Circular Motion

Chapter 6

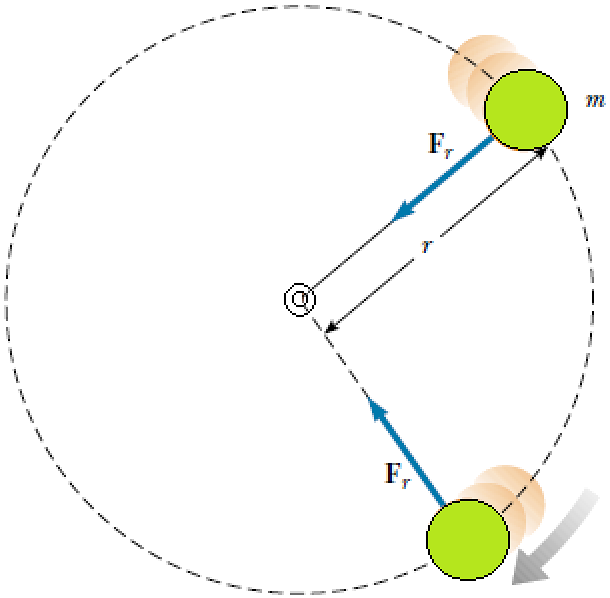
6.1 Newton's Second Law Applied to Uniform Circular Motion

- a particle moving with uniform speed ***v*** *in a circular* path of radius ***r*** *experiences an acceleration* $\mathbf{a}_r$ *that has a magnitude*

$$a_r = \frac{v^2}{r}$$

- If we apply Newton's second law along the radial direction, we find that the value of the net force causing the centripetal acceleration can be evaluated:

$$\sum F_r = ma_r = m\frac{v^2}{r}$$



Problems

- Problem (1) :
- A ball of mass 0.5 kg is attached to the end of a cord 1.50 m long. The ball is whirled in a horizontal circle. If the cord can withstand a maximum tension of 50 N, what is the maximum speed the ball can attain before the cord breaks? Assume that the string remains horizontal during the motion.
- Solution:
- Because the force causing the centripetal acceleration in this case is the force ***T*** exerted by the cord on the ball,

$$\sum F_r = ma_r$$

$$T = m\frac{v^2}{r}$$

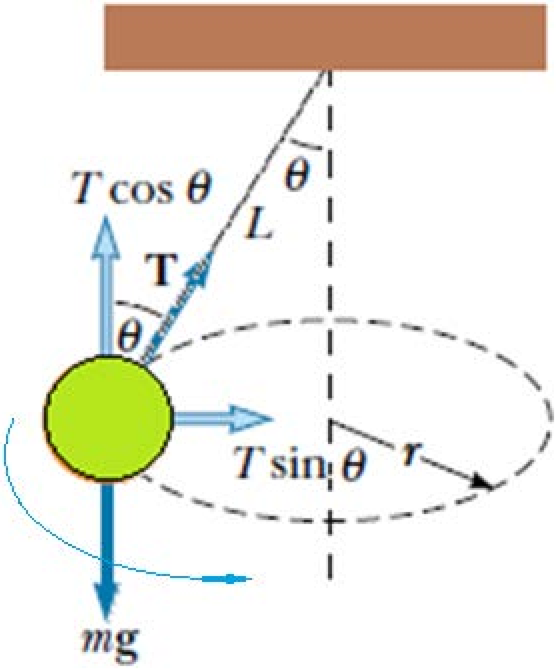
Solving for ***v**, we have*

$$v = \sqrt{\frac{Tr}{m}}$$

$$v_{\text{max}} = \sqrt{\frac{T_{\text{max}} r}{m}} = \sqrt{\frac{(50.0\ \text{N})(1.50\ \text{m})}{0.500\ \text{kg}}}$$

$$= \quad 12.2\ \text{m/s}$$

- Problem (2) :
- A small object of mass ***m*** *is suspended from a string of length* ***L****. The object revolves with constant speed v in a horizontal* circle of radius ***r*** *.Find an expression for* ***v****.*
- Solution:



$$\Sigma F = ma$$

$$T\cos\theta = mg \qquad (1)$$

$$T\sin\theta = \frac{mv^2}{r} \qquad (2)$$

Dividing (2) by (1)

$$\tan\theta = \frac{v^2}{rg} \quad \Rightarrow \quad v = \sqrt{rg\tan\theta}$$

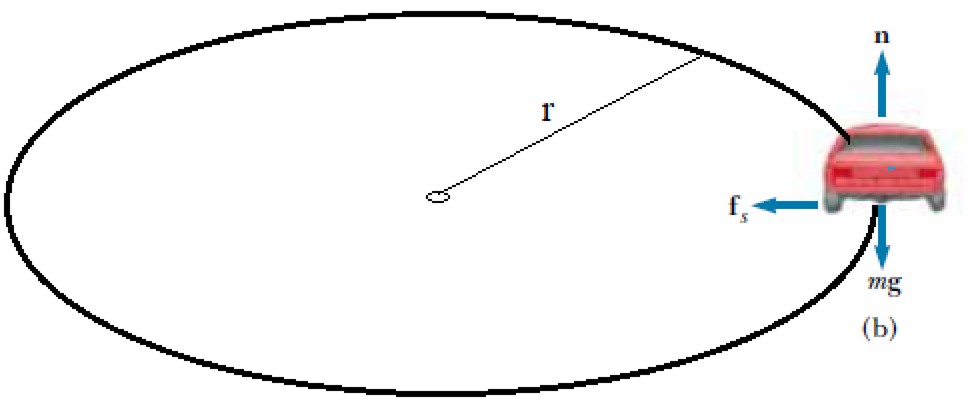
note that r = L sin θ ;

$$v = \sqrt{Lg\sin\theta\tan\theta}$$

- Problem (3) :

A 1 500-kg car moving on a flat, horizontal road negotiates a curve, as illustrated in Figure 6.5. If the radius of the curve is 35.0 m and the coefficient of static friction between the tires and dry pavement is 0.500, find the maximum speed the car can have and still make the turn successfully.

- Solution:



- In this case, the force that enables the car to remain in its circular path is the force of static friction.

$$f_s = m\frac{v^2}{r} \quad , \quad f_{s,\max} = \mu_s n. \quad , \quad f_{s,\max} = \mu_s mg.$$

$$v_{\max} = \sqrt{\frac{f_{s,\max} r}{m}} = \sqrt{\frac{\mu_s mgr}{m}} = \sqrt{\mu_s gr}$$

$$= \sqrt{(0.500)(9.80 \text{ m/s}^2)(35.0 \text{ m})} = 13.1 \text{ m/s}$$