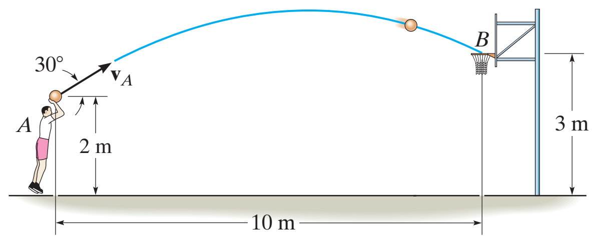
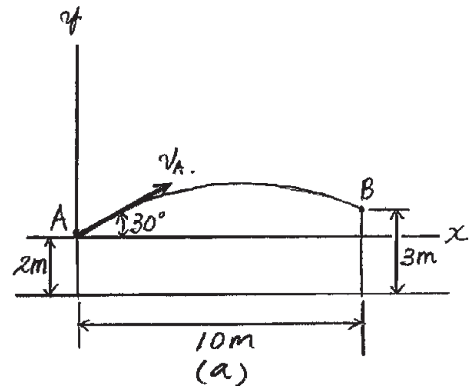
12–86.

Neglecting the size of the ball, determine the magnitude v_A of the basketball's initial velocity and its velocity when it passes through the basket.



SOLUTION

Coordinate System. The origin of the x-y coordinate system will be set to coinside with point A as shown in Fig. a



Horizontal Motion. Here $(v_A)_x = v_A \cos 30° \rightarrow$, $(s_A)_x = 0$ and $(s_B)_x = 10 \text{ m} \rightarrow$.

$$(\overset{+}{\rightarrow}) \quad (s_B)_x = (s_A)_x + (v_A)_x t$$

$$10 = 0 + v_A \cos 30° \, t$$

$$t = \frac{10}{v_A \cos 30°} \qquad \textbf{(1)}$$

Also,

$$(\overset{+}{\rightarrow}) \quad (v_B)_x = (v_A)_x = v_A \cos 30° \qquad \textbf{(2)}$$

Vertical Motion. Here, $(v_A)_y = v_A \sin 30° \uparrow$, $(s_A)_y = 0$, $(s_B)_y = 3 - 2 = 1 \text{ m} \uparrow$ and $a_y = 9.81 \text{ m/s}^2 \downarrow$

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

$$1 = 0 + v_A \sin 30° \, t + \frac{1}{2}(-9.81)t^2$$

$$4.905t^2 - 0.5 \, v_A \, t + 1 = 0 \qquad \textbf{(3)}$$

Also

$$(+\uparrow) \quad (v_B)_y = (v_A)_y + a_y t$$

$$(v_B)_y = v_A \sin 30° + (-9.81)t$$

$$(v_B)_y = 0.5 \, v_A - 9.81t \qquad \textbf{(4)}$$

Solving Eq. (1) and (3)

$$v_A = 11.705 \text{ m/s} = 11.7 \text{ m/s} \qquad \textbf{Ans.}$$

$$t = 0.9865 \text{ s}$$

Substitute these results into Eq. (2) and (4)

$$(v_B)_x = 11.705 \cos 30° = 10.14 \text{ m/s} \rightarrow$$

$$(v_B)_y = 0.5(11.705) - 9.81(0.9865) = -3.825 \text{ m/s} = 3.825 \text{ m/s} \downarrow$$

Thus, the magnitude of $\mathbf{v}_B$ is

$$v_B = \sqrt{(v_B)_x^2 + (v_B)_y^2} = \sqrt{10.14^2 + 3.825^2} = 10.83 \text{ m/s} = 10.8 \text{ m/s} \qquad \textbf{Ans.}$$

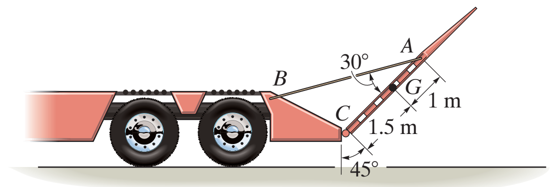
And its direction is defined by

$$\theta_B = \tan^{-1}\left[\frac{(v_B)_y}{(v_B)_x}\right] = \tan^{-1}\left(\frac{3.825}{10.14}\right) = 20.67° = 20.7° \qquad \textbf{Ans.}$$

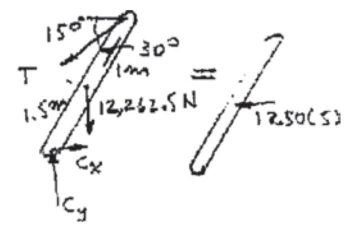
Ans:
$v_A = 11.7 \text{ m/s}$
$v_B = 10.8 \text{ m/s}$
$\theta = 20.7° \searrow$

***17–48.**

The drop gate at the end of the trailer has a mass of 1.25 Mg and mass center at G. If it is supported by the cable AB and hinge at C, determine the tension in the cable when the truck begins to accelerate at 5 m/s^2. Also, what are the horizontal and vertical components of reaction at the hinge C?



SOLUTION



$\zeta + \Sigma M_C = \Sigma(M_k)_C;\quad T\sin 30°(2.5) - 12\,262.5(1.5\cos 45°) = 1250(5)(1.5\sin 45°)$

$T = 15\,708.4\text{ N} = 15.7\text{ kN}$ **Ans.**

$\overset{+}{\leftarrow} \Sigma F_x = m(a_G)_x;\quad -C_x + 15\,708.4\cos 15° = 1250(5)$

$C_x = 8.92\text{ kN}$ **Ans.**

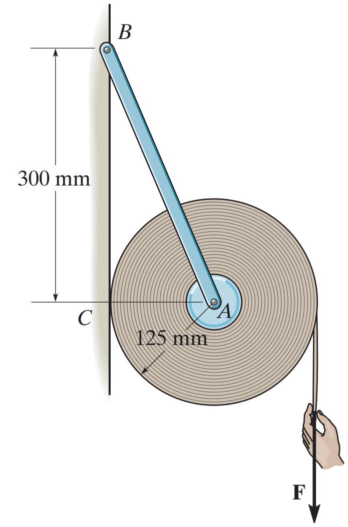
$+\uparrow \Sigma F_y = m(a_G)_y;\quad C_y - 12\,262.5 - 15\,708.4\sin 15° = 0$

$C_y = 16.3\text{ kN}$ **Ans.**

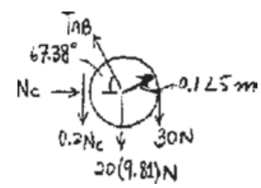
Ans:
$T = 15.7$ kN
$C_x = 8.92$ kN
$C_y = 16.3$ kN

17–62.

The 20-kg roll of paper has a radius of gyration $k_A = 90$ mm about an axis passing through point A. It is pin supported at both ends by two brackets AB. If the roll rests against a wall for which the coefficient of kinetic friction is $\mu_k = 0.2$ and a vertical force $F = 30$ N is applied to the end of the paper, determine the angular acceleration of the roll as the paper unrolls.



SOLUTION



$\xrightarrow{+} \Sigma F_x = m(a_G)_x; \qquad N_C - T_{AB}\cos 67.38^\circ = 0$

$+\uparrow \Sigma F_y = m(a_G)_y; \qquad T_{AB}\sin 67.38^\circ - 0.2N_C - 20(9.81) - 30 = 0$

$\circlearrowleft + \Sigma M_A = I_A\,\alpha; \qquad -0.2N_C(0.125) + 30(0.125) = 20(0.09)^2\alpha$

Solving:

$N_C = 103$ N

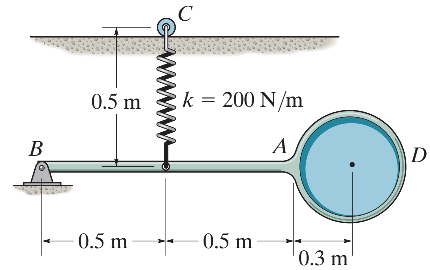
$T_{AB} = 267$ N

$\alpha = 7.28 \text{ rad/s}^2$ **Ans.**

Ans:
$\alpha = 7.28 \text{ rad/s}^2$

18–59.

The pendulum consists of a 6-kg slender rod fixed to a 15-kg disk. If the spring has an unstretched length of 0.2 m, determine the angular velocity of the pendulum when it is released from rest and rotates clockwise 90° from the position shown. The roller at C allows the spring to always remain vertical.



SOLUTION

Kinetic Energy. The mass moment of inertia of the pendulum about B is $I_B = \left[\frac{1}{12}(6)(1^2) + 6(0.5^2)\right] + \left[\frac{1}{2}(15)(0.3^2) + 15(1.3^2)\right] = 28.025\ \text{kg}\cdot\text{m}^2$. Thus

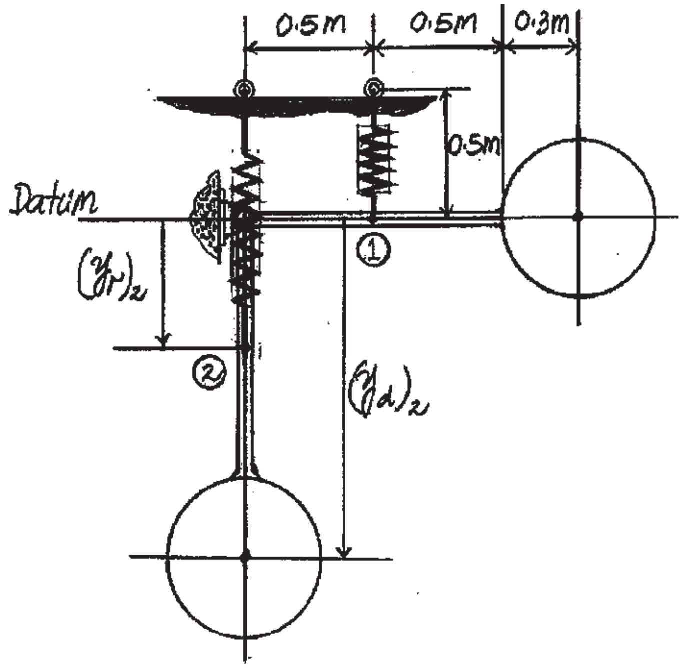
$$T = \frac{1}{2}I_B\,\omega^2 = \frac{1}{2}(28.025)\,\omega^2 = 14.0125\,\omega^2$$

Since the pendulum is released from rest, $T_1 = 0$.

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

$$(V_g)_1 = m_r g(y_r)_1 + m_d g(y_d)_1 = 0$$

$$\begin{aligned}(V_g)_2 &= m_r g(y_r)_2 + m_d g(y_d)_2\\ &= 6(9.81)(-0.5) + 15(9.81)(-1.3)\\ &= -220.725\ \text{J}\end{aligned}$$



(a)

The stretch of the spring when the pendulum is at positions ① and ② are

$$x_1 = 0.5 - 0.2 = 0.3\ \text{m}$$

$$x_2 = 1 - 0.2 = 0.8\ \text{m}$$

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

$$(V_e)_1 = \frac{1}{2}kx_1^2 = \frac{1}{2}(200)(0.3^2) = 9.00\ \text{J}$$

$$(V_e)_2 = \frac{1}{2}kx_2^2 = \frac{1}{2}(200)(0.8^2) = 64.0\ \text{J}$$

Conservation of Energy.

$$T_1 + V_1 = T_2 + V_2$$

$$0 + (0 + 9.00) = 14.0125\omega^2 + (-220.725) + 64.0$$

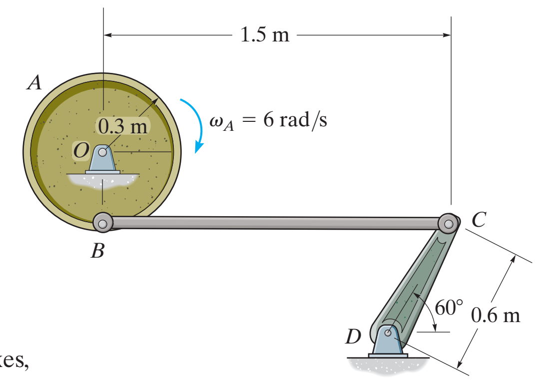
$$\omega = 3.4390\ \text{rad/s} = 3.44\ \text{rad/s}$$

Ans.

Ans:
$\omega = 3.44\ \text{rad/s}$

***16–72.**

If the flywheel is rotating with an angular velocity of $\omega_A = 6$ rad/s, determine the angular velocity of rod BC at the instant shown.



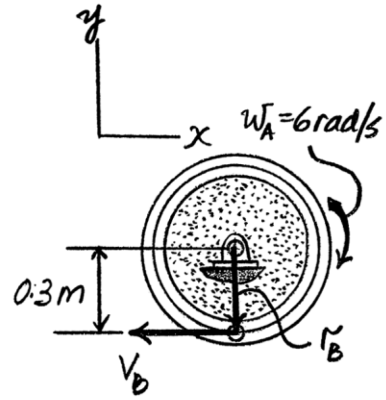
SOLUTION

Rotation About a Fixed Axis: Flywheel A and rod CD rotate about fixed axes, Figs. *a* and *b*. Thus, the velocity of points B and C can be determined from

$$v_B = \omega_A \times \mathbf{r}_B = (-6\mathbf{k}) \times (-0.3\mathbf{j}) = [-1.8\mathbf{i}] \text{ m/s}$$

$$v_C = \omega_{CD} \times \mathbf{r}_C = (\omega_{CD}\mathbf{k}) \times (0.6\cos 60°\,\mathbf{i} + 0.6\sin 60°\,\mathbf{j})$$

$$= -0.5196\omega_{CD}\mathbf{i} + 0.3\omega_{CD}\mathbf{j}$$



(a)

General Plane Motion: By referring to the kinematic diagram of link BC shown in Fig. *c* and applying the relative velocity equation, we have

$$\mathbf{v}_B = \mathbf{v}_C + \omega_{BC} \times \mathbf{r}_{B/C}$$

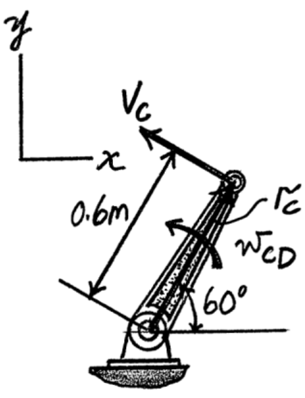
$$-1.8\mathbf{i} = -0.5196\omega_{CD}\mathbf{i} + 0.3\omega_{CD}\mathbf{j} + (\omega_{BC}\mathbf{k}) \times (-1.5\mathbf{i})$$

$$-1.8\mathbf{i} = -0.5196\omega_{CD}\mathbf{i} + (0.3\omega_{CD} - 1.5\omega_{BC})\mathbf{j}$$

Equating the **i** and **j** components

$$-1.8 = -0.5196\omega_{CD}$$

$$0 = 0.3\omega_{CD} - 1.5\omega_{BC}$$

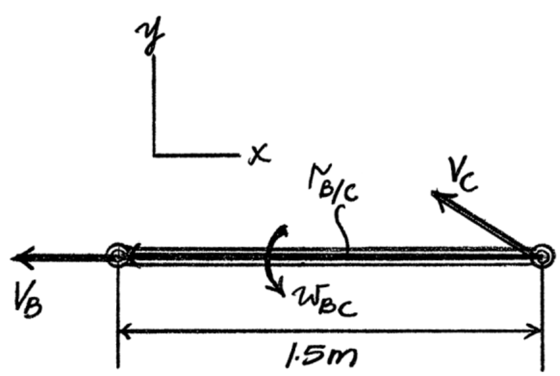


(b)

Solving,

$$\omega_{CD} = 3.46 \text{ rad/s}$$

$$\omega_{BC} = 0.693 \text{ rad/s} \quad \textbf{Ans.}$$



(c)

Ans:
$\omega_{BC} = 0.693$ rad/s