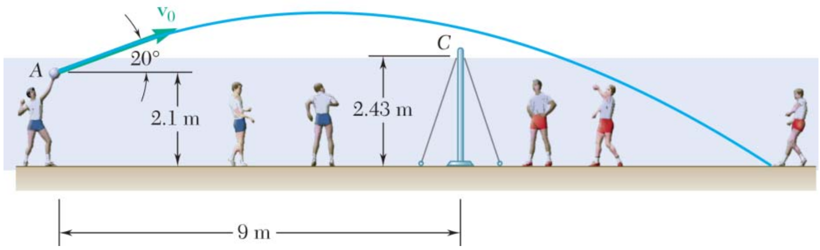


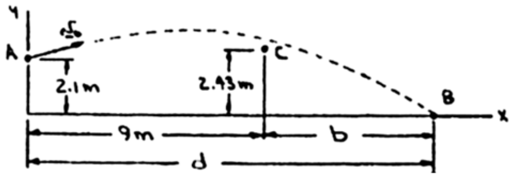
PROBLEM 11.103

A volleyball player serves the ball with an initial velocity $\mathbf{v}_0$ of magnitude 13.40 m/s at an angle of 20° with the horizontal. Determine (*a*) if the ball will clear the top of the net, (*b*) how far from the net the ball will land.

SOLUTION

First note

$$(v_x)_0 = (13.40 \text{ m/s}) \cos 20° = 12.5919 \text{ m/s}$$
$$(v_y)_0 = (13.40 \text{ m/s}) \sin 20° = 4.5831 \text{ m/s}$$



(*a*) Horizontal motion. (Uniform)

$$x = 0 + (v_x)_0 t$$

At C $\quad 9 \text{ m} = (12.5919 \text{ m/s})t \quad \text{or} \quad t_C = 0.71475 \text{ s}$

Vertical motion. (Uniformly accelerated motion)

$$y = y_0 + (v_y)_0 t - \frac{1}{2} g t^2$$

At C:

$$y_C = 2.1 \text{ m} + (4.5831 \text{ m/s})(0.71475 \text{ s}) - \frac{1}{2}(9.81 \text{ m/s}^2)(0.71475 \text{ s})^2 = 2.87 \text{ m}$$

$y_C > 2.43 \text{ m}$ (height of net) $\Rightarrow$ ball clears net ◀

(*b*) At B, $y = 0$:

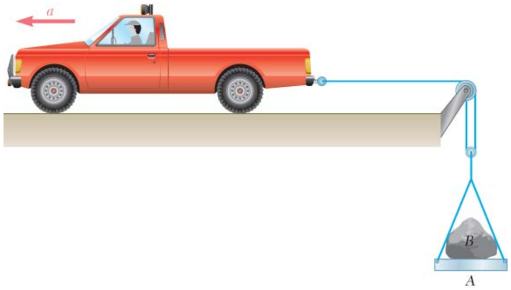
$$0 = 2.1 \text{ m} + (4.5831 \text{ m/s})t - \frac{1}{2}(9.81 \text{ m/s}^2)t^2$$

Solving $\quad t_B = 1.271175 \text{ s}$ (the other root is negative)

Then

$$d = (v_x)_0 t_B = (12.5919 \text{ m/s})(1.271175 \text{ s}) = 16.01 \text{ m}$$

The ball lands $\quad b = (16.01 - 9.00) \text{ m} = 7.01 \text{ m}$ from the net ◀



PROBLEM 12.17

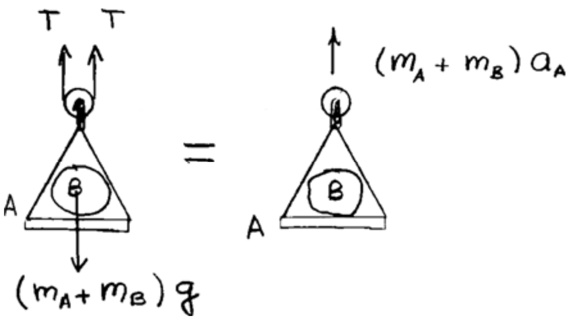
A 5000-lb truck is being used to lift a 1000 lb boulder *B* that is on a 200 lb pallet *A*. Knowing the acceleration of the truck is
1 ft/s^2, determine (*a*) the horizontal force between the tires and the ground, (*b*) the force between the boulder and the pallet.

SOLUTION

Kinematics:
$$\mathbf{a}_T = 1 \text{ m/s}^2 \longleftarrow$$
$$\mathbf{a}_A = \mathbf{a}_B = 0.5 \text{ m/s}^2 \uparrow$$

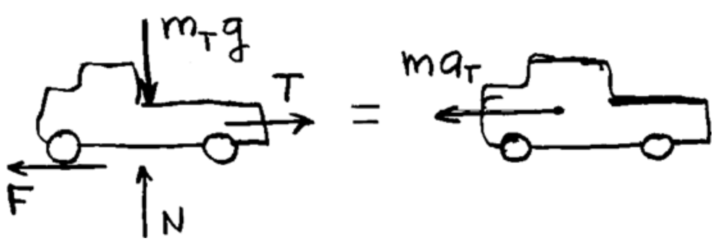
Masses:
$$m_T = \frac{5000}{32.2} = 155.28 \text{ slugs}$$
$$m_A = \frac{200}{32.2} = 6.211 \text{ slugs}$$
$$m_B = \frac{1000}{32.2} = 31.056 \text{ slugs}$$

Let *T* be the tension in the cable. Apply Newton's second law to the lower pulley, pallet and boulder.



Vertical components $+\uparrow$:
$$2T - (m_A + m_B)g = (m_A + m_B)a_A$$
$$2T - (37.267)(32.2) = (37.267)(0.5)$$
$$T = 609.32 \text{ lb}$$

Apply Newton's second law to the truck.



PROBLEM 12.17 (Continued)

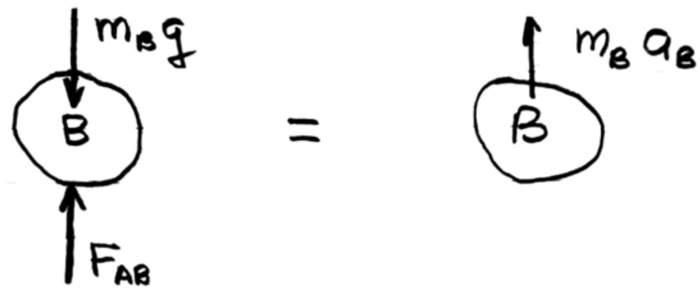
Horizontal components $\overset{+}{\leftarrow}$: $F - T = m_T a_T$

(*a*) Horizontal friction force between tires and ground.

$$F = T + m_T a_T = 609.32 + (155.28)(1.0)$$

$F = 765$ lb ◀

Apply Newton's second law to the boulder.

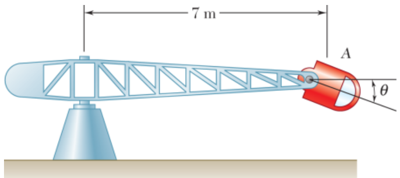


Vertical components $+\uparrow$: $F_{AB} - m_B g = m_B a_B$

$$F_{AB} = m_B (g + a) = 31.056(32.2 + 0.5)$$

(*b*) Contact force between boulder and pallet: $F_{AB} = 1016$ lb ◀

PROBLEM 12.38



Human centrifuges are often used to simulate different acceleration levels for pilots. When aerospace physiologists say that a pilot is pulling 9*g's*, they mean that the resultant normal force on the pilot from the bottom of the seat is nine times their weight. Knowing that the centrifuge starts from rest and has a constant angular acceleration of 1.5 RPM per second until the pilot is pulling 9*g*'s and then continues with a constant angular velocity, determine (*a*) how long it will take for the pilot to reach 9*g's* (*b*) the angle θ of the normal force once the pilot reaches 9 g's. Assume that the force parallel to the seat is zero.

SOLUTION

Given:

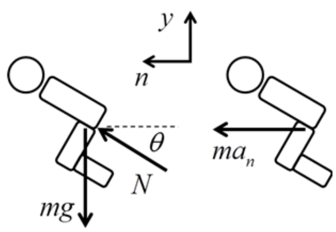
$\alpha = 1.5 \text{ RPM/s} = 0.157 \text{ rad/s}^2$

$\omega_0 = 0$

$\text{N} = 9\,\text{mg}$

$R = 7 \text{ m}$

Free Body Diagram of Pilot:



Equations of Motion:

$$\sum F_y = ma_y$$
$$N\sin\theta - mg = m(0)$$
$$N\sin\theta = mg \qquad (1)$$

$$\sum F_n = ma_n$$
$$\text{N}\cos\theta = mR\omega^2$$
$$\omega = \sqrt{\frac{\text{N}\cos\theta}{mR}} \qquad (2)$$

Substitute N=9mg into (1):

$$9mg\sin\theta = mg$$
$$\theta = \sin^{-1}\left(\frac{1}{9}\right)$$
$$\theta = 6.379°$$

Substitute N=9mg and θ into (2):

$$\omega = \sqrt{\frac{9*9.81\cos 6.379°}{7}}$$
$$\omega = 3.540 \text{ rad/s}$$

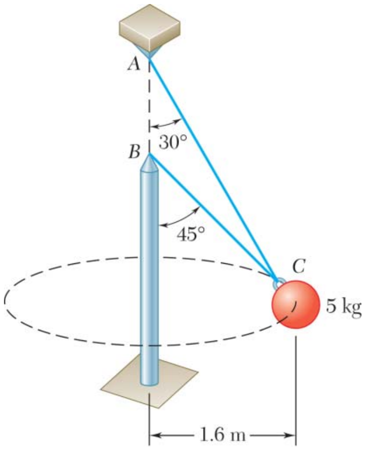
For constant angular acceleration:

$$\omega = \omega_0 + \alpha t$$
$$3.540 = 0 + 0.157 * t$$

(*a*) Solving for t: $t = 22.55$ s ◀

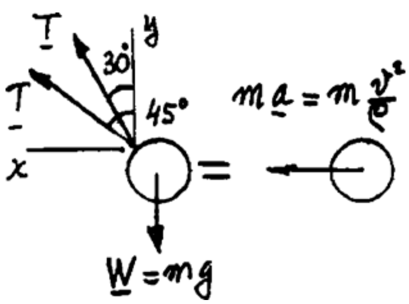
From earlier: $\theta = 6.379°$ ◀

PROBLEM 12.39



A single wire *ACB* passes through a ring at *C* attached to a sphere which revolves at a constant speed *v* in the horizontal circle shown. Knowing that the tension is the same in both portions of the wire, determine the speed *v*.

SOLUTION



$\overset{+}{\leftarrow} \Sigma F_x = ma: \quad T(\sin 30° + \sin 45°) = \dfrac{mv^2}{\rho}$ (1)

$+\uparrow \Sigma F_y = 0: \quad T(\cos 30° + \cos 45°) - mg = 0$

$T(\cos 30° + \cos 45°) = mg$ (2)

Divide Eq. (1) by Eq. (2): $\dfrac{\sin 30° + \sin 45°}{\cos 30° + \cos 45°} = \dfrac{v^2}{\rho g}$

$v^2 = 0.76733 \rho g = 0.76733\ (1.6\ \text{m})(9.81\ \text{m/s}^2) = 12.044\ \text{m}^2/\text{s}^2$ $\quad v = 3.47\ \text{m/s}$ ◀