Solution \(11.135\)

\[
(a_n)_{\text{max}} = 3g = 3(9.81) = 29.43 \text{ m/s}^2
\]

\(q_t = 0\)

\(g = 25 \text{ m}\)

\[
(a_n) = \frac{v^2}{s} \quad \Rightarrow \quad V_{\text{max}}^2 = s(a_n)_{\text{max}}
\]

\[
V_{\text{max}} = \left(12.5 \times 29.43\right)^{1/2}
\]

\[V_{\text{max}} = 27.123 \text{ m/s}\]

\[
V_{\text{max}} = \frac{(27.125) \text{ m/s}}{1 \text{ km}} \times \frac{1 \text{ km}}{1000 \text{ m}} \times \frac{3600 \text{ s}}{1 \text{ h}}
\]

\[= 97.6 \frac{\text{ km}}{\text{ h}}\]
Solution M. 140

Given:

- Velocity at A: \( V_A = 0 \)
- Velocity at C: \( V_C = 100 \text{ km/h} = 27.78 \text{ m/s} \)
- Distance B-C: \( X_{BC} = 160 \text{ m} \)
- Distance A-B: \( X_{AB} = \frac{150}{2} = 75 \text{ m} \)
- Distance A-C: \( X_{AC} = X_{AB} + X_{BC} = 235.62 + 160 = 395.62 \text{ m} \)

(a) To find the speed at point B:

\[
V_B^2 = V_A^2 + 2a_t X_{AC} \quad (a_t: \text{ tangential component of acceleration})
\]

\[
(27.78)^2 = 0^2 + 2a_t (395.62) \implies a_t = \frac{1.1155}{m/s^2}
\]

at point B:

\[
V_B^2 = V_A^2 + 2a_t X_{AB}
\]

\[
V_B^2 = 0^2 + 2 \left( \frac{1.1155}{m/s^2} \right) (235.62) \implies V_B = 23.27 \text{ m/s}
\]

(b) To find the magnitude of total acceleration when \( t = 20 \text{ s} \):

Total acceleration: \( \vec{a} = \vec{a}_n + \vec{a}_t \), \( |a| = \sqrt{a_n^2 + a_t^2} \)

\[
a_t = \frac{1.1155}{m/s^2} = \text{ constant}
\]

\[
a_n = \frac{V_t^2}{R} = (a_n)_{t=20} = \frac{V_t}{R}
\]

when \( t = 20 \): \( V_{20} = V_A + a_t t = 0 + (1.1155)(20) = 22.31 \text{ m/s} \)

\[
|a| = \sqrt{a_n^2 + a_t^2} = \sqrt{1.1155^2 + 3.521^2} = 3.71 \text{ m/s}^2
\]
Let \( \theta \) be the slope angle of the trajectory at an arbitrary point C:

Then, the normal acceleration at point C: 
\[
(a_C)_n = \frac{v_C^2}{r_c} = g \cos \theta \tag{1}
\]
\[
\Rightarrow r_c = \frac{v_C^2}{g \cos \theta} \tag{2}
\]

where \( r_c \) is the radius of curvature at point C.

The horizontal component of velocity is constant.

\[
(v_A)_x = (v_C)_x = v_0 \cos \alpha \tag{3}
\]

Also from the figure at point C

\[
(v_C)_x = v_C \cos \theta \tag{4}
\]

From equations (3) and (4):

\[
(v_C)_x = v_0 \cos \alpha \Rightarrow v_C = \frac{v_0 \cos \alpha}{\cos \theta} \tag{5}
\]

Using equation (5) in equation (2):

\[
S_c = \frac{v_C^2}{g \cos \theta} = \frac{\frac{v_0^2 \cos^2 \alpha}{\cos \theta}}{g \cos^2 \theta} \tag{6}
\]
Since $V_0$, $\alpha$, and $g$ are constants, $S_C$ is minimum at point B where $\cos \theta$ is maximum or $\theta = 0$.

Then from equation (16) when $\theta = 0$:

$$S_{\text{min}} = S_B = \frac{V_0^2 \cos^2 \alpha}{g}$$

At point C:

$$S_C = \frac{V_0^2 \cos^2 \alpha}{g (\cos^2 \theta)} = \frac{S_{\text{min}}}{\cos^2 \theta}$$
Solution 11.1bt.

\[ \Gamma = 0.2 + 1.92t - 6.72t^2 + 64t^3 \]
\[ \dot{\Gamma} = 1.92 - 13.44t + 19.2t^2 \]
\[ \ddot{\Gamma} = -13.44 + 38.4t \]
\[ \Theta = 0.5e^{-0.8t} \sin 3nt \]
\[ \dot{\Theta} = -0.4e^{-0.8t} \sin 3nt + 1.571e^{-0.8t} \cos 3nt \]
\[ \ddot{\Theta} = 0.32e^{-0.8t} \sin 3nt - 1.2e^{-0.8t} \cos 3nt \]
\[ = 1.2e^{-0.8t} \cos 3nt - 1.571e^{-0.8t} \sin 3nt \]

At \( t = 0.5 \) s:
\[ \Gamma = 0.28 \text{ m} \]
\[ \dot{\Theta} = 0 \text{ m/s} \]
\[ \ddot{\Theta} = 5.76 \text{ m/s}^2 \]

(a) Velocity of collar:
\[ \vec{V} = \vec{r}\dot{e}_r + \vec{r}\dot{e}_\Theta \]
\[ = 0\vec{e}_r + (0.28)(0.26872)\vec{e}_\Theta = 0.075 \vec{e}_\Theta \text{ m/s} \]

\( V_r = 0, \quad V_\Theta = 0.075 \text{ m/s} \)

(b) Acceleration of collar:
\[ \vec{a} = (\vec{r} - \vec{r}\ddot{e}_\Theta)\dot{e}_r + (\vec{r}\dddot{e}_r + 2\dddot{e}_\Theta)\dot{e}_\Theta = a_r\dot{e}_r + a_\Theta\dot{e}_\Theta \]
\[ = (5.76 - 10.28)(0.26872)\dot{e}_r + [(0.26872)(29.54) + 2(0.26872)]\dot{e}_\Theta \]
\[ = 5.76\dot{e}_r + 8.28\dot{e}_\Theta \Rightarrow a_r = 5.76 \text{ m/s}^2 \]
\[ a_\Theta = 8.28 \text{ m/s}^2 \]

(c) The motion of the collar respect to the rod is rectilinear and defined by coordinate \( r \). Then:
\[ \vec{a}_{\text{global}} = \vec{r}\dddot{e}_r = (5.76 \text{ m/s}^2)\dot{e}_r \]
Solution 12.1.

At all latitudes: \( m = 2 \text{ kg} \)

(a) \( \phi = 0^\circ \Rightarrow g = g_{\text{atm}} (1 + 0.0053 \sin^2 0^\circ) \)

\[ = 9.7807 \text{ m/s}^2 \]

\[ W = mg = 2 \times 9.7807 = 19.56 \text{ kgm/s}^2 = 19.56 \text{ N} \]

(b) \( \phi = 45^\circ \Rightarrow g = g_{\text{atm}} (1 + 0.0053 \sin^2 45^\circ) \)

\[ = 9.8066 \text{ m/s}^2 \]

\[ W = mg = 2 \times 9.8066 = 19.61 \text{ kgm/s}^2 = 19.61 \text{ N} \]

(c) \( \phi = 60^\circ \Rightarrow g = g_{\text{atm}} (1 + 0.0053 \sin^2 60^\circ) \)

\[ = 9.8196 \text{ m/s}^2 \]

\[ W = mg = 2 \times 9.8196 = 19.64 \text{ kgm/s}^2 = 19.64 \text{ N} \]
Solution 12.11:

Given:  
\[ V_0 = 80 \text{ km/h} = 25 \text{ m/s} \]  
\[ V_{\text{end}} = 0 \]  
\[ \Sigma F_t = 16 + 60 = 76 \text{ kN} = 76000 \text{ N} \]  
\[ \Sigma M = 6800 + 7600 = 14400 \text{ kg} \]

\[ \Sigma F_x = ma \Rightarrow -76000 = (14400)a \]

\[ a = \frac{-76000}{14400} = -5.317 \text{ m/s}^2 \]

For constant acceleration:  
\[ V_{\text{end}}^2 - V_0^2 = 2a (x-x_0) \]

(a) \[ \Delta x = x-x_0 = \frac{0 - (25)^2}{2(-5.317)} = 60.4 \text{ m} \] The distance traveled by the tractor-trailer before it comes to a stop.

(b)

Free Body Diagram:

\[ \Sigma F_x = ma = -F_H - 16000 = 6800(-5.170) \]

\[ F_H = 6800(-5.170) + 16000 \]

\[ F_H = 19456 \text{ N in } (-\hat{i}) \text{ direction} \]
Solution 12.44.

Given: \( W = 60 \text{ lb} \Rightarrow m = \frac{W}{g} = \frac{60}{32.2} = 1.8664 \text{ lb/ft} \)

(a) Swing is held at rest, \( \ddot{a} = 0 \Rightarrow a_n = 0 \)
\[ a_T = 0 \]

From figure: \( \sum F_y = 0 \Rightarrow 2T_{AB} \cos 40^\circ - W = 0 \)

\[ T_{AB} = \frac{W}{2 \cos 40^\circ} = \frac{60}{2 \cos 40^\circ} = 39.2 \text{ lb} \]

(b) Swing is released, \( P = 0, \dot{V} = 0 \Rightarrow a_n = \frac{V^2}{S} = \frac{0}{S} = 0 \)

From figure: \( \sum F_n = ma_n = 0 \Rightarrow 2T_{AB} - W \cos 40^\circ = 0 \)

\[ T_A = \frac{W \cos 40^\circ}{2} = \frac{60 \cos 40^\circ}{2} \]
\[ = 23 \text{ lb}. \]
Solution 12.47

Given: \( W_{\text{block}} = 0.22 \text{kg} \times 9.81 = 2.158 \text{N} \)

\[ N_{\theta = 180} = 3.5 \text{ N} \]

The coordinate system is:

The forces acting on the block B are:

- \( W \): the weight of the block
- \( F_s \): Spring force
- \( N \): Contact force on the face of cavity.

(*) When there is no contact, \( N \) is zero.

(*) \( F_s \) remains constant while the block is in contact with the face of the cavity.

Since the speed is constant, \( a_t = 0 \), \( a_n = \text{constant} \)

From figure: \( F_n = N - F_s + W \cos \theta = m a_n \)

\[ F_s + m a_n = N + W \cos \theta \]

When \( \theta = 180 \Rightarrow F_s + m a_n = 3.5 \pm 1.342 0 = 1.342 \text{ N} \)

When contact is broken \( N = 0 \) From equation (1):

\[ F_s + m a_n = W \cos \theta \rightarrow \cos \theta = \frac{F_s + m a_n}{W} = \frac{1.342}{2.158} = 0.62187 \]

\[ \theta = 51.6^\circ \]

The block is not in contact with the face of the cavity for \( \theta < 51.6^\circ \).