Chapter 6: Circular Motion and Other Applications of Newton's Laws

SOLUTIONS TO PROBLEMS

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

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

Symbolically, write $\sum F_{\text{slow}} = \left(\dfrac{m}{r}\right)(14.0\text{ m/s})^2$ and $\sum F_{\text{fast}} = \left(\dfrac{m}{r}\right)(18.0\text{ m/s})^2$.

Dividing gives $\dfrac{\sum F_{\text{fast}}}{\sum F_{\text{slow}}} = \left(\dfrac{18.0}{14.0}\right)^2$, or

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

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

P6.9 $T\cos 5.00° = mg = (80.0\text{ kg})(9.80\text{ m/s}^2)$

(a) $T = 787\text{ N}$: $\mathbf{T} = \boxed{(68.6\text{ N})\hat{\mathbf{i}} + (784\text{ N})\hat{\mathbf{j}}}$

(b) $T\sin 5.00° = ma_c$: $\boxed{a_c = 0.857\text{ m/s}^2}$ 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.

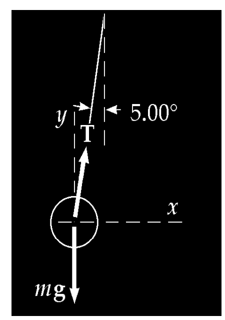

FIG. P6.9

P6.18 At the top of the vertical circle,

$$T = m\frac{v^2}{R} - mg$$

or $T = (0.400)\dfrac{(4.00)^2}{0.500} - (0.400)(9.80) = \boxed{8.88\text{ N}}$

P6.19 (a) $v = 20.0 \text{ m/s}$,

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

$R = 10.0 \text{ m}$.

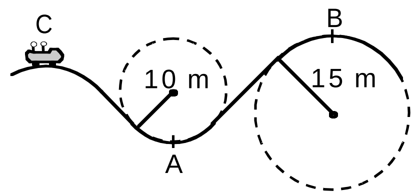

FIG. P6.19

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

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 max speed at B corresponds to

$n = 0$

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

P6.31 $a_r = \left(\frac{4\pi^2 R_e}{T^2}\right)\cos 35.0° = 0.027\,6 \text{ m/s}^2$

We take the y axis along the local vertical.

$(a_{\text{net}})_y = 9.80 - (a_r)_y = 9.78 \text{ m/s}^2$

$(a_{\text{net}})_x = 0.015\,8 \text{ m/s}^2$

$\theta = \arctan\frac{a_x}{a_y} = \boxed{0.092\,8°}$

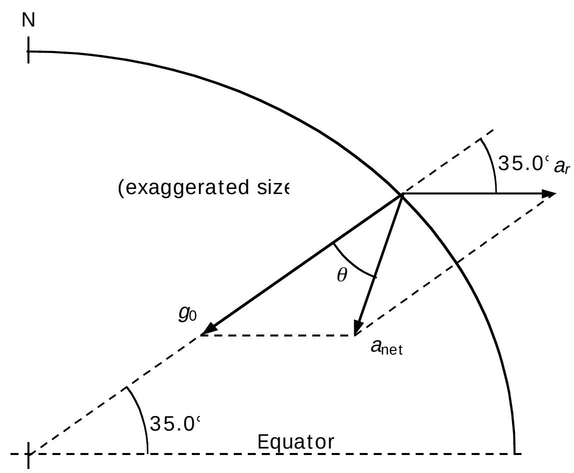

FIG. P6.31