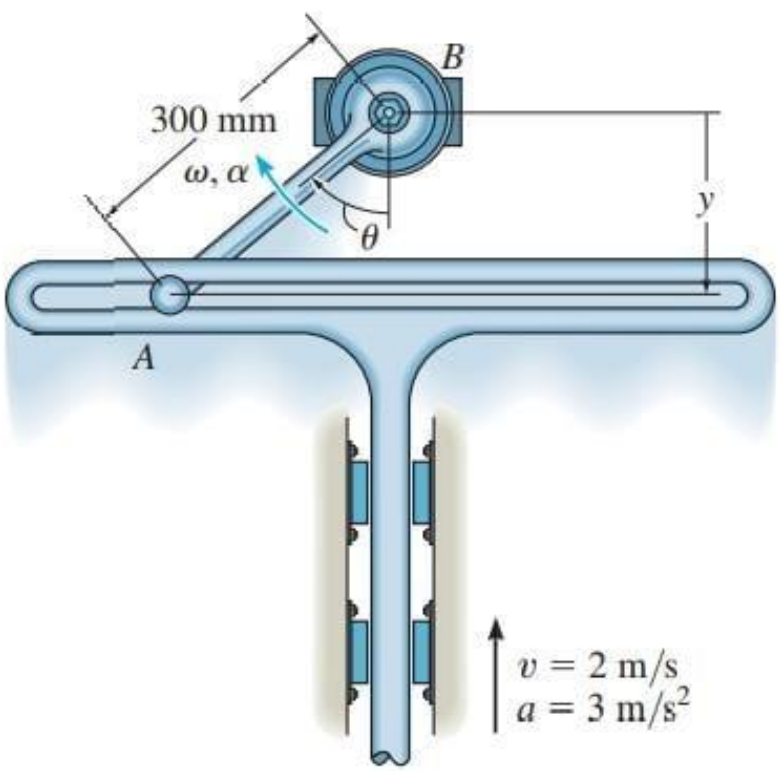
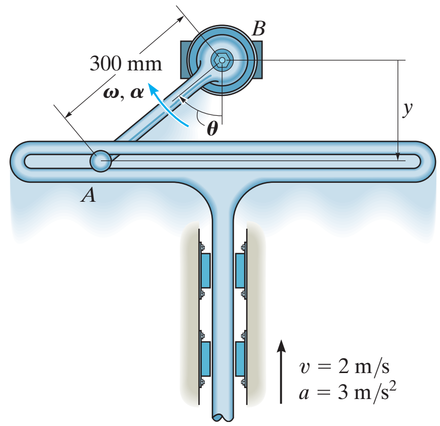
16–41. At the instant $\theta = 50^\circ$, the slotted guide is moving upward with an acceleration of $3\ \text{m/s}^2$ and a velocity of $2\ \text{m/s}$. Determine the angular acceleration and angular velocity of link AB at this instant. *Note:* The upward motion of the guide is in the negative y direction.



Prob. 16–41

16–41.

At the instant $\theta = 50°$, the slotted guide is moving upward with an acceleration of $3\ \text{m/s}^2$ and a velocity of $2\ \text{m/s}$. Determine the angular acceleration and angular velocity of link AB at this instant. *Note:* The upward motion of the guide is in the negative y direction.



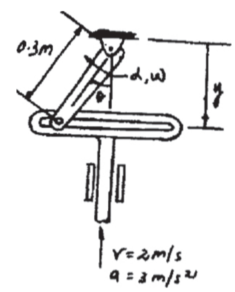
SOLUTION

$$y = 0.3 \cos \theta$$

$$\dot{y} = v_y = -0.3 \sin \theta \dot{\theta}$$

$$\ddot{y} = a_y = -0.3\left(\sin \theta \ddot{\theta} + \cos \theta \dot{\theta}^2\right)$$

Here $v_y = -2\ \text{m/s}$, $a_y = -3\ \text{m/s}^2$, and $\dot{\theta} = \omega, \dot{\theta} = \omega, \ddot{\theta} = \alpha, \theta = 50°$.

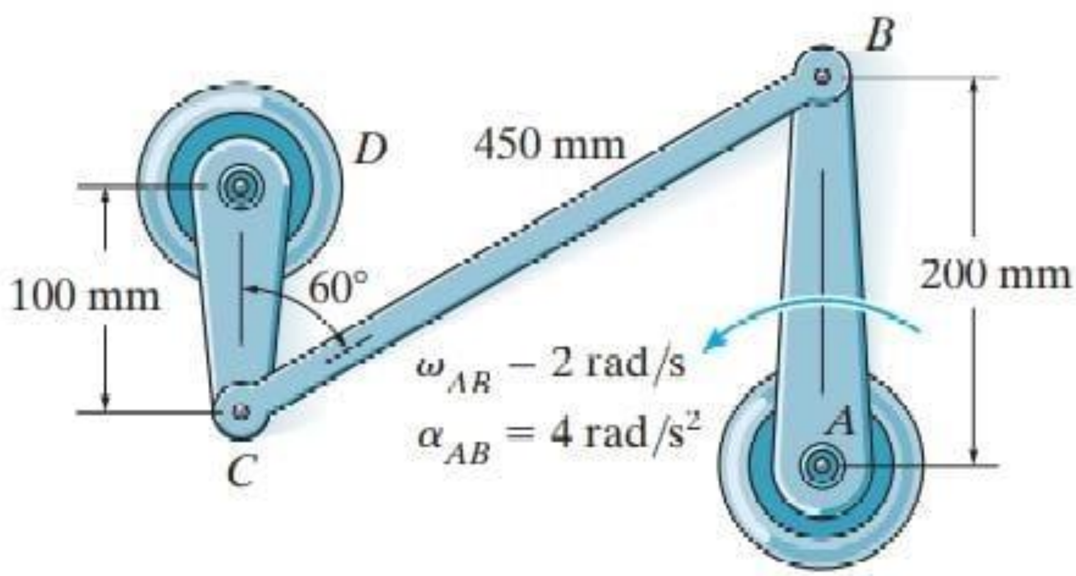


$-2 = -0.3 \sin 50°(\omega)$ $\qquad \omega = 8.70\ \text{rad/s}$ **Ans.**

$-3 = -0.3[\sin 50°(\alpha) + \cos 50°(8.70)^2]$ $\qquad \alpha = -50.5\ \text{rad/s}^2$ **Ans.**

Ans:
$\omega = 8.70\ \text{rad/s}$
$\alpha = -50.5\ \text{rad/s}^2$

16–109. Member AB has the angular motions shown. Determine the angular velocity and angular acceleration of members CB and DC.



Prob. 16–109

16–109.

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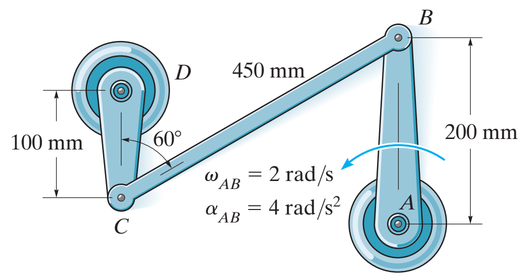


SOLUTION

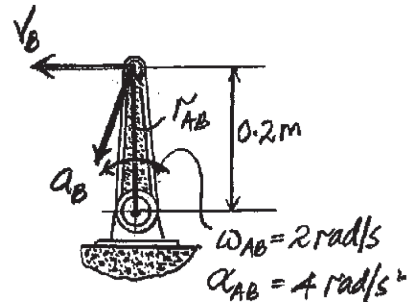
Rotation About A Fixed Axis. For crank AB, refer to Fig. *a*.

$$v_B = \omega_{AB} r_{AB} = 2(0.2) = 0.4 \text{ m/s} \leftarrow$$

$$\mathbf{a}_B = \boldsymbol{\alpha}_{AB} \times \mathbf{r}_{AB} - \omega_{AB}^2 \mathbf{r}_{AB}$$

$$= (4\mathbf{k}) \times (0.2\mathbf{j}) - 2^2(0.2\mathbf{j})$$

$$= \{-0.8\mathbf{i} - 0.8\mathbf{j}\} \text{ m/s}^2$$



(a)

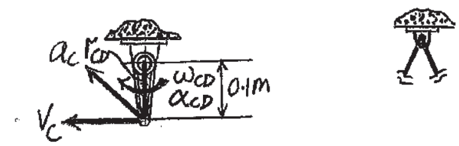
For link CD, refer to Fig. *b*.

$$v_C = \omega_{CD} r_{CD} = \omega_{CD}(0.1)$$

$$\mathbf{a}_C = \alpha_{CD} \times \mathbf{r}_{CD} - \omega_{CD}^2 \mathbf{r}_{CD}$$

$$= (-\alpha_{CD}\mathbf{k}) \times (-0.1\mathbf{j}) - \omega_{CD}^2(-0.1\mathbf{j})$$

$$= -0.1\alpha_{CD}\mathbf{i} + 0.1\omega_{CD}^2\mathbf{j}$$



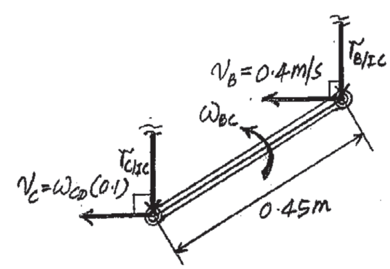
(b)

General Plane Motion. The IC of link CD can be located using $\mathbf{v}_B$ and $\mathbf{v}_C$ of which in this case is at infinity as indicated in Fig. *c*. Thus, $r_{B/IC} = r_{C/IC} = \infty$. Thus, kinematics gives

$$\omega_{BC} = \frac{v_B}{r_{B/IC}} = \frac{0.4}{\infty} = 0 \qquad \textbf{Ans.}$$

Then

$$v_C = v_B; \qquad \omega_{CD}(0.1) = 0.4 \qquad \omega_{CD} = 4.00 \text{ rad/s} \circlearrowright \qquad \textbf{Ans.}$$



(c)

Applying the relative acceleration equation by referring to Fig. *d*,

$$\mathbf{a}_C = \mathbf{a}_B + \boldsymbol{\alpha}_{BC} \times \mathbf{r}_{C/B} - \omega_{BC}^2 \mathbf{r}_{C/B}$$

$$-0.1\alpha_{CD}\mathbf{i} + 0.1(4.00^2)\mathbf{j} = (-0.8\mathbf{i} - 0.8\mathbf{j}) + (\alpha_{BC}\mathbf{k}) \times (-0.45 \sin 60°\mathbf{i} - 0.45 \cos 60°\mathbf{j}) - \mathbf{0}$$

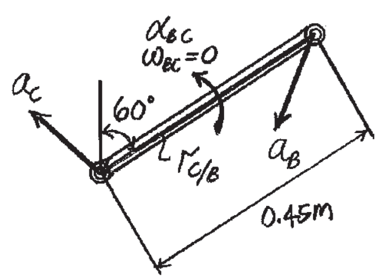
$$-0.1\alpha_{CD}\mathbf{i} + 1.6\mathbf{j} = (0.225\alpha_{BC} - 0.8)\mathbf{i} + (-0.8 - 0.3897\alpha_{BC})\mathbf{j}$$

Equating $\mathbf{j}$ components,

$$1.6 = -0.8 - 0.3897\alpha_{BC}; \qquad \alpha_{BC} = -6.1584 \text{ rad/s}^2 = 6.16 \text{ rad/s}^2 \circlearrowright \qquad \textbf{Ans.}$$

Then $\mathbf{i}$ components give

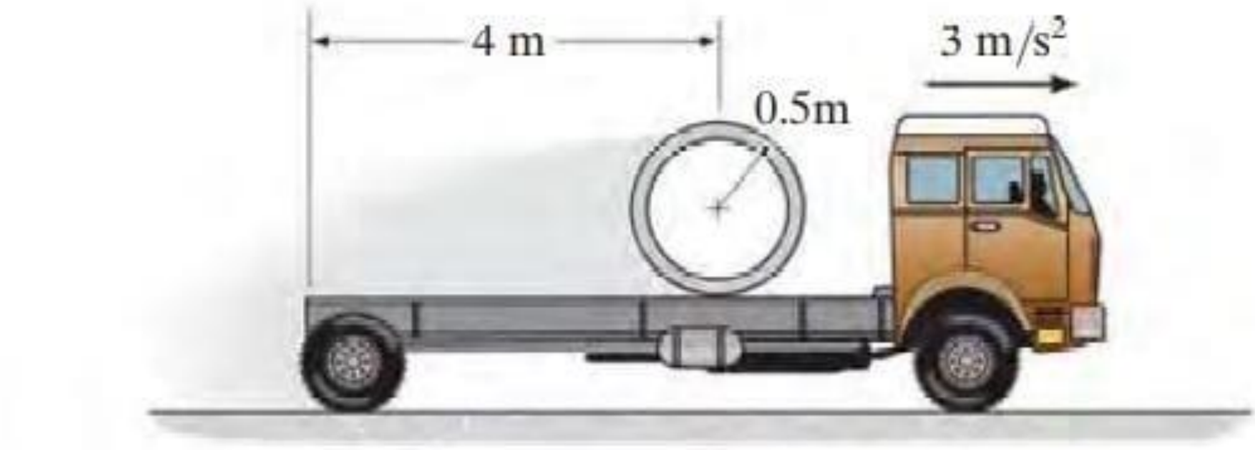
$$-0.1\alpha_{CD} = 0.225(-6.1584) - 0.8; \qquad \alpha_{CD} = 21.86 \text{ rad/s}^2 = 21.9 \text{ rad/s}^2 \circlearrowright \qquad \textbf{Ans.}$$



(d)

Ans:
$\omega_{BC} = 0$
$\omega_{CD} = 4.00 \text{ rad/s} \circlearrowright$
$\alpha_{BC} = 6.16 \text{ rad/s}^2 \circlearrowright$
$\alpha_{CD} = 21.9 \text{ rad/s}^2 \circlearrowright$

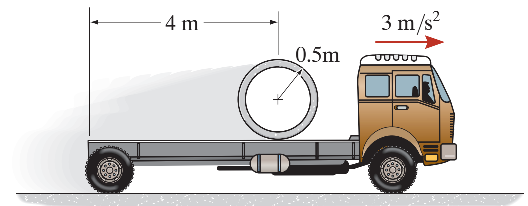
17–109. The 500-kg concrete culvert has a mean radius of 0.5 m. If the truck has an acceleration of $3\,\text{m/s}^2$, determine the culvert's angular acceleration. Assume that the culvert does not slip on the truck bed, and neglect its thickness.



Prob. 17–109

17–109.

The 500-kg concrete culvert has a mean radius of 0.5 m. If the truck has an acceleration of $3\,\text{m/s}^2$, determine the culvert's angular acceleration. Assume that the culvert does not slip on the truck bed, and neglect its thickness.



SOLUTION

Equations of Motion: The mass moment of inertia of the culvert about its mass center is $I_G = mr^2 = 500(0.5^2) = 125\ \text{kg}\cdot\text{m}^2$. Writing the moment equation of motion about point A using Fig. a,

$$\circlearrowleft + \Sigma M_A = \Sigma (M_k)_A; \quad 0 = 125\alpha - 500a_G(0.5) \qquad \textbf{(1)}$$

Kinematics: Since the culvert does not slip at A, $(a_A)_t = 3\ \text{m/s}^2$. Applying the relative acceleration equation and referring to Fig. b,

$$\mathbf{a}_G = \mathbf{a}_A + \alpha \times \mathbf{r}_{G/A} - \omega^2 r_{G/A}$$

$$a_G\mathbf{i} = 3\mathbf{i} + (a_A)_n\mathbf{j} + (\alpha\mathbf{k} \times 0.5\mathbf{j}) - \omega^2(0.5\mathbf{j})$$

$$a_G\mathbf{i} = (3 - 0.5\alpha)\mathbf{i} + \left[(a_A)_n - 0.5\omega^2\right]\mathbf{j}$$

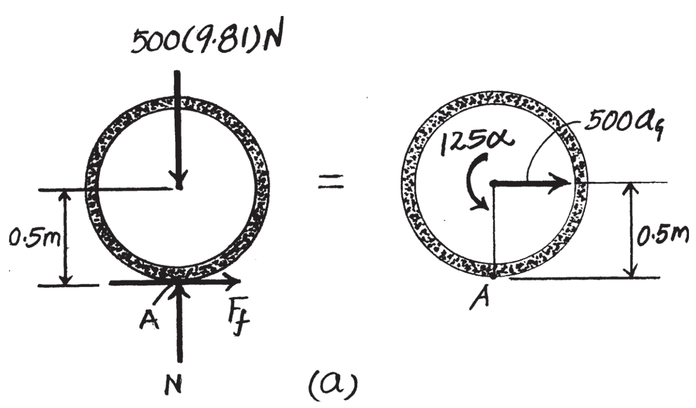
Equating the **i** components,

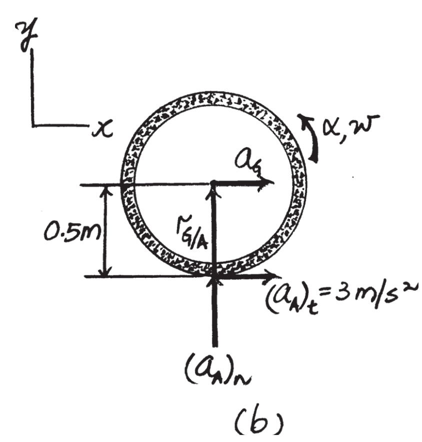
$$a_G = 3 - 0.5\alpha \qquad \textbf{(2)}$$

Solving Eqs. (1) and (2) yields

$$a_G = 1.5\ \text{m/s}^2 \rightarrow$$

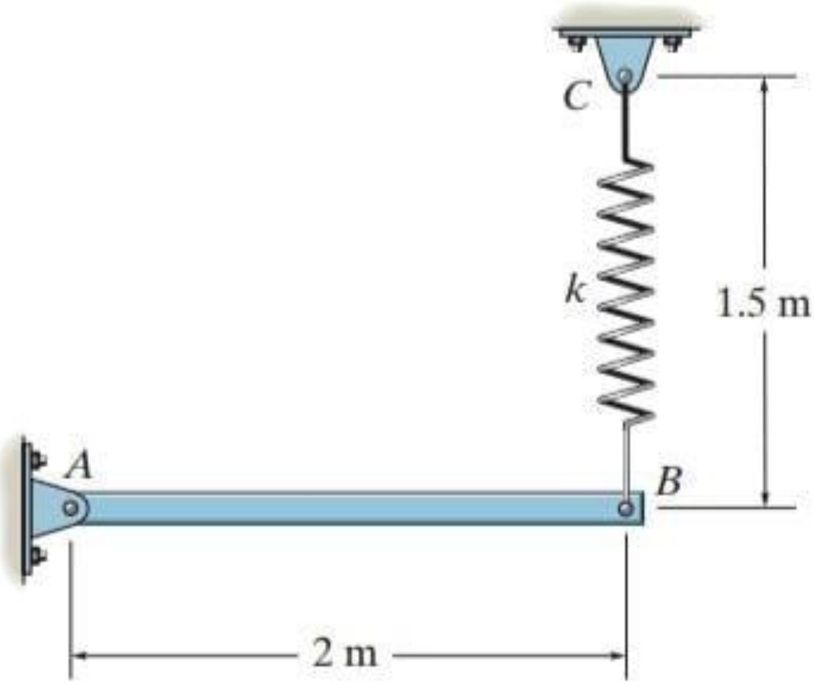
$$\alpha = 3\ \text{rad/s}^2 \qquad \textbf{Ans.}$$





Ans:
$\alpha = 3\ \text{rad/s}^2$

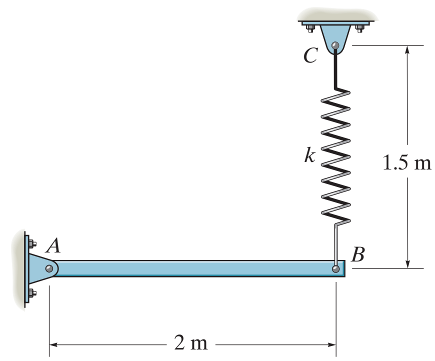
18–58. The slender 6-kg bar AB is horizontal and at rest and the spring is unstretched. Determine the stiffness k of the spring so that the motion of the bar is momentarily stopped when it has rotated clockwise 90° after being released.



Prob. 18–58

18–58.

The slender 6-kg bar AB is horizontal and at rest and the spring is unstretched. Determine the stiffness k of the spring so that the motion of the bar is momentarily stopped when it has rotated clockwise 90° after being released.



SOLUTION

Kinetic Energy. The mass moment of inertia of the bar about A is

$I_A = \frac{1}{12}(6)(2^2) + 6(1^2) = 8.00 \text{ kg}\cdot\text{m}^2$. Then

$$T = \frac{1}{2}I_A\,\omega^2 = \frac{1}{2}(8.00)\,\omega^2 = 4.00\,\omega^2$$

Since the bar is at rest initially and required to stop finally, $T_1 = T_2 = 0$.

Potential Energy. With reference to the datum set in Fig. *a*, the gravitational potential energies of the bar when it is at positions ① and ② are

$$(V_g)_1 = mgy_1 = 0$$

$$(V_g)_2 = mgy_2 = 6(9.81)(-1) = -58.86 \text{ J}$$

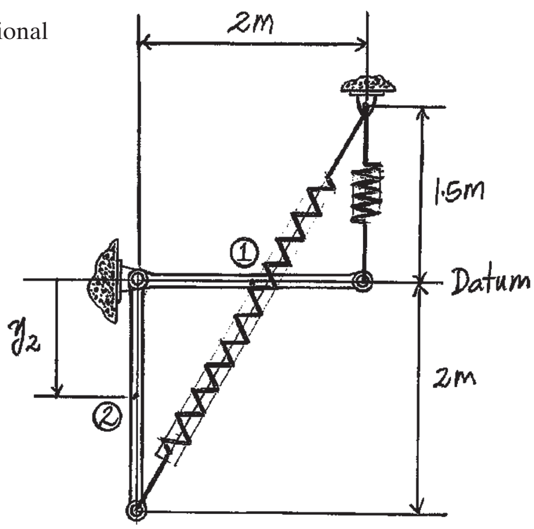
The stretch of the spring when the bar is at position ② is

$$x_2 = \sqrt{2^2 + 3.5^2} - 1.5 = 2.5311 \text{ m}$$

Thus, the initial and final elastic potential energy of the spring are

$$(V_e)_1 = \frac{1}{2}kx_1^2 = 0$$

$$(V_e)_2 = \frac{1}{2}k(2.5311^2) = 3.2033k$$



(a)

Conservation of Energy.

$$T_1 + V_1 = T_2 + V_2$$

$$0 + (0 + 0) = 0 + (-58.86) + 3.2033k$$

$$k = 18.3748 \text{ N/m} = 18.4 \text{ N/m}$$ **Ans.**

Ans:
$k = 18.4 \text{ N/m}$