Uniform Circular Motion

Uniform Circular Motion

- An object moves at a constant speed in a circular path. Is it accelerating?

Yes! The object is changing direction so its velocity is changing.

- What is the direction of the acceleration?

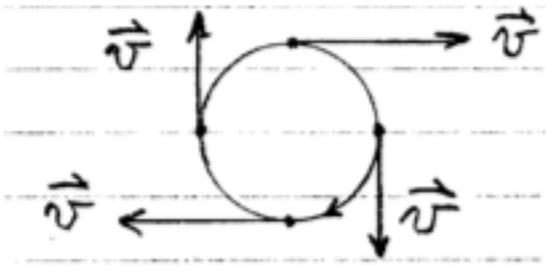


FIGURE 10.15 ▲
The only force that is exerted on the whirling can (neglecting gravity) is directed *toward* the center of circular motion. This is a *centripetal* force. No outward force acts on the can.

Dynamics of Uniform Circular Motion

- There are **<u>TWO</u>** ways to accelerate: By changing speed OR changing direction of motion.
- For changing speed:

$$a_T = \frac{v - v_0}{t}$$

- a_T = tangential acceleration

For changing direction:

$$\boxed{a_c = \frac{v^2}{r}}$$

a_c = centripetal acceleration

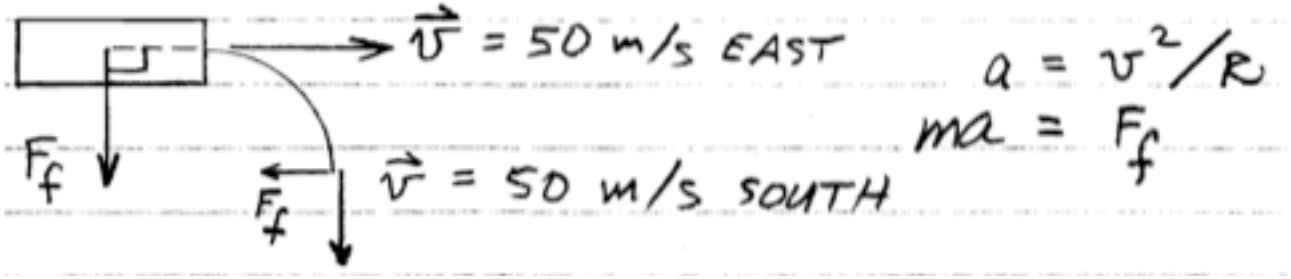
- Acceleration means that velocity changes. Velocity is a vector, thus it has magnitude and direction. Therefore, an object can accelerate either by changing its speed and/or changing its direction of motion.

Ex: A mass of 7 kg is swung in a circle of radius 4 m with a velocity of 3 m/s. What is the object's centripetal acceleration?

Forces Cause Acceleration

- Forces cause acceleration, therefore a force is necessary to change either the speed or the direction of motion.
- If the force and the velocity are parallel, only the speed of the object changes.

- If the force and the velocity are perpendicular, only the direction of motion changes. Looking down on the car:



- The car is accelerating because it is changing its direction of motion. F_f causes this acceleration.

Centripetal Force

- An object in motion wants to keep moving in a straight line (Inertia).
- In order to move in a circle, a CENTRIPETAL FORCE is required.
- If we remove the inward force acting on the particle, the object will no longer accelerate. Then, it will fly off tangent and move in a straight line at constant speed.

- The velocity vector is always TANGENT to the path.
- <u>Tangent</u> = skimming the circle
- <u>Centripetal</u> = toward the center
- <u>Centrifugal</u> = away from the center
- There is no F_C, centrifugal force. The only forces allowed diagram are REAL FORCES (F_g, F_T, F_S, F_N, F_f).

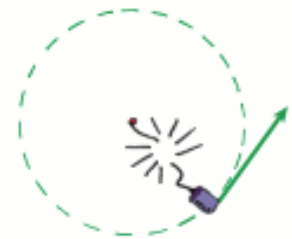
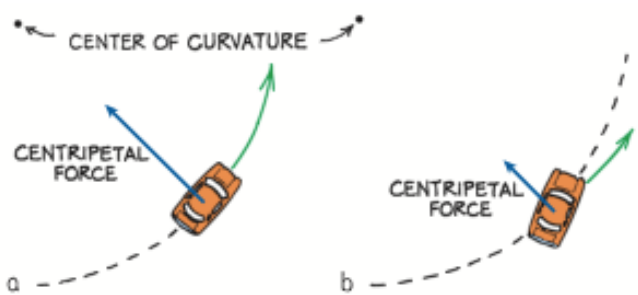


FIGURE 10.14 ▲
When the string breaks, the whirling can moves in a straight line, tangent to—not outward from the center of—its circular path.



◀ **FIGURE 10.9**
Centripetal force holds a car in a curved path.
a. For the car to go around a curve, there must be sufficient friction to provide the required centripetal force.
b. If the force of friction is not great enough, skidding occurs.

REMINDER:

- Only real forces are allowed on our force diagram.
- *Inward forces are (+), Outward are (-)*
- Occasionally there may be outward forces such as F_N, but the inward force will always dominate to cause the curving in the proper direction.

Ex1: A 1000 kg car goes around a curve of radius 50 m. The coefficient of friction between the road and the tires is 0.8. What is the greatest speed the car can take the turn?

Vocab:

Frequency	f = revolutions/time
	f = [cycles/second] = [Hertz]
Period	T = time/revolution
	T = [sec]
Speed	v = distance/time = [m/s]
Formulas:	f = 1/T

$$v = 2\pi r f$$

Ex 2: A bucket swinging on a circular path of radius 2 m has a frequency of 8 Hz. What is its period? Its velocity?

Ex 3: A 150 g ball tied to a string of radius 0.6 m travels in a horizontal circle and makes 20 revolutions per minute. What is the tension in the string?