Circular Motion Worksheet

1. A 0.5 kg ball moves in a circle that is 0.4 m in radius at a speed of 4.0 m/s. Calculate its centripetal acceleration.

$$a_c = \frac{v^2}{r} = \frac{4^2}{0.4} = 40\ m\,s^{-2}$$

2. Calculate the centripetal force on the ball in question #1.

$$F = Ma_c = 0.5 \times 40 = 20\ N$$

3. A toy cart at the end of a string 0.70 m long moves in a circle on a table. The cart has a mass of 2.0 kg and the string has a breaking strength of 40. N. Calculate the maximum speed the cart can attain without breaking the string.

$$T = F_c = \frac{mv^2}{r} \qquad v = \sqrt{\frac{rT}{m}} = \sqrt{\frac{0.7 \times 40}{2}} = 3.7\ m\,s^{-1}$$

4. The minute hand of a large clock is 0.50 m long.

(A) Calculate its linear speed at its tip in meters per second.

$$v = \frac{2\pi r}{T} \qquad T = 60\ min = 3600\ s \qquad v = \frac{2\pi \times 0.5}{3600} = 0.0009\ m\,s^{-1}$$

(B) Calculate the centripetal acceleration of the tip of the hand.

$$a_c = \frac{v^2}{r} = 1.5 \times 10^{-6}\ m\,s^{-2}$$

5. A phonograph record 30.0 cm in diameter rotates 33.5 times per minute.

(A) What is its frequency?

$$f = \frac{33.5}{60} = 0.56\ rev\ s^{-1}$$

(B) What is its period?

$$T = \frac{1}{f} = 1.8\ s$$

(C) What is the linear speed of a point on its rim?

$$v = \frac{2\pi r}{T} = \frac{2\pi \times 0.15}{1.8} = 0.53\ m\,s^{-1}$$

(D) What is the centripetal acceleration of a point on its rim?

$$a = \frac{v^2}{r} = \frac{0.53^2}{1.8} = 0.16\ m\,s^{-2}$$

6. What is the minimum radius at which an airplane flying at 300 m/s can make a U-turn if its centripetal acceleration is NOT to exceed 4 gs?

$$\frac{v^2}{r} = 4g \qquad r = \frac{v^2}{4g} = \frac{300^2}{4\times 9.8} = 2293\ m$$

7. A string 1.0 m long breaks when its tension is 100 N. What is the greatest speed at which it can be used to whirl a 1.0 kg stone? (Neglect the gravitational pull of the earth on the stone.)

$$T = F_c = \frac{mv^2}{r} \qquad v = \sqrt{\frac{Tr}{m}} = \sqrt{\frac{100\times 1}{1}} = 10\ m\,s^{-1}$$

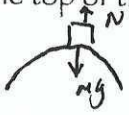
8. What is the centripetal force needed to keep a 3.0 kg mass moving in a circle of radius 0.50 m at a speed of 8.0 m/s?

$$F_c = \frac{mv^2}{r} = \frac{3\times 8^2}{0.5} = 384\ N$$

9. A 2000 kg car is rounding a curve of radius 200 m on a level road. The maximum frictional force the road can exert on the tires of the car is 4000 N. What is the highest speed at which the car can round the curve?

$$F_{fr} = F_c = \frac{mv^2}{r} \qquad v = \sqrt{\frac{F_{fr}\,r}{m}} = \sqrt{\frac{4000\times 200}{2000}} = 20\ m\,s^{-1}$$

10. A road has a round hump 12.0 m in radius. What is the minimum speed at which a car can leave the road at the top of the hump?



$$N = 0 \qquad mg - N = \frac{mv^2}{r} \qquad \frac{mv^2}{r} = mg$$

$$v = \sqrt{gr} = 10.8\ m\,s^{-1}$$

11. A physics student swings a pail of water in a vertical circle 1.0 m in radius at a constant speed. If the water is NOT to spill on him/her:

(A) calculate the minimum speed of the pail of water

$$v = \sqrt{gr} = 3.1\ m\,s^{-1}$$

(B) calculate the maximum time per revolution (period) of the swing

$$T = \frac{2\pi r}{v} = \frac{2\pi \times 1}{3.1} = 2\ s$$

12. A 1.0 m string with a 5 g stopper on the end is whirled in a vertical circle. The speed of the stopper is 8 m/s at the top of the circle.

(A) What is the speed of the stopper at the bottom of the circle? (HINT: Use energy conservation principles!)

$$mgh + \frac{mu^2}{2} = \frac{mv^2}{2} \qquad v = \sqrt{2gh + u^2}$$

$$= \sqrt{2 \times 9.8 \times 2 + 8^2} = 10.2\ m\ s^{-1}$$

(B) What is the tension in the string when the stopper is at the top of the circle?

$$T + mg = \frac{mv^2}{r} \qquad T = \frac{mv^2}{r} - mg = 0.27\ N$$

(C) What is the tension in the string when the stopper is at the bottom of the circle?

$$T - mg = \frac{mv^2}{r}$$

$$T = \frac{mv^2}{r} + mg$$

$$= \frac{0.005 \times 10.2^2}{1} + 0.005 \times 9.8$$

$$= 0.57\ N$$