Dynamics: Circular Motion

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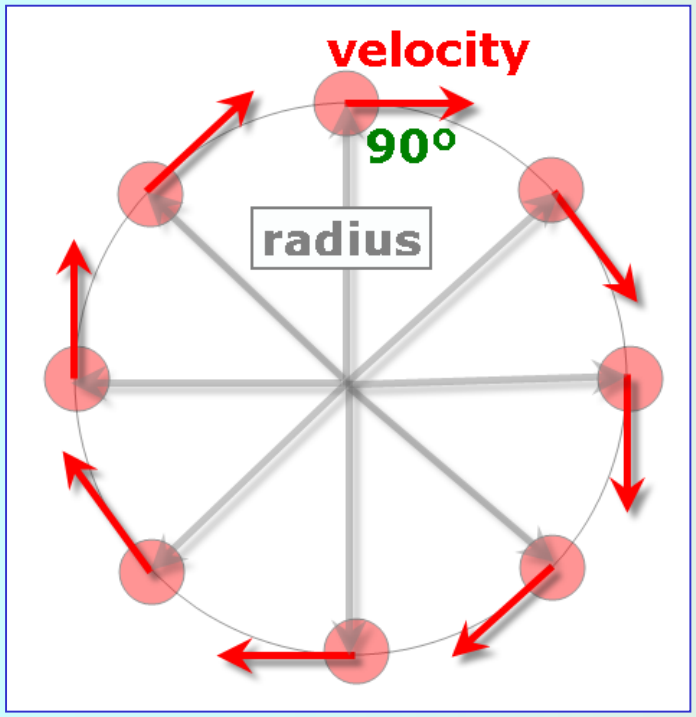


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Circular motion at constant speed

When a body moves in a circular motion the velocity vector is perpendicular to the radius at each point.

For circular motion at constant speed the magnitude of the velocity vector is contant but its direction is always changing.

The magnitude of linear velocity is:

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

where T is the **period** (time needed to complete a cycle or a full circle)

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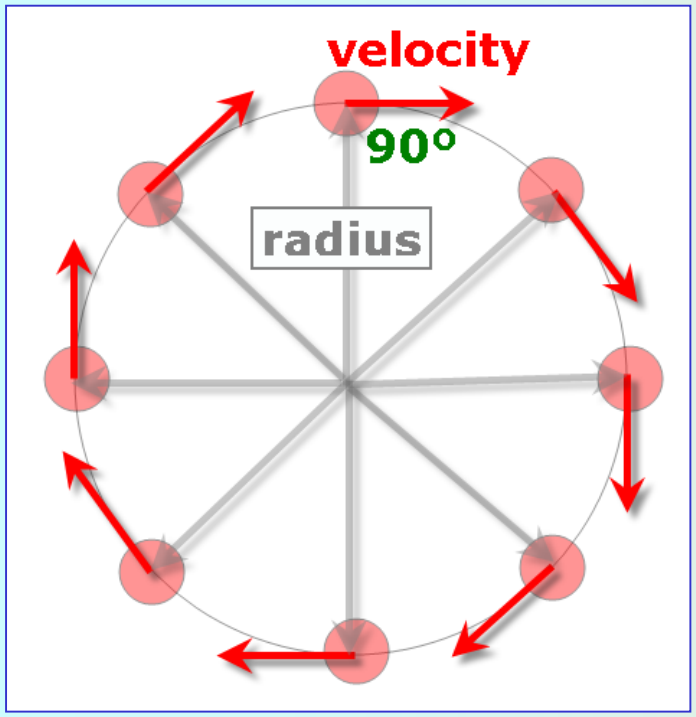


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Circular motion at constant speed

Angular velocity is the rate of change of the angle (given in radians)

The magnitude of angular velocity is:

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

Both velocities (linear and angular) are related by this espression:

$$v = \frac{2\pi R}{T} = \left(\frac{2\pi}{T}\right) * R = \omega * R$$

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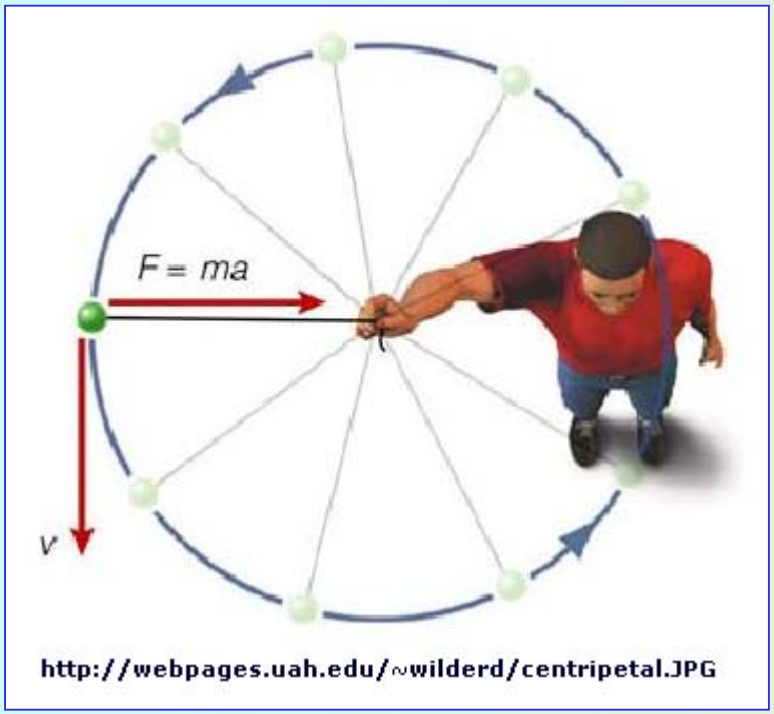

http://webpages.uah.edu/~wilderd/centripetal.JPG

The acceleration vector in circular motion

In this type of motion, even if the magnitude of velocity doesn't change, there is an acceleration because the velocity is changing in direction.

This type of acceleration (when there is only a change in direction) is called centripetal (or radial) acceleration and can be calculated by this expression:

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

R ... radius
v ... velocity
T ... period

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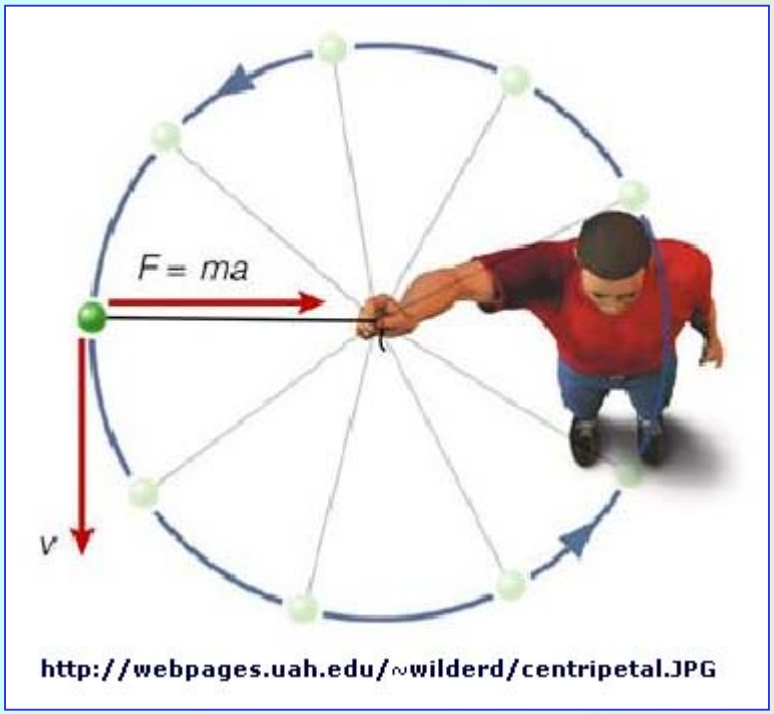

Problem

The period of a stone swung in an horizontal circle on a 2 m radius is 1 s.

a) what is its angular velocity in rad/s?
b) what is its linear speed in m/s?
c) what is its radial acceleration in m/s^2?

Solution

a) Its angular velocity is

$$\omega = \frac{\text{angle (rad)}}{\text{time (s)}} = \frac{2\pi \text{ rad}}{1 \text{ s}} = 2\pi \frac{\text{rad}}{\text{s}}$$

b) The linear speed is

$$v = \frac{\text{length of 1 revolution (m)}}{\text{time spent or period (s)}} = \frac{2\pi * 2 \text{ m}}{1 \text{ s}} = 12.57 \frac{\text{m}}{\text{s}}$$

c) The radial acceleration

$$a = \frac{v^2}{R} = \frac{\left(12.57 \frac{\text{m}}{\text{s}}\right)^2}{2 \text{ m}} = 79 \frac{\text{m}}{\text{s}^2} = 8 \text{ g}$$

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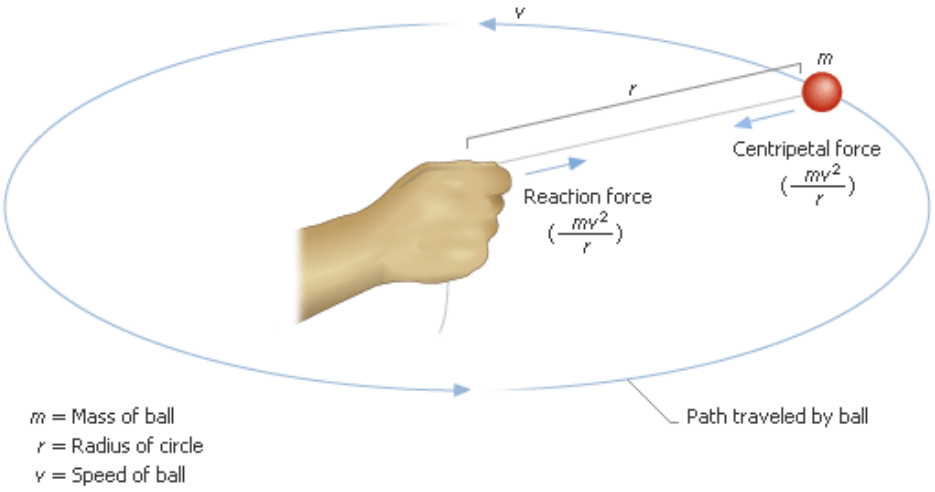


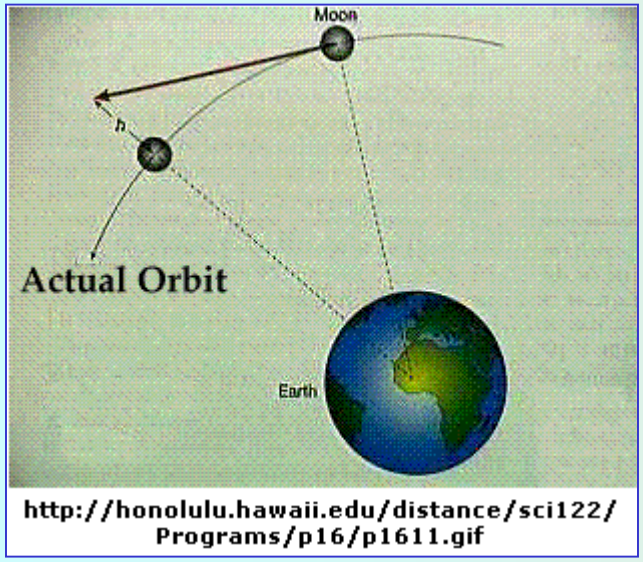
http://images.encarta.msn.com/xrefmedia/aencmed/targets/illus/ilt/T038747A.gif

Force needed for circular motion

By Newton's second law, the net force acting on an object has to follow the next equation:

$$F = m * a \rightarrow F_c = m * a_c = \frac{mv^2}{R}$$

$$\rightarrow F_c = m\omega^2 R = m\,\frac{4\pi^2 R}{T^2}$$



http://honolulu.hawaii.edu/distance/sci122/Programs/p16/p1611.gif

http://www1.istockphoto.com/file_thumbview_approve/2191757/2/istockphoto_2191757_carnival_ride_swing_chairs.jpg

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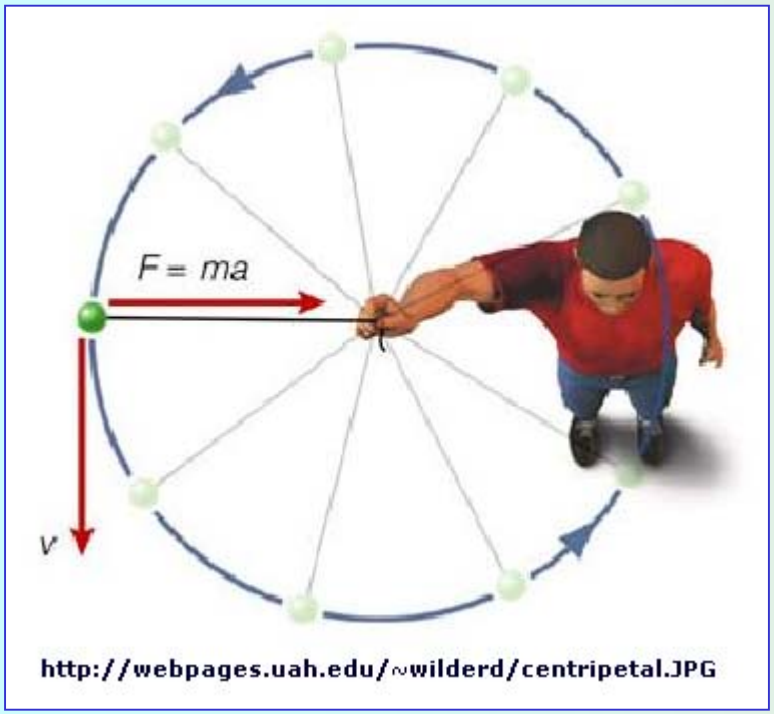

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Problem

A body of mass=0.06 kg moves in a horizontal circle. The radius is 0.30 m and the speed of the body 2 m/s. Determine the centripetal force on that body.

Solution

We apply the equation:

$$F_c = m^* a_c = \frac{mv^2}{R} = \frac{(0.06\ kg)(2\ m/s)^2}{0.3\ m}$$

$$F_c = 0.80\ N$$