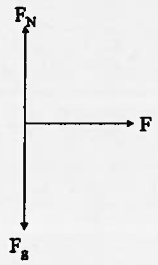
PROBLEM

6. (a)

The centripetal force is supplied by the wall of the cylinder pushing against the rider ($\vec{F}$).



$$F_C = \frac{m4\pi^2 R}{T^2}$$

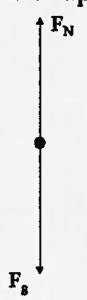
$$= \frac{60\text{ kg}(4\pi^2)(8.0\text{ m})}{(4.0\text{ s})^2}$$

$$F_C = 1.2 \times 10^3\text{ N}$$

The centripetal force acting is 1.2 × 10³ N.

(b)

The free-body diagram of the rider at the bottom of the circle:
Let "up" be negative and "down" be positive.



$$\vec{F}_C = \vec{F}_g + \vec{F}_N$$

$$\vec{F}_N = \vec{F}_C - \vec{F}_G$$

$$= \vec{F}_C - mg$$

$$= -1184\text{ N} - (60.0\text{ kg})(9.8\text{ N/kg})$$

$$\vec{F}_N = -1.8 \times 10^3\text{ N}$$

The normal force acting on the rider is 1.8 × 10³ N (upward).

(c)

At the top of the circle when $\vec{F}_N \to 0$, the free-body diagram becomes:

$$\vec{F}_C = \vec{F}_g$$

$$\frac{mv^2}{R} = mg$$

$$v = \sqrt{Rg}$$

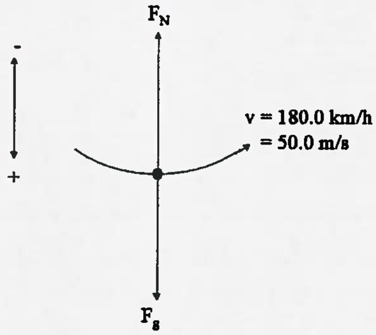
$$= \sqrt{8.0\ \text{m}\ (9.8\ \text{N/kg})}$$

$$v = 8.9\ \text{m/s}$$

The minimum speed is 8.9 m/s.

10. (a)

The free-body diagram of the pilot at the bottom of the arc:



F_N = force of seat exerted upward on the pilot (the normal force)

$F_N = 4\ mg$

$$\vec{F}_C = \vec{F}_N + \vec{F}_g$$

$$\frac{-mv^2}{R} = -4mg + mg$$

$$\frac{mv^2}{R} = 3mg$$

$$R = \frac{v^2}{3g}$$

$$= \frac{(50.0\ \text{m/s})^2}{3(9.8\ \text{N/kg})}$$

$$R = 85\ \text{m}$$

The radius of the arc is 85 m.

(b)

If the pilot's apparent weight becomes zero at the top of the arc, then the centripetal force is being supplied entirely by gravity.

$F_C = Fg$

$$\frac{mv^2}{R} = mg$$

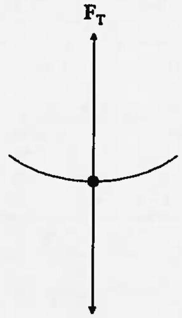
$$v = \sqrt{Rg}$$

$$= \sqrt{85\ \text{m}\ (9.8\ \text{N/kg})}$$

$$v = 29\ \text{m/s}$$

The pilot's speed must be 29 m/s.

11. (a)
Maximum tension occurs at the bottom of the circle.



Let "up" be negative and "down" be positive:

$$\vec{F}_C = \vec{F}_T + \vec{F}_g$$

$$\vec{F}_T = \vec{F}_C - \vec{F}_g$$

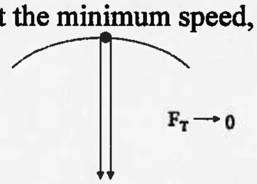
$$= -\frac{mv^2}{R} - mg$$

$$= -\frac{6.0\text{ kg}(8.0\text{ m/s})^2}{1.0\text{ m}} - 6.0\text{ kg}(9.8\text{ N/kg})$$

$$\vec{F}_T = -4.4 \times 10^2\text{ N}$$

The maximum tension is 4.4 × 10^2 N [upward].

(b)
At the minimum speed, the tension in the string becomes zero at the top of the circle.



$$\vec{F}_C = \vec{F}_g$$

$$\frac{mv^2}{R} = mg$$

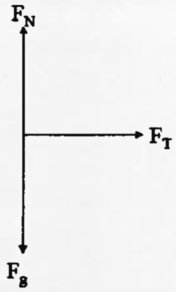
$$v = \sqrt{Rg}$$

$$= \sqrt{1.0\text{ m}(9.8\text{ N/kg})}$$

$$v = 3.1\text{ m/s}$$

The minimum speed of rotation is 3.1 m/s.

(c)
If rotating on a horizontal surface:



$\vec{F}_C = \vec{F}_T$

$= \dfrac{mv^2}{R}$

$= \dfrac{6.0 \text{ kg}(8.0 \text{ m/s})^2}{1.0 \text{ m}}$

$\vec{F}_C = 3.8 \times 10^2 \text{ N}$

The tension in the string would be 3.8×10^2 N.

12. (a)

The centripetal force is supplied by static friction.

$\vec{F}_C = \vec{F}_S$ and $F_S \le \mu_S F_N \le \mu_S F_g \le \mu_S mg$

$\dfrac{m4\pi^2 R}{T^2} \le \mu_S mg$

$\mu_S \ge \dfrac{4\pi^2 R}{T^2 g}$

$\ge \dfrac{4\pi^2(0.010 \text{ m})}{(60 \text{ s})^2(9.8 \text{ N/kg})}$

$\mu_S \ge 1.1 \times 10^{-5}$

The minimum coefficient of static friction is 1.1×10^{-5}.