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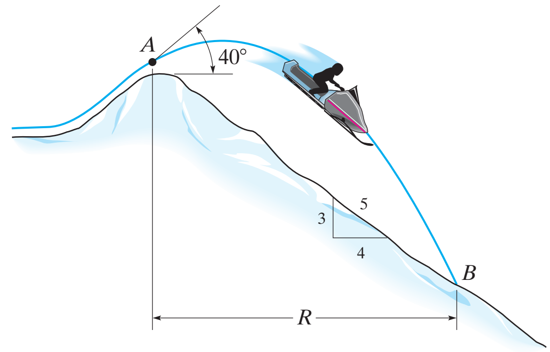
12–107.

The snowmobile is traveling at 10 m/s when it leaves the embankment at A. Determine the time of flight from A to B and the range R of the trajectory.



SOLUTION

$(\xrightarrow{+})$ $\quad s_B = s_A + v_A t$

$$R = 0 + 10 \cos 40^\circ\, t$$

$(+\uparrow)$ $\quad s_B = s_A + v_A t + \frac{1}{2} a_c t^2$

$$-R\left(\frac{3}{4}\right) = 0 + 10 \sin 40^\circ t - \frac{1}{2}(9.81)\, t^2$$

Solving:

$R = 19.0$ m **Ans.**

$t = 2.48$ s **Ans.**

Ans:
$R = 19.0$ m
$t = 2.48$ s

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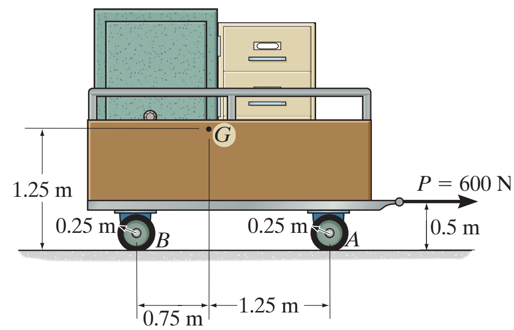
***17–36.**

The trailer with its load has a mass of 150 kg and a center of mass at G. If it is subjected to a horizontal force of $P = 600$ N, determine the trailer's acceleration and the normal force on the pair of wheels at A and at B. The wheels are free to roll and have negligible mass.



SOLUTION

Equations of Motion: Writing the force equation of motion along the x axis,

$\xrightarrow{+} \Sigma F_x = m(a_G)_x; \quad 600 = 150a \qquad a = 4 \text{ m/s}^2 \rightarrow$ **Ans.**

Using this result to write the moment equation about point A,

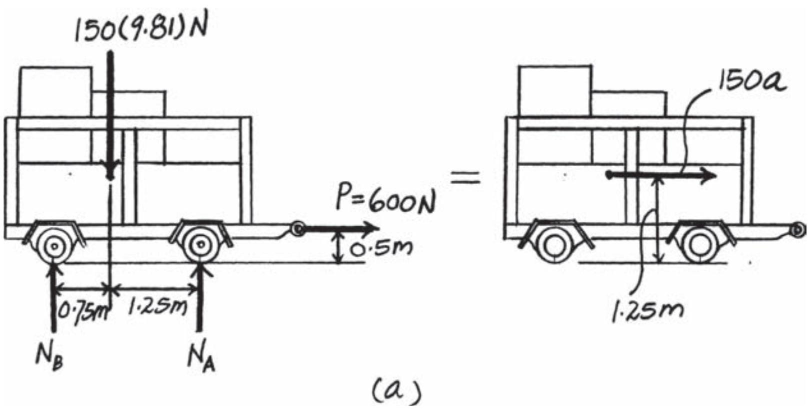
$\circlearrowleft + \Sigma M_A = (M_k)_A; \quad 150(9.81)(1.25) - 600(0.5) - N_B(2) = -150(4)(1.25)$

$N_B = 1144.69 \text{ N} = 1.14 \text{ kN}$ **Ans.**

Using this result to write the force equation of motion along the y axis,

$+\uparrow \Sigma F_y = m(a_G)_y; \quad N_A + 1144.69 - 150(9.81) = 150(0)$

$N_A = 326.81 \text{ N} = 327 \text{ N}$ **Ans.**



Ans:
$a = 4 \text{ m/s}^2 \rightarrow$
$N_B = 1.14$ kN
$N_A = 327$ N

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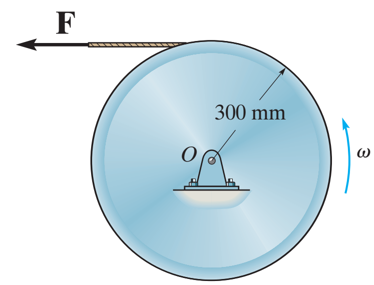
17–71.

A cord is wrapped around the outer surface of the 8-kg disk. If a force of $F = (\frac{1}{4}\theta^2)$ N, where θ is in radians, is applied to the cord, determine the disk's angular acceleration when it has turned 5 revolutions. The disk has an initial angular velocity of $\omega_0 = 1$ rad/s.



SOLUTION

Equations of Motion. The mass moment inertia of the disk about O is $I_O = \frac{1}{2}mr^2 = \frac{1}{2}(8)(0.3^2) = 0.36\ \text{kg}\cdot\text{m}^2$. Referring to the FBD of the disk, Fig. a,

$$\circlearrowleft + \Sigma M_O = I_O\,\alpha; \qquad \left(\frac{1}{4}\theta^2\right)(0.3) = 0.36\,\alpha$$

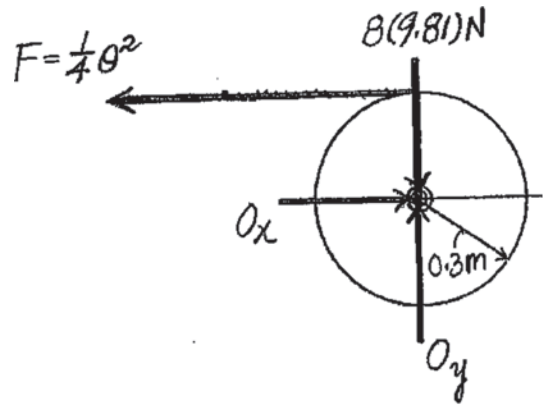
$$\alpha = \left(0.2083\,\theta^2\right)\ \text{rad/s}^2$$

Kinematics. Using the result of α, integrate $\omega d\omega = \alpha d\theta$ with the initial condition $\omega = 0$ when $\theta = 0$,

$$\int_1^{\omega} \omega d\omega = \int_0^{5(2\pi)} 0.2083\,\theta^2\,d\theta$$

$$\left(\frac{1}{2}\right)\left(\omega_2 - 1\right) = 0.06944\,\theta^3\Big|_0^{5(2\pi)}$$

$$\omega = 65.63\ \text{rad/s} = 65.6\ \text{rad/s} \qquad \textbf{Ans.}$$



Ans:
$\omega = 65.6$ rad/s

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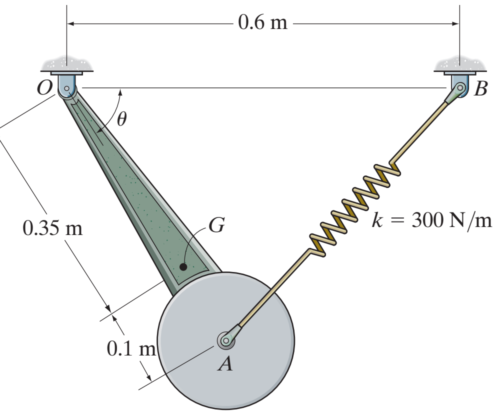
18–62. The 30 kg pendulum has its mass center at G and a radius of gyration about point G of $k_G = 300$ mm. If it is released from rest when $\theta = 0°$, determine its angular velocity at the instant $\theta = 90°$. Spring AB has a stiffness of $k = 300$ N/m and is unstretched when $\theta = 0°$.



SOLUTION

Potential Energy: With reference to the datum in Fig. *a*, the gravitational potential energy of the pendulum at positions (1) and (2) is

$$\left(V_g\right)_1 = W(y_G)_1 = 30(9.81)(0) = 0$$

$$\left(V_g\right)_2 = -W(y_G)_2 = -30(9.81)(0.35) = -103.005 \text{ J}$$

Since the spring is unstretched initially, $(V_e)_1 = 0$. When $\theta = 90°$, the spring stretches $s = AB - A'B = \sqrt{0.45^2 + 0.6^2} - 0.15 = 0.6$ m. Thus,

$$(V_e)_2 = \frac{1}{2}ks^2 = \frac{1}{2}(300)\left(0.6^2\right) = 54 \text{ J}$$

and

$$V_1 = \left(V_g\right)_1 + (V_e)_1 = 0$$

$$V_2 = \left(V_g\right)_2 + (V_e)_2 = -103.005 + 54 = -49.005 \text{ J}$$

Kinetic Energy: Since the pendulum rotates about a fixed axis, $v_G = \omega r_G = \omega(0.35)$. The mass moment of inertia of the pendulum about its mass center is $I_G = mk_G{}^2 = 30\left(0.3^2\right) = 2.7 \text{ kg}\cdot\text{m}^2$. Thus, the kinetic energy of the pendulum is

$$T = \frac{1}{2}mv_G{}^2 + \frac{1}{2}I_G\omega^2$$

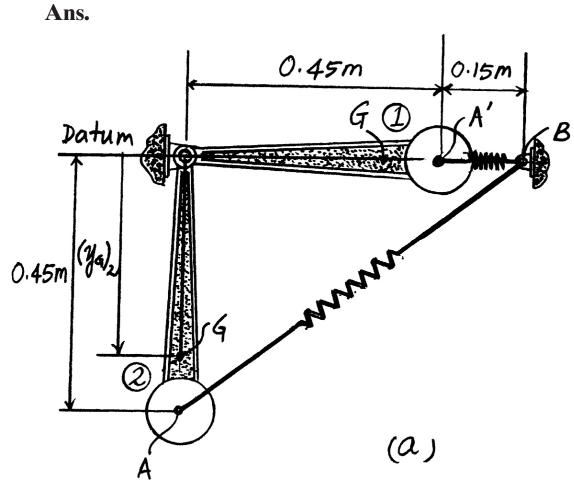
$$= \frac{1}{2}(30)\left[\omega(0.35)\right]^2 + \frac{1}{2}(2.7)\omega^2 = 3.1875\omega^2$$

Conservation of Energy:

$$T_1 + V_1 = T_2 + V_2$$

$$0 + 0 = 3.1875\omega^2 - 49.005$$

$$\omega = 3.92 \text{ rad/s}$$ **Ans.**



(a)

Ans:
$\omega = 3.92$ rad/s

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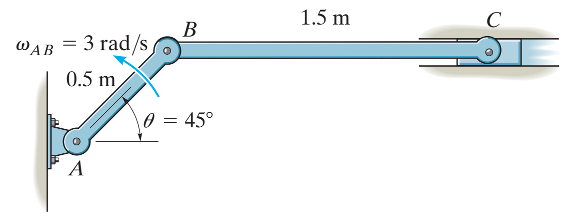
16–61.

The link AB has an angular velocity of 3 rad/s. Determine the velocity of block C and the angular velocity of link BC at the instant $\theta = 45°$. Also, sketch the position of link BC when $\theta = 60°$, $45°$, and $30°$ to show its general plane motion.



SOLUTION

Rotation About Fixed Axis. For link AB, refer to Fig. a.

$$\mathbf{v}_B = \boldsymbol{\omega}_{AB} \times \mathbf{r}_{AB}$$
$$= (3\mathbf{k}) \times (0.5 \cos 45°\mathbf{i} + 0.5 \sin 45°\mathbf{j})$$
$$= \{-1.0607\mathbf{i} + 1.0607\mathbf{j}\} \text{ m/s}$$

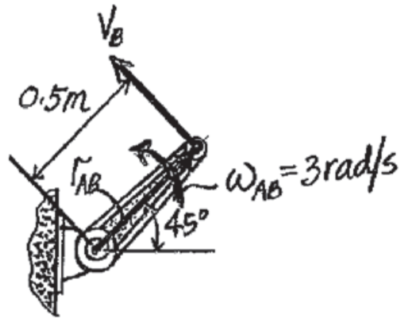
General Plane Motion. For link BC, refer to Fig. b. Applying the relative velocity equation,

$$\mathbf{v}_C = \mathbf{v}_B + \boldsymbol{\omega}_{BC} \times \mathbf{r}_{C/B}$$
$$-v_C\mathbf{i} = (-1.0607\mathbf{i} + 1.0607\mathbf{j}) + (-\omega_{BC}\mathbf{k}) \times (1.5\mathbf{i})$$
$$-v_C\mathbf{i} = -1.0607\mathbf{i} + (1.0607 - 1.5\omega_{BC})\mathbf{j}$$

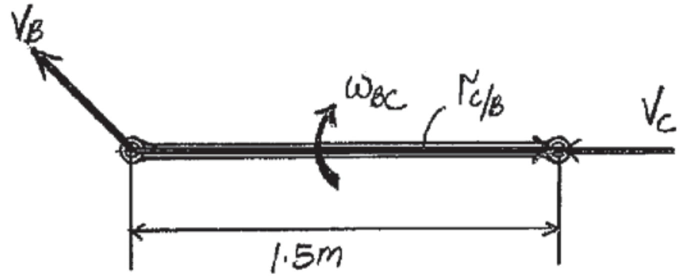
Equating **i** and **j** components;

$$-v_C = -1.0607 \qquad v_C = 1.0607 \text{ m/s} = 1.06 \text{ m/s} \qquad \textbf{Ans.}$$
$$0 = 1.0607 - 1.5\omega_{BC} \qquad \omega_{BC} = 0.7071 \text{ rad/s} = 0.707 \text{ rad/s} \qquad \textbf{Ans.}$$

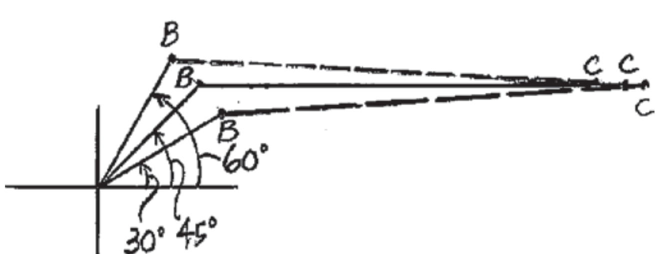
The general plane motion of link BC is described by its orientation when $\theta = 30°$, $45°$ and $60°$ shown in Fig. c.



(a)



(b)



(c)

Ans:
$v_C = 1.06 \text{ m/s} \leftarrow$
$\omega_{BC} = 0.707 \text{ rad/s} \circlearrowright$