P6.1 We are given $m = 3.00$ kg, $r = 0.800$ m. The string will break if the tension exceeds the weight corresponding to 25.0 kg, so

$$T_{max} = Mg = (25.0\text{ kg})(9.80\text{ m/s}^2) = 245\text{ N}$$

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

so $\quad T = \dfrac{mv^2}{r}$

Then

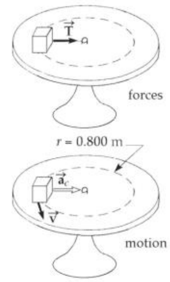
$$v^2 = \frac{rT}{m} = \frac{(0.800\text{ m})T}{3.00\text{ kg}} \le \frac{(0.800\text{ m})T_{max}}{3.00\text{ kg}}$$
$$= \frac{(0.800\text{ m})(245\text{ N})}{3.00\text{ kg}} = 65.3\text{ m}^2/\text{s}^2$$

This represents the maximum value of v^2, or

$$0 \le v \le \sqrt{65.3}\text{ m/s}$$

which gives

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



ANS. FIG. P6.1

P6.3 (a) The force acting on the electron in the Bohr model of the hydrogen atom is directed radially inward and is equal to

$$F = \frac{mv^2}{r} = \frac{(9.11\times10^{-31}\text{ kg})(2.20\times10^6\text{ m/s})^2}{0.529\times10^{-10}\text{ m}}$$
$$= \boxed{8.33\times10^{-8}\text{ N inward}}$$

(b) $a = \dfrac{v^2}{r} = \dfrac{(2.20\times10^6\text{ m/s})^2}{0.529\times10^{-10}\text{ m}} = \boxed{9.15\times10^{22}\text{ m/s}^2\text{ inward}}$

P6.4 In $\sum F = m\dfrac{v^2}{r}$, both m and r are unknown but remain constant. Symbolically, write

$$\sum F_{slow} = \left(\frac{m}{r}\right)(14.0\text{ m/s})^2 \text{ and } \sum F_{fast} = \left(\frac{m}{r}\right)(18.0\text{ m/s})^2$$

Therefore, $\sum F$ is proportional to v^2 and increases by a factor of $\left(\dfrac{18.0}{14.0}\right)^2$ as v increases from 14.0 m/s to 18.0 m/s. The total force at the higher speed is then

$$\sum F_{fast} = \left(\frac{18.0}{14.0}\right)^2 \sum F_{slow} = \left(\frac{18.0}{14.0}\right)^2 (130\text{ N}) = \boxed{215\text{ N}}$$

This force must be $\boxed{\text{horizontally inward}}$ to produce the driver's centripetal acceleration.

P6.8 ANS. FIG. P6.8 shows the free-body diagram for this problem.

(a) The forces acting on the pendulum in the vertical direction must be in balance since the acceleration of the bob in this direction is zero. From Newton's second law in the y direction,

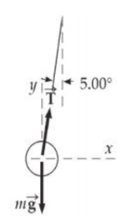
$$\sum F_y = T\cos\theta - mg = 0$$

Solving for the tension T gives

$$T = \frac{mg}{\cos\theta} = \frac{(80.0\text{ kg})(9.80\text{ m/s}^2)}{\cos 5.00°} = 787\text{ N}$$

In vector form,

$$\vec{\mathbf{T}} = T\sin\theta\hat{\mathbf{i}} + T\cos\theta\hat{\mathbf{j}}$$
$$= \boxed{(68.6\text{ N})\hat{\mathbf{i}} + (784\text{ N})\hat{\mathbf{j}}}$$



ANS. FIG. P6.8

(b) From Newton's second law in the x direction,

$$\sum F_x = T\sin\theta = ma_c$$

which gives

$$a_c = \frac{T\sin\theta}{m} = \frac{(787\text{ N})\sin 5.00°}{80.0\text{ kg}} = \boxed{0.857\text{ m/s}^2}$$

toward the center of the circle.

The length of the wire is unnecessary information. We could, on the other hand, use it to find the radius of the circle, the speed of the bob, and the period of the motion.

P6.9 ANS. FIG. P6.9 shows the constant maximum speed of the turntable and the centripetal acceleration of the coin.

(a) The force of $\boxed{\text{static friction}}$ causes the centripetal acceleration.

(b) From ANS. FIG. P6.9,

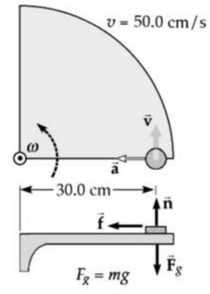
$$ma\hat{\mathbf{i}} = f\hat{\mathbf{i}} + n\hat{\mathbf{j}} + mg(-\hat{\mathbf{j}})$$
$$\sum F_y = 0 = n - mg$$

thus, $n = mg$ and

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

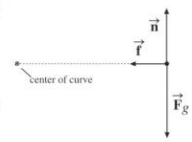
Then,

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



ANS. FIG. P6.9

P6.11 Call the mass of the egg crate m. The forces on it are its weight $F_g = mg$ vertically down, the normal force n of the truck bed vertically up, and static friction f_s directed to oppose relative sliding motion of the crate on the truck bed. The friction force is directed radially inward. It is the only horizontal force on the crate, so it must provide the centripetal acceleration. When the truck has maximum speed, friction f_s will have its maximum value with $f_s = \mu_s n$.



ANS. FIG. P6.11

Newton's second law in component form becomes

$$\sum F_y = ma_y \quad \text{giving} \quad n - mg = 0 \quad \text{or} \quad n = mg$$
$$\sum F_x = ma_x \quad \text{giving} \quad f_s = ma_r$$

From these three equations,

$$\mu_s n \le \frac{mv^2}{r} \quad \text{and} \quad \mu_s mg \le \frac{mv^2}{r}$$

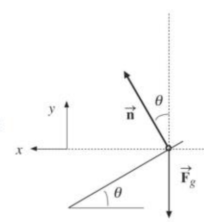
The mass divides out. The maximum speed is then

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

P6.42 The free-body diagram for the object is shown in ANS. FIG. P6.42. The object travels in a circle of radius $r = L\cos\theta$ about the vertical rod.

Taking inward toward the center of the circle as the positive x direction, we have

$$\sum F_x = ma_x: \quad n\sin\theta = \frac{mv^2}{r}$$
$$\sum F_y = ma_y:$$
$$n\cos\theta - mg = 0 \rightarrow n\cos\theta = mg$$



ANS. FIG. P6.42

Dividing, we find

$$\frac{n\sin\theta}{n\cos\theta} = \frac{mv^2/r}{gr} \quad \rightarrow \quad \tan\theta = \frac{v^2}{gr}$$

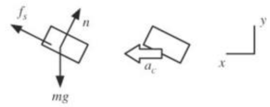
Solving for v gives

$$v^2 = gr\tan\theta$$
$$v^2 = g(L\cos\theta)\tan\theta$$
$$\boxed{v = (gL\sin\theta)^{1/2}}$$

P6.47 (a) The speed of the bag is

$$\frac{2\pi(7.46\text{ m})}{38\text{ s}} = 1.23\text{ m/s}$$

The total force on it must add to



ANS. FIG. P6.47

$$ma_c = \frac{mv^2}{r}$$
$$= \frac{(30\text{ kg})(1.23\text{ m/s})^2}{7.46\text{ m}} = 6.12\text{ N}$$

Newton's second law gives

$$\sum F_x = ma_x: \quad f_s\cos 20.0° - n\sin 20.0° = 6.12\text{ N}$$
$$\sum F_y = ma_y: \quad f_s\sin 20.0° + n\cos 20.0° - (30.0\text{ kg})(9.80\text{ m/s}^2) = 0$$

Solving for the normal force gives

$$n = \frac{f_s\cos 20.0° - 6.12\text{ N}}{\sin 20.0°}$$

Substituting,

$$f_s\sin 20.0° + f_s\frac{\cos^2 20.0°}{\sin 20.0°} - (6.12\text{ N})\frac{\cos 20.0°}{\sin 20.0°} = 294\text{ N}$$
$$f_s(2.92) = 294\text{ N} + 16.8\text{ N}$$
$$f_s = \boxed{106\text{ N}}$$

(b) The speed of the bag is now

$$v = \frac{2\pi(7.94\text{ m})}{34\text{ s}} = 1.47\text{ m/s}$$

which corresponds to a total force of

$$ma_c = \frac{mv^2}{r}$$
$$= \frac{(30\text{ kg})(1.47\text{ m/s})^2}{7.94\text{ m}} = 8.13\text{ N}$$

Newton's second law then gives

$$f_s\cos 20 - n\sin 20 = 8.13\text{ N}$$
$$f_s\sin 20 + n\cos 20 = 294\text{ N}$$

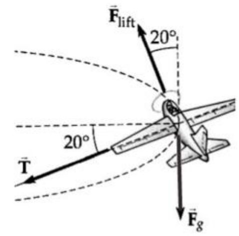
Solving for n,

$$n = \frac{f_s\cos 20.0° - 8.13\text{ N}}{\sin 20.0°}$$

Substituting,

$$f_s\sin 20.0° + f_s\frac{\cos^2 20.0°}{\sin 20.0°} - (8.13\text{ N})\frac{\cos 20.0°}{\sin 20.0°} = 294\text{ N}$$
$$f_s(2.92) = 294\text{ N} + 22.4\text{ N}$$
$$f_s = 108\text{ N}$$
$$n = \frac{(108\text{ N})\cos 20.0° - 8.13\text{ N}}{\sin 20.0°} = 273\text{ N}$$
$$\mu_s = \frac{f_s}{n} = \frac{108\text{ N}}{273\text{ N}} = \boxed{0.396}$$

P6.63 The plane's acceleration is toward the center of the circle of motion, so it is horizontal. The radius of the circle of motion is (60.0 m) cos 20.0° = 56.4 m and the acceleration is



ANS. FIG. P6.63

$$a_c = \frac{v^2}{r} = \frac{(35\text{ m/s})^2}{56.4\text{ m}}$$
$$= 21.7\text{ m/s}^2$$

We can also calculate the weight of the airplane:

$$F_g = mg$$
$$= (0.750\text{ kg})(9.80\text{ m/s}^2)$$
$$= 7.35\text{ N}$$

We define our axes for convenience. In this case, two of the forces—one of them our force of interest—are directed along the 20.0° line. We define the x axis to be directed in the $+\vec{T}$ direction, and the y axis to be directed in the direction of lift. With these definitions, the x component of the centripetal acceleration is

$$a_{cx} = a_c\cos 20.0°$$

and $\quad \sum F_x = ma_x$ yields $\quad T + F_g\sin 20.0° = ma_{cx}$

Solving for T,

$$T = ma_{cx} - F_g\sin 20.0°$$

Substituting,

$$T = (0.750\text{ kg})(21.7\text{ m/s}^2)\cos 20.0° - (7.35\text{ N})\sin 20.0°$$

Computing,

$$T = 15.3\text{ N} - 2.51\text{ N} = \boxed{12.8\text{ N}}$$