Chapter 6 Solutions

P6.1 $m = 3.00\text{ kg}$, $r = 0.800\text{ m}$. The string will break if the tension exceeds the weight corresponding to 25.0 kg, so

$$T_{max} = Mg = 25.0(9.80) = 245\text{ N}$$

When the 3.00 kg mass rotates in a horizontal circle, the tension causes the centripetal acceleration,

so $$T = \frac{mv^2}{r} = \frac{(3.00)v^2}{0.800}$$

Then

$$v^2 = \frac{rT}{m} = \frac{(0.800)T}{3.00} \le \frac{(0.800)T_{max}}{3.00} = \frac{0.800(245)}{3.00} = 65.3\text{ m}^2/\text{s}^2$$

and $$0 \le v \le \sqrt{65.3}$$

or $$\boxed{0 \le v \le 8.08\text{ m/s}}$$

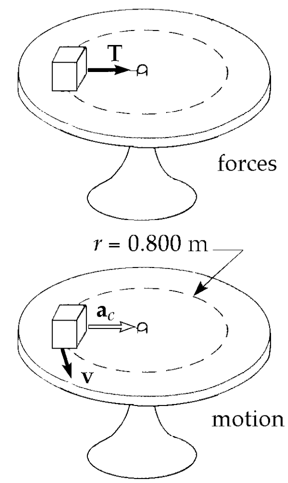

FIG. P6.1

P6.3 (a) $$F = \frac{mv^2}{r} = \frac{\left(9.11\times10^{-31}\text{ kg}\right)\left(2.20\times10^{6}\text{ m/s}\right)^2}{0.530\times10^{-10}\text{ m}} = \boxed{8.32\times10^{-8}\text{ N inward}}$$

(b) $$a = \frac{v^2}{r} = \frac{\left(2.20\times10^{6}\text{ m/s}\right)^2}{0.530\times10^{-10}\text{ m}} = \boxed{9.13\times10^{22}\text{ m/s}^2\text{ inward}}$$

P6.5 (a) $\boxed{\text{static friction}}$

(b) $$m\mathbf{a} = f\,\mathbf{i} + n\mathbf{j} + mg(-\mathbf{j})$$

$$\sum F_y = 0 = n - mg$$

thus $n = mg$ and $\sum F_r = m\frac{v^2}{r} = f = \mu n = \mu mg$.

Then $\mu = \frac{v^2}{rg} = \frac{(50.0\text{ cm/s})^2}{(30.0\text{ cm})(980\text{ cm/s}^2)} = \boxed{0.085\ 0}$.

P6.7 Standing on the inner surface of the rim, and moving with it, each person will feel a normal force exerted by the rim. This inward force causes the 3.00 m/s^2 centripetal acceleration:

$a_c = v^2/r$ so $$v = \sqrt{a_c r} = \sqrt{(3.00\text{ m/s}^2)(60.0\text{ m})} = 13.4\text{ m/s}$$

The period of rotation comes from $v = \frac{2\pi r}{T}$: $$T = \frac{2\pi r}{v} = \frac{2\pi(60.0\text{ m})}{13.4\text{ m/s}} = 28.1\text{ s}$$

so the frequency of rotation is $f=\frac{1}{T}=\frac{1}{28.1\text{ s}}=\frac{1}{28.1\text{ s}}\left(\frac{60\text{ s}}{1\text{ min}}\right)=\boxed{2.14\text{ rev/min}}$.

P6.9 $n=mg$ since $a_y=0$

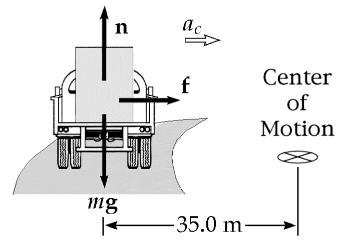

FIG. P6.9

The force causing the centripetal acceleration is the frictional force f.

From Newton•s second law $f=ma_c=\frac{mv^2}{r}$.

But the friction condition is $f\le \mathrm{m}_s n$

i.e., $\frac{mv^2}{r}\le \mathrm{m}_s mg$

$$v\le\sqrt{\mathrm{m}_s rg}=\sqrt{0.600(35.0\text{ m})(9.80\text{ m/s}^2)}\qquad v\le\boxed{14.3\text{ m/s}}$$

P6.11 $F_g=mg=(4\text{ kg})(9.8\text{ m/s}^2)=39.2\text{ N}$

$\sin q=\frac{1.5\text{ m}}{2\text{ m}}$

$q=48.6°$

$r=(2\text{ m})\cos 48.6°=1.32\text{ m}$

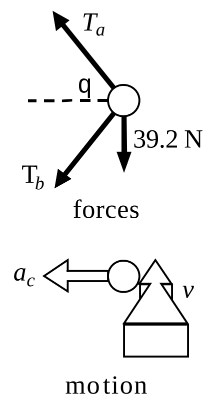

FIG. P6.11

$$\sum F_x=ma_x=\frac{mv^2}{r}$$

$$T_a\cos 48.6°+T_b\cos 48.6°=\frac{(4\text{ kg})(6\text{ m/s})^2}{1.32\text{ m}}$$

$$T_a+T_b=\frac{109\text{ N}}{\cos 48.6°}=165\text{ N}$$

$$\sum F_y=ma_y$$

$$+T_a\sin 48.6°-T_b\sin 48.6°-39.2\text{ N}=0$$

$$T_a-T_b=\frac{39.2\text{ N}}{\sin 48.6°}=52.3\text{ N}$$

(a) To solve simultaneously, we add the equations in T_a and T_b:

$$T_a+T_b+T_a-T_b=165\text{ N}+52.3\text{ N}$$

$$T_a=\frac{217\text{ N}}{2}=\boxed{108\text{ N}}$$

(b) $T_b=165\text{ N}-T_a=165\text{ N}-108\text{ N}=\boxed{56.2\text{ N}}$

P6.13 $M = 40.0\text{ kg}$, $R = 3.00\text{ m}$, $T = 350\text{ N}$

(a)

$$\sum F = 2T - Mg = \frac{Mv^2}{R}$$

$$v^2 = (2T - Mg)\left(\frac{R}{M}\right)$$

$$v^2 = [700 - (40.0)(9.80)]\left(\frac{3.00}{40.0}\right) = 23.1\ (\text{m}^2/\text{s}^2)$$

$$\boxed{v = 4.81\ \text{m/s}}$$

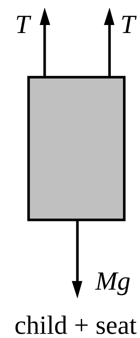

FIG. P6.13(a)

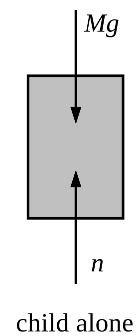

FIG. P6.13(b)

(b)

$$n - Mg = F = \frac{Mv^2}{R}$$

$$n = Mg + \frac{Mv^2}{R} = 40.0\left(9.80 + \frac{23.1}{3.00}\right) = \boxed{700\text{ N}}$$

P6.14 (a) $v = 20.0\ \text{m/s}$,

$n =$ force of track on roller coaster, and

$R = 10.0\text{ m}$.

$$\sum F = \frac{Mv^2}{R} = n - Mg$$

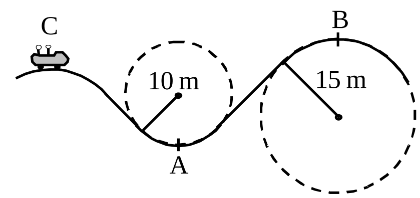

FIG. P6.14

From this we find

$$n = Mg + \frac{Mv^2}{R} = (500\text{ kg})(9.80\ \text{m/s}^2) + \frac{(500\text{ kg})(20.0\ \text{m/s}^2)}{10.0\text{ m}}$$

$$n = 4\,900\text{ N} + 20\,000\text{ N} = \boxed{2.49 \times 10^4\ \text{N}}$$

(b) At B, $n - Mg = -\frac{Mv^2}{R}$

The maximum speed at B corresponds to

$$n = 0$$

$$-Mg = -\frac{Mv_{\max}^2}{R} \Rightarrow v_{\max} = \sqrt{Rg} = \sqrt{15.0(9.80)} = \boxed{12.1\ \text{m/s}}$$

P6.17

$$\sum F_y = \frac{mv^2}{r} = mg + n$$

But $n = 0$ at this minimum speed condition, so

$$\frac{mv^2}{r} = mg \Rightarrow v = \sqrt{gr} = \sqrt{(9.80\ \text{m/s}^2)(1.00\text{ m})} = \boxed{3.13\ \text{m/s}}$$

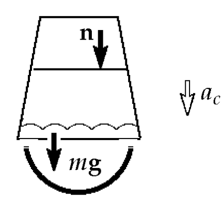

FIG. P6.17