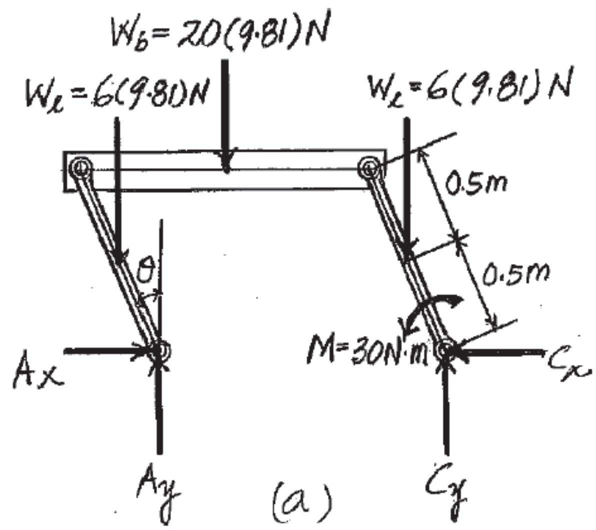
$$= 2\left[\frac{1}{2}(2.00)\omega^2\right] + \frac{1}{2}(20)[\omega(1)]^2$$

$$= 12.0\omega^2$$

Initially, $\omega = 2$ rad/s. Then

$$T_1 = 12.0(2^2) = 48.0 \text{ J}$$

Work. Referring to the FBD of the assembly, Fig. *a*, the weights W_b, W_c and couple moment **M** do positive work when the links undergo an angular displacement θ. When $\theta = 90^\circ = \frac{\pi}{2}$ rad,



$$U_{W_b} = W_b s_b = 20(9.81)(1) = 196.2 \text{ J}$$

$$U_{W_c} = W_c s_c = 6(9.81)(0.5) = 29.43 \text{ J}$$

$$U_M = M\theta = 30\left(\frac{\pi}{2}\right) = 15\pi \text{ J}$$

Principle of Work and Energy.

$$T_1 + \Sigma U_{1-2} = T_2$$

$$48.0 + [196.2 + 2(29.43) + 15\pi] = 12.0\,\omega^2$$

$$\omega = 5.4020 \text{ rad/s} = 5.40 \text{ rad/s}$$ **Ans.**