

CIRCULAR MOTION - SOLUTIONS

1. GIVEN:

$$m = 61 \text{ kg}$$

$$R = 4.0 \text{ m}$$

$$v = 4.00 \frac{\text{m}}{\text{s}}$$

$$F_c = ?$$

$$F_c = m a_c$$

$$= m \frac{v^2}{R}$$

$$= (61) \frac{(4.00)^2}{4.0}$$

$$= 240 \text{ N}$$

THE FORCE IS EXERTED BY THE ICE AS SHE CUTS INTO IT WITH HER SKATES.

2. a) GIVEN:

$$m = 5.0 \text{ kg}$$

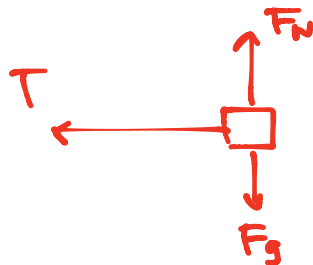
$$v = 2.0 \frac{\text{m}}{\text{s}}$$

$$R = 35 \text{ cm} = 0.35 \text{ m}$$

$$a_c = ?$$

$$\begin{aligned} a_c &= \frac{v^2}{R} \\ &= \frac{(2.0)^2}{0.35} \\ &= 11 \frac{\text{m}}{\text{s}^2} \end{aligned}$$

b)



$$F_c = m a_c$$

$$\begin{aligned} T &= m \frac{v^2}{R} \\ &= (5.0) \frac{(2.0)^2}{0.35} \end{aligned}$$

$$= 58 \text{ N}$$

c) GIVEN:
 $m = 5.0 \text{ kg}$
 $v = 2.0 \frac{\text{m}}{\text{s}}$
 $R = 35 \text{ cm} = 0.35 \text{ m}$
 $T = ?$

$$v = \frac{d}{t}$$

$$= \frac{2\pi R}{T}$$

$$T = \frac{2\pi R}{v}$$

$$= \frac{2\pi(0.35)}{(2.0)}$$

$$= 1.1 \text{ s}$$

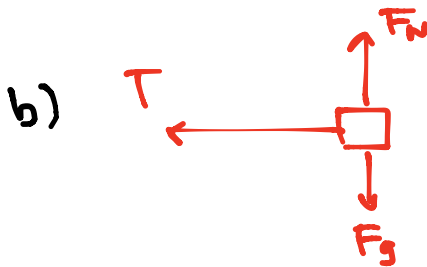
3. a) GIVEN:
 $R = 40. \text{ cm} = 0.40 \text{ m}$
 $m = 0.50 \text{ kg}$
 $f = 3.0 \frac{\text{rev}}{\text{s}} \leftarrow \frac{\text{rev}}{\text{s}} = \text{Hz}$
 $a_c = ?$

$$T = \frac{1}{f} = \frac{1}{3.0} = 0.33 \text{ s}$$

$$a_c = \frac{4\pi^2 R}{T^2}$$

$$= \frac{4\pi^2(0.40)}{(0.33)^2}$$

$$= 140 \frac{\text{m}}{\text{s}^2}$$



$$F_c = m a_c$$

$$T = m \frac{4\pi^2 R}{T^2}$$

$$= (0.50) \frac{4\pi^2(0.40)}{(0.33)^2}$$

$$= 71 \text{ N}$$

c) 71 N OUTWARD (TOWARDS THE ORBITTING BODY)

4. a)

$$a_{cx} : a_{cy}$$

$$\frac{4\pi^2 R_x}{T_x^2} : \frac{4\pi^2 R_y}{T_y^2}$$

$$T_x = T_y = T$$

$$\frac{\cancel{4\pi^2} \cancel{r}}{\cancel{T^2}} : \frac{\cancel{4\pi^2} (2\cancel{r})}{\cancel{T^2}}$$

$$1 : 2$$

b)

$$F_{cx} : F_{cy}$$

$$m_x \frac{4\pi^2 R_x}{T_x^2} : m_y \frac{4\pi^2 R_y}{T_y^2}$$

$$\cancel{m} \frac{\cancel{4\pi^2} \cancel{r}}{\cancel{T^2}} : (2\cancel{m}) \frac{\cancel{4\pi^2} (2\cancel{r})}{\cancel{T^2}}$$

$$1 : (2)(2)$$

$$1 : 4$$

c)

$$v_x : v_y$$

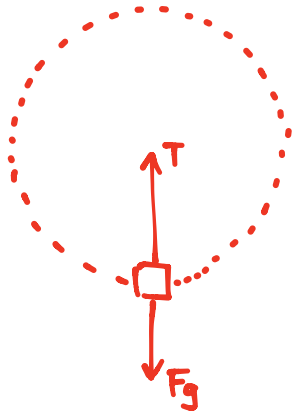
$$\frac{d}{t} : \frac{d}{t}$$

$$\frac{2\pi R_x}{T_x} : \frac{2\pi R_y}{T_y}$$

$$\frac{\cancel{2\pi} \cancel{r}}{\cancel{T}} : \frac{\cancel{2\pi} (2\cancel{r})}{\cancel{T}}$$

$$1 : 2$$

5. a)



$$F_c = ma_c$$

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

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

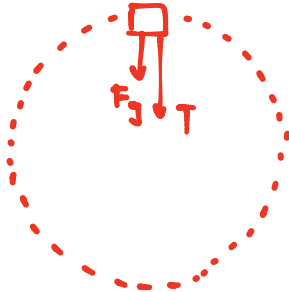
$$T = m \frac{v^2}{R} + mg$$

$$= m \left(\frac{v^2}{R} + g \right)$$

$$= 3.0 \left(\frac{(20.)^2}{1.5} + 9.8 \right)$$

$$= 830 \text{ N}$$

b)



$$F_c = ma_c$$

$$T + F_g = m \frac{v^2}{R}$$

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

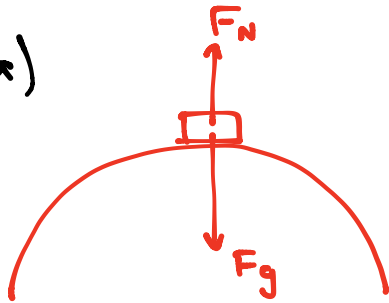
$$T = m \frac{v^2}{R} - mg$$

$$= m \left(\frac{v^2}{R} - g \right)$$

$$= 3.0 \left(\frac{(20.)^2}{1.5} - 9.8 \right)$$

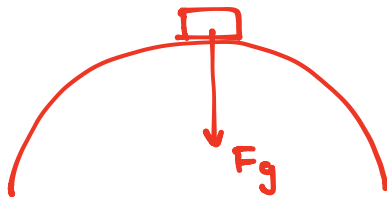
$$= 770 \text{ N}$$

6. a)



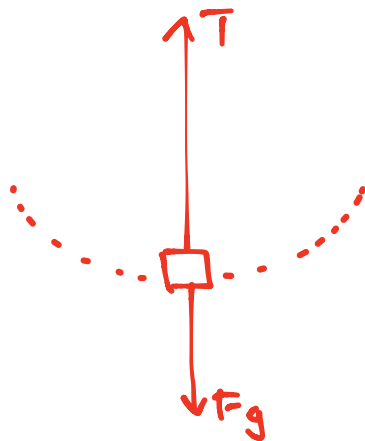
$$\begin{aligned}
 F_c &= ma_c \\
 F_g - F_N &= m \frac{v^2}{R} \\
 mg - F_N &= m \frac{v^2}{R} \\
 F_N &= mg - m \frac{v^2}{R} \\
 &= m \left(g - \frac{v^2}{R} \right) \\
 &= (70.) \left(9.8 - \frac{(5.0)^2}{5.0} \right) \\
 &= 340 \text{ N}
 \end{aligned}$$

b)



$$\begin{aligned}
 F_c &= ma_c \\
 F_g &= m \frac{v^2}{R} \\
 \cancel{mg} &= \cancel{m} \frac{v^2}{R} \\
 v &= \sqrt{gR} \\
 &= \sqrt{(9.8)(5.0)} \\
 &= 7.0 \frac{\text{m}}{\text{s}}
 \end{aligned}$$

7. TENSION IS THE GREATEST AT THE BOTTOM OF THE SWING WHEN T MUST INCREASE TO OPPOSE THE FORCE OF GRAVITY



$$F_c = ma_c$$

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

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

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

$$v = \sqrt{\frac{R}{m} (T - mg)}$$

$$= \sqrt{\frac{(5.0)}{(1.00 \times 10^3)} [2.0 \times 10^3 - (1.00 \times 10^3)(9.8)]}$$

$$= 7.1 \frac{\text{m}}{\text{s}}$$

8. a) GIVEN :

$$m = 1200 \text{ kg}$$

$$R = 50.0 \text{ m}$$

$$v = 80.0 \frac{\text{km}}{\text{h}} = 22.2 \frac{\text{m}}{\text{s}}$$

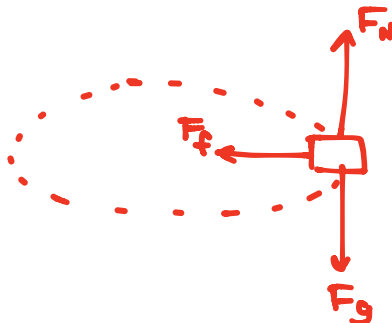
$$a_c = ?$$

$$a_c = \frac{v^2}{R}$$

$$= \frac{(22.2)^2}{50.0}$$

$$= 9.9 \frac{\text{m}}{\text{s}^2}$$

b)



$$F_c = ma_c$$

$$= m \frac{v^2}{R}$$

$$= (1200) \frac{(22.2)^2}{50.0}$$

$$= 12000 \text{ N}$$

$$c) \quad F_N = F_g \\ = mg$$

$$F_f = \mu F_N \\ = \mu mg \\ = (0.25)(1200)(9.8) \\ = 2900 \text{ N}$$

$$F_f < F_c$$

NO

9. a) GIVEN:

$$m = 1.0 \times 10^3 \text{ kg}$$

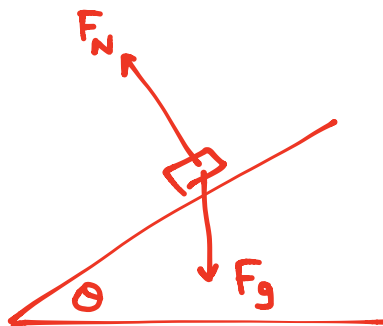
$$R = 40. \text{ m}$$

$$v = 48 \frac{\text{km}}{\text{h}} = 13.3 \frac{\text{m}}{\text{s}}$$

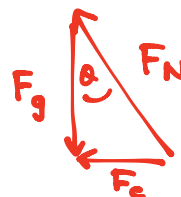
$$F_c = ?$$

$$F_c = m \frac{v^2}{R} \\ = (1.0 \times 10^3) \frac{(13.3)^2}{40.} \\ = 4400 \text{ N}$$

b)



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



$$\tan \theta = \frac{F_c}{F_g}$$

$$= \frac{\cancel{m} \frac{v^2}{R}}{\cancel{m} g}$$

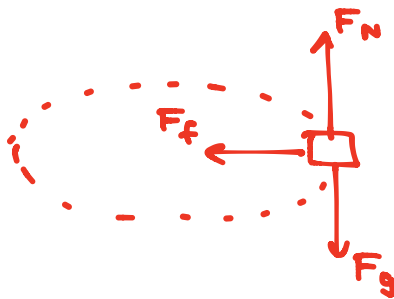
$$= \frac{v^2}{Rg}$$

$$\theta = \tan^{-1} \left(\frac{v^2}{Rg} \right)$$

$$= \tan^{-1} \left(\frac{(13.3)^2}{(40.)(9.8)} \right)$$

$$= 24^\circ$$

10.



$$F_N = F_g$$

$$= mg$$

$$F_c = ma_c$$

$$F_f = m \frac{v^2}{R}$$

$$\cancel{m} g = \cancel{m} \frac{v^2}{R}$$

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

$$v = 50 \frac{\text{km}}{\text{h}}$$

$$= 13.8 \frac{\text{m}}{\text{s}}$$

$$= \frac{(13.8)^2}{(0.60)(9.8)}$$

$$= 33 \text{ m}$$