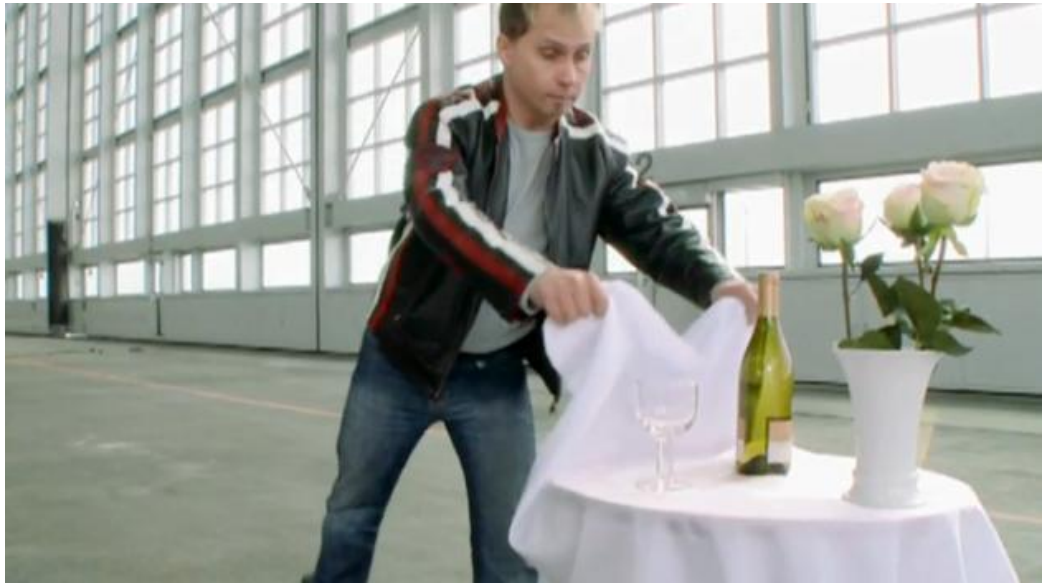
Defining Circular Motion

IB PHYSICS | CIRCULAR MOTION

Remember Newton's 1st?

A body will remain at rest or moving with constant velocity unless acted upon by an unbalanced force

"Law of Inertia"



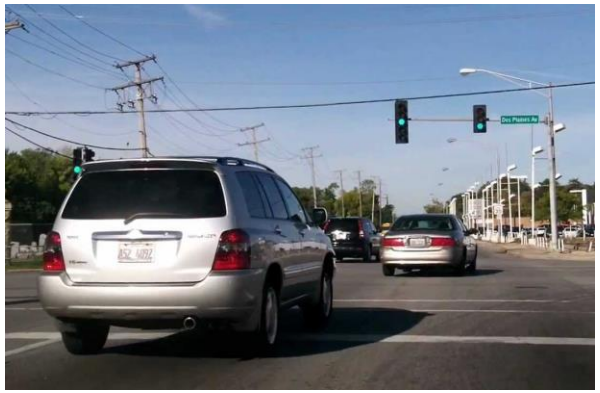
Try This…

I'm usually running late for school and sometimes I forget my plate of pop tarts on the top of my car. What happens when I take a sharp turn to the right? Why?

Pop Tarts will keep moving forward (in a straight line) unless an outside force acts upon them

Remember back…

There are 3 ways that an object can be experiencing acceleration?



Speeding Up

Slowing Down

Changing Direction

You already know some of this…

If each blade in the wind farm animation is 30 meters long, estimate the speed (in m s^{-1}) of the tip of one turbine blade.

Distance travelled by the tip of the blade for one revolution:

$$d = 2\pi r = 2\pi(30) = \mathbf{188.5\ m}$$

Time for one revolution = **2.9 seconds**

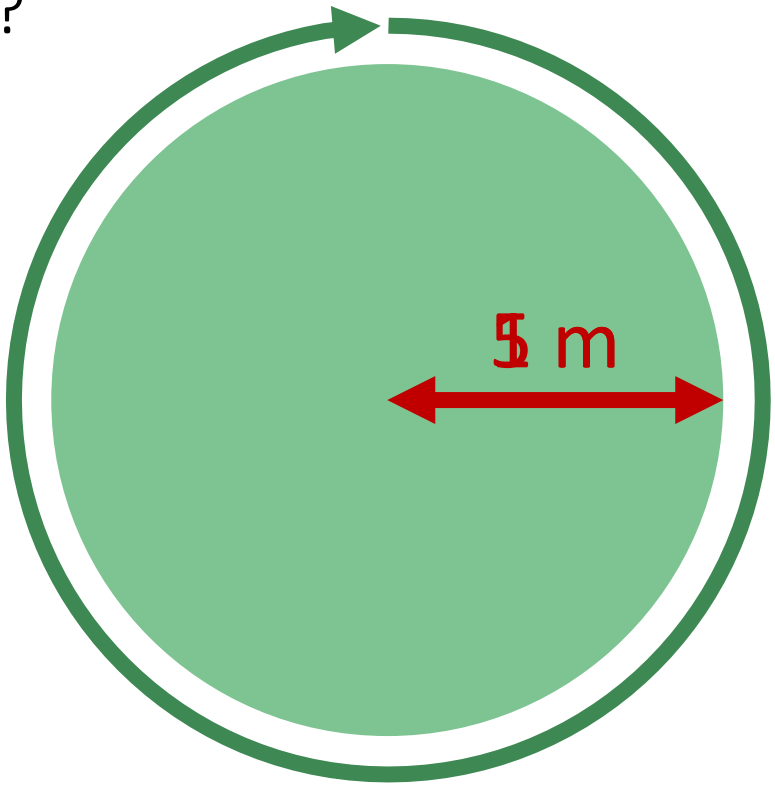
$$v = \frac{d}{t} = \frac{188.5\ \mathrm{m}}{2.9\ \mathrm{s}} = \mathbf{65.0\ m\ s^{-1}}$$

Think about the Circle…

If you walked around this circle once, what is your total distance?

$C = 2\pi r = 2\pi(5\text{ m})$

$C = 31.4$ meters



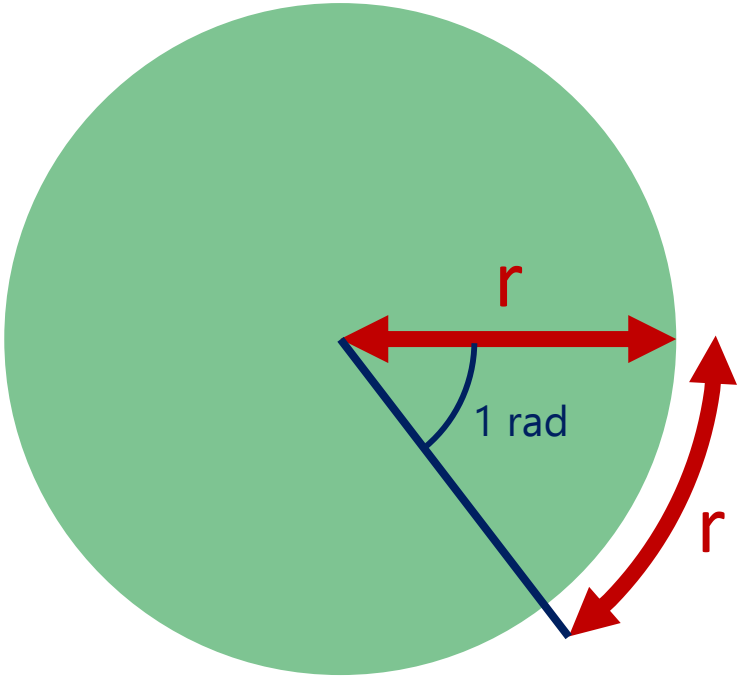
What is a Radian??

We can define a circular distance in terms of a generic radius, r…

$$C = 2\pi r$$

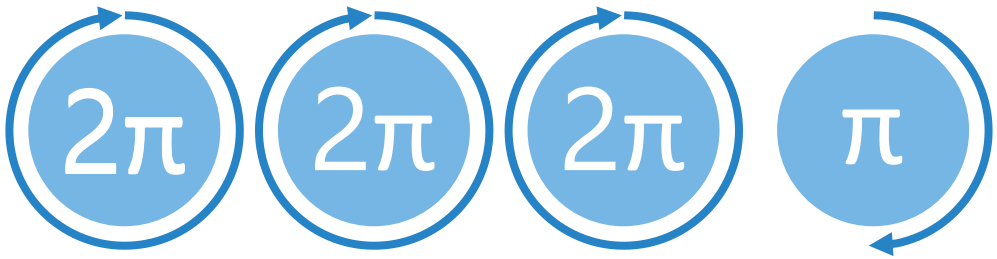
How many radians are there in one full revolution?

$$2\pi \text{ radians}$$



Try this....

If a child on a merry-go-round rotates 3.5 times, what is their **angular distance** in radians?



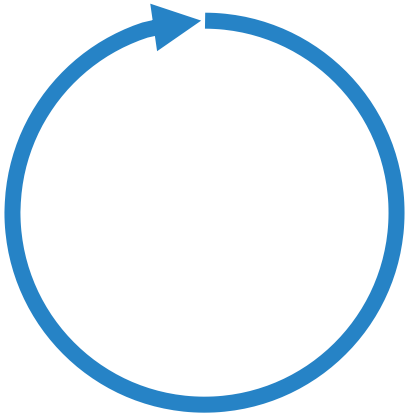
$$3.5(2\pi) = 7\pi$$
$$= 22 \text{ rad}$$

If an ant on a record player spins for an angular displacement of 14 radians, how many revolutions has it experienced?

$$\frac{14}{2\pi} = 2.23\ revolutions$$

Timing Circular Motion

Period	T	[s]
Time for complete revolution		



Angular Velocity

For Linear Motion:

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

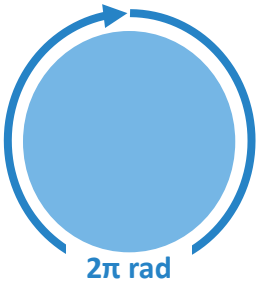
For Circular Motion:

Angular Velocity [rad s^{-1}]

$$\omega = \frac{angular\ distance}{time}$$

If you have a single revolution:

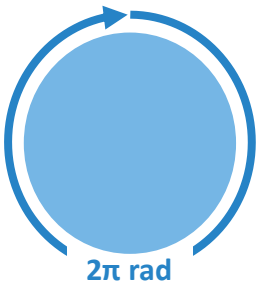
$$\omega = \frac{angular\ distance}{time} = \frac{2\pi}{T}$$



Time for one revolution = T

Try this....

A ferris wheel takes $\overset{T}{\boxed{\text{40 seconds}}}$ to make on full revolution, what is its angular velocity in rad/s?



$$\omega = \frac{2\pi}{T} = \frac{2\pi}{40} = 0.157\ rad\ s^{-1}$$

A car tire rotates with an average angular velocity of 29 rad/s. In what time interval will the tire rotate 3.5 times?

$$\omega = \frac{angular\ distance}{time} \qquad 29\,\frac{rad}{s} = \frac{3.5(2\pi)}{t} \qquad t = 0.758\ \mathrm{s}$$

$$\omega = \frac{2\pi}{T} \qquad 29\,\frac{rad}{s} = \frac{2\pi}{T} \qquad T = 0.217\ \mathrm{s}$$

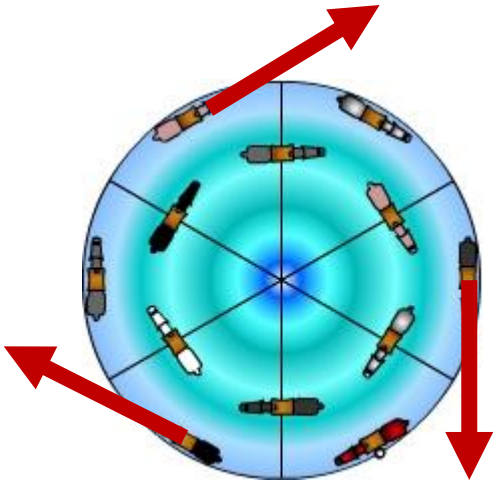
Time for one revolution

$$0.217 \times 3.5 = \mathbf{0.758\ s}$$

Linear Velocity

At any given point, an object with circular motion will also have an instantaneous linear velocity.

This velocity will be in the direction _tangent_ to the curve



Calculating Linear Velocity

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

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

Distance of one complete rotation (circumference)

Time for one complete rotation (Period)

Calculating Linear Velocity

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

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

$$\boxed{v = \omega r}$$

IB Physics Data Booklet

Sub-topic 6.1 – Circular motion

$$v = \omega r$$

$$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$$

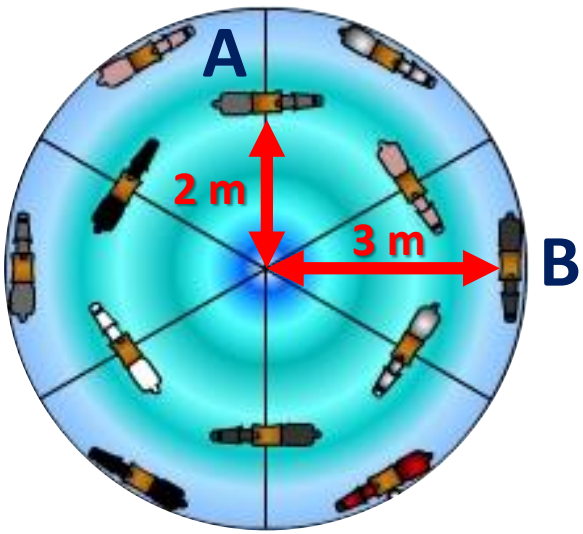
$$F = \frac{mv^2}{r} = m\omega^2 r$$

$$\omega = \frac{angular\ distance}{time}$$

For one revolution:

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

Try this....



Time for 1 Rotation:

T = 10 s

If the carousel spins at 1 complete rotation every 10 seconds, what is the angular and linear velocity of each row?

A	$\omega = \frac{2\pi}{T}$ $\omega = \frac{2\pi}{10}$ $= 0.63\ rad\ s^{-1}$	$v = \omega r$ $v = (0.63)(2)$ $= 1.3\ m\ s^{-1}$
B	$\omega = \frac{2\pi}{T}$ $\omega = \frac{2\pi}{10}$ $= 0.63\ rad\ s^{-1}$	$v = \omega r$ $v = (0.63)(3)$ $= 1.9\ m\ s^{-1}$

Try this....

If you were sitting 4 m from the center of a carousel spinning at 12 rad s^{-1} and threw a ball in the air, how fast would the ball continue in a straight line?

$r = 4$ m

$\omega = 12$ rad s^{-1}

$v = \omega r = (12)(4) =$ **48 m s^{-1}**

A woman passes through a revolving door with a tangential speed of 1.8 m s^{-1}. If she is 0.8 m from the center of the door, what is the door's angular velocity?

$v = 1.8$ m s^{-1}

$r = 0.8$ m

$v = \omega r$

$1.8 = \omega(0.8)$

$\omega = 2.25$ rad s^{-1}

Lesson Takeaways

- ❑ I can convert between angular displacement in revolutions and radians
- ❑ I can define and measure the **period** of circular motion
- ❑ I can calculate angular velocity in rad/s
- ❑ I can describe and calculate tangential velocity based on the angular velocity and radius