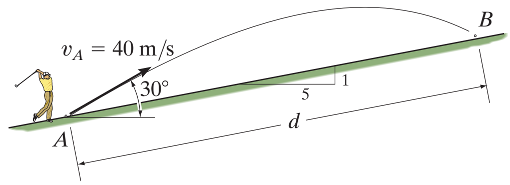
***12–96.** The golf ball is hit at A with a speed of $v_A = 40\text{ m/s}$ and directed at an angle of 30° with the horizontal as shown. Determine the distance d where the ball strikes the slope at B.



SOLUTION

Coordinate System: The x–y coordinate system will be set so that its origin coincides with point A.

x-Motion: Here, $(v_A)_x = 40\cos 30° = 34.64\text{ m/s}$, $x_A = 0$, and $x_B = d\left(\frac{5}{\sqrt{5^2+1}}\right) = 0.9806d$. Thus,

$$\left(\overset{+}{\rightarrow}\right) \qquad x_B = x_A + (v_A)_x t$$

$$0.9806d = 0 + 34.64t$$

$$t = 0.02831d \qquad \textbf{(1)}$$

y-Motion: Here, $(v_A)_y = 40\sin 30° = 20\text{ m/s}$, $y_A = 0$, $y_B = d\left(\frac{1}{\sqrt{5^2+1}}\right) = 0.1961d$, and $a_y = -g = -9.81\text{ m/s}^2$.

Thus,

$$(+\uparrow) \qquad y_B = y_A + (v_A)_y t + \frac{1}{2}a_y t^2$$

$$0.1961d = 0 + 20t + \frac{1}{2}(-9.81)t^2$$

$$4.905t^2 - 20t + 0.1961d = 0 \qquad \textbf{(2)}$$

Substituting Eq. (1) into Eq. (2) yields

$$4.905(0.02831d)^2 - 20(0.02831d) + 0.1961d = 0$$

$$3.9303\left(10^{-3}\right)d^2 - 0.37002d = 0$$

$$d\left[3.9303\left(10^{-3}\right)d - 0.37002\right] = 0$$

Since $d \neq 0$, then

$$3.9303\left(10^{-3}\right)d = 0.37002 = 0$$

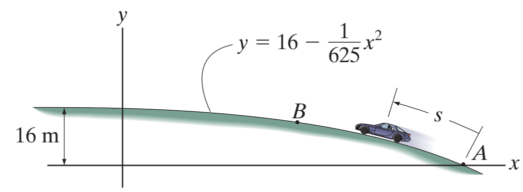
$$d = 94.1\text{ m} \qquad \textbf{Ans.}$$

Ans:

$d = 94.1$ m

12–121.

If the car passes point A with a speed of 20 m/s and begins to increase its speed at a constant rate of $a_t = 0.5\ \text{m/s}^2$, determine the magnitude of the car's acceleration when $s = 101.68$ m and $x = 0$.



SOLUTION

Velocity: The speed of the car at C is

$$v_C{}^2 = v_A{}^2 + 2a_t\,(s_C - s_A)$$

$$v_C{}^2 = 20^2 + 2(0.5)(100 - 0)$$

$$v_C = 22.361\ \text{m/s}$$

Radius of Curvature:

$$y = 16 - \frac{1}{625}x^2$$

$$\frac{dy}{dx} = -3.2\left(10^{-3}\right)x$$

$$\frac{d^2y}{dx^2} = -3.2\left(10^{-3}\right)$$

$$\rho = \frac{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2}}{\left|\frac{d^2y}{dx^2}\right|} = \left.\frac{\left[1 + \left(-3.2\left(10^{-3}\right)x\right)^2\right]^{3/2}}{\left|-3.2\left(10^{-3}\right)\right|}\right|_{x=0} = 312.5\ \text{m}$$

Acceleration:

$$a_t = \dot{v} = 0.5\ \text{m/s}$$

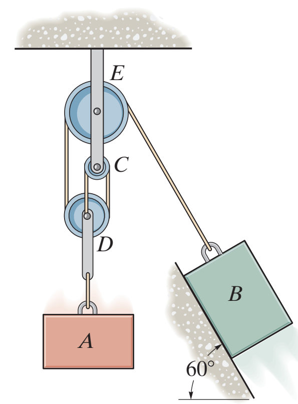
$$a_n = \frac{v_C{}^2}{\rho} = \frac{22.361^2}{312.5} = 1.60\ \text{m/s}^2$$

The magnitude of the car's acceleration at C is

$$a = \sqrt{a_t^2 + a_n^2} = \sqrt{0.5^2 + 1.60^2} = 1.68\ \text{m/s}^2 \qquad \textbf{Ans.}$$

Ans:
$a = 1.68\ \text{m/s}^2$

***13–20.** Determine the required mass of block A so that when it is released from rest it moves the 5-kg block B 0.75 m up along the smooth inclined plane in $t = 2$ s. Neglect the mass of the pulleys and cords.

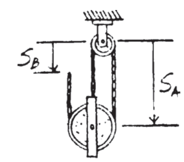


SOLUTION

Kinematic: Applying equation $s = s_0 + v_0 t + \frac{1}{2} a_c t^2$, we have

$$(\nwarrow +) \qquad 0.75 = 0 + 0 + \frac{1}{2} a_B \left(2^2\right) \qquad a_B = 0.375 \text{ m/s}^2$$

Establishing the position - coordinate equation, we have



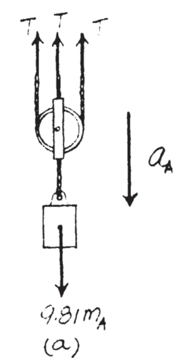
$$2s_A + (s_A - s_B) = l \qquad 3s_A - s_B = l$$

Taking time derivative twice yields

$$3a_A - a_B = 0 \tag{1}$$

From Eq.(1),

$$3a_A - 0.375 = 0 \qquad a_A = 0.125 \text{ m/s}^2$$



Equation of Motion: The tension T developed in the cord is the same throughout the entire cord since the cord passes over the smooth pulleys. From FBD(b),

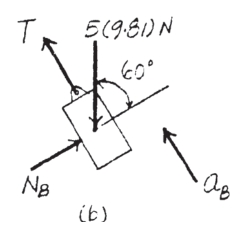
$$\nwarrow + \Sigma F_{y'} = ma_{y'}; \qquad T - 5(9.81)\sin 60° = 5(0.375)$$

$$T = 44.35 \text{ N}$$

From FBD(a),

$$+\uparrow \Sigma F_y = ma_y; \qquad 3(44.35) - 9.81m_A = m_A(-0.125)$$

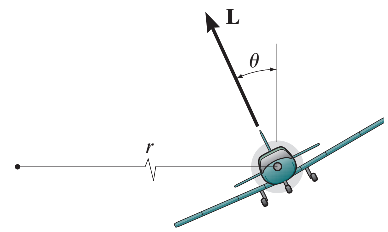
$$m_A = 13.7 \text{ kg} \qquad \textbf{Ans.}$$



Ans:
$m_A = 13.7$ kg

13–55.

A 5-Mg airplane is flying at a constant speed of 350 km/h along a horizontal circular path of radius $r = 3000\,\text{m}$. Determine the uplift force $\mathbf{L}$ acting on the airplane and the banking angle θ. Neglect the size of the airplane.



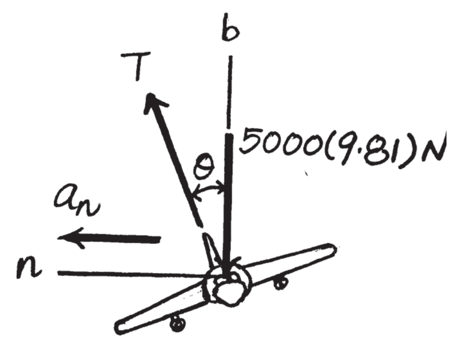
SOLUTION

Free-Body Diagram: The free-body diagram of the airplane is shown in Fig. (a). Here, $\mathbf{a}_n$ must be directed towards the center of curvature (positive n axis).

Equations of Motion: The speed of the airplane is $v = \left(350\,\dfrac{\text{km}}{\text{h}}\right)\left(\dfrac{1000\text{ m}}{1\text{ km}}\right)\left(\dfrac{1\text{ h}}{3600\text{ s}}\right) = 97.22\text{ m/s}$. Realizing that $a_n = \dfrac{v^2}{\rho} = \dfrac{97.22^2}{3000} = 3.151\text{ m/s}^2$ and referring to Fig. (a),

$+\uparrow \Sigma F_b = 0; \qquad T\cos\theta - 5000(9.81) = 0 \qquad$ **(1)**

$\overset{+}{\leftarrow} \Sigma F_n = ma_n; \qquad T\sin\theta = 5000(3.151) \qquad$ **(2)**



(a)

Solving Eqs. (1) and (2) yields

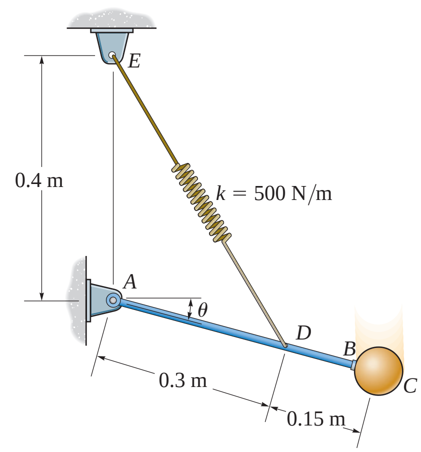
$\theta = 17.8^\circ \qquad T = 51517.75 = 51.5\text{ kN}$ **Ans.**

Ans:

$T = 51.5\text{ kN}$

***14–96.**

The 10-kg sphere C is released from rest when $\theta = 0°$ and the tension in the spring is 100 N. Determine the speed of the sphere at the instant $\theta = 90°$. Neglect the mass of rod AB and the size of the sphere.



SOLUTION

Potential Energy: With reference to the datum set in Fig. a, the gravitational potential energy of the sphere at positions (1) and (2) are $\left(V_g\right)_1 = mgh_1 = 10(9.81)(0.45) = 44.145$ J and $\left(V_g\right)_2 = mgh_2 = 10(9.81)(0) = 0$. When the sphere is at position (1), the spring stretches $s_1 = \dfrac{100}{500} = 0.2$ m. Thus, the unstretched length of the spring is $l_0 = \sqrt{0.3^2 + 0.4^2} - 0.2 = 0.3$ m, and the elastic potential energy of the spring is $\left(V_e\right)_1 = \frac{1}{2}ks_1{}^2 = \frac{1}{2}(500)(0.2^2) = 10$ J. When the sphere is at position (2), the spring stretches $s_2 = 0.7 - 0.3 = 0.4$ m, and the elastic potential energy of the spring is $\left(V_e\right)_2 = \frac{1}{2}ks_2{}^2 = \frac{1}{2}(500)(0.4^2) = 40$ J.

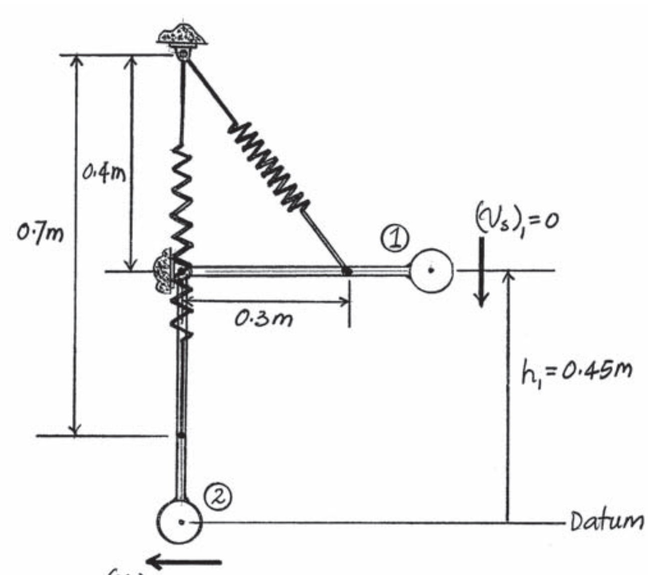
Conservation of Energy:

$$T_1 + V_1 = T_2 + V_2$$

$$\frac{1}{2}m_s\left(v_s\right)_1{}^2 + \left[\left(V_g\right)_1 + \left(V_e\right)_1\right] = \frac{1}{2}m_s\left(v_s\right)_2{}^2 + \left[\left(V_g\right)_2 + \left(V_e\right)_2\right]$$

$$0 + (44.145 + 10) = \frac{1}{2}(10)(v_s)_2{}^2 + (0 + 40)$$

$$(v_s)_2 = 1.68 \text{ m/s} \qquad \textbf{Ans.}$$



(a)

Ans:
$v = 1.68$ m/s