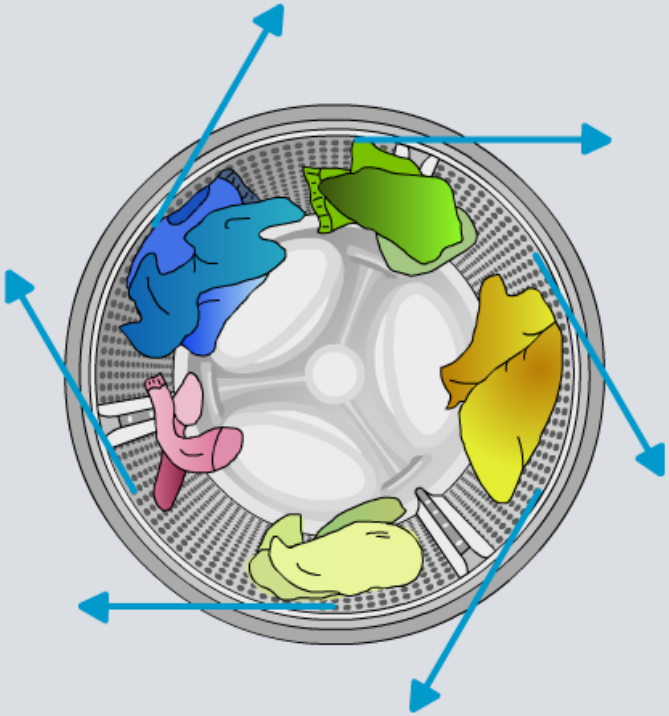
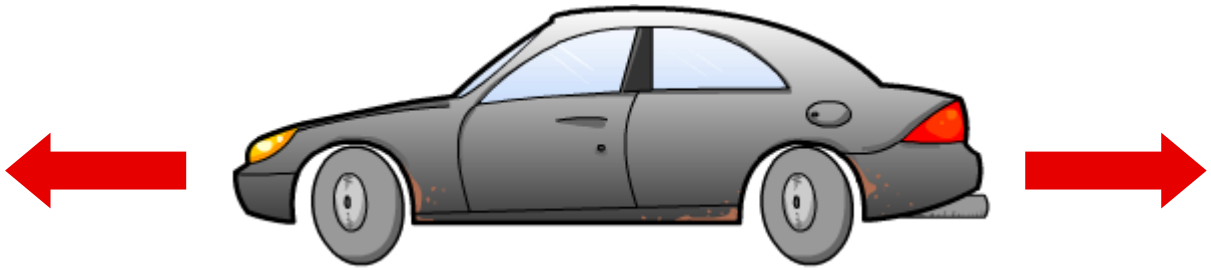
Circular Motion

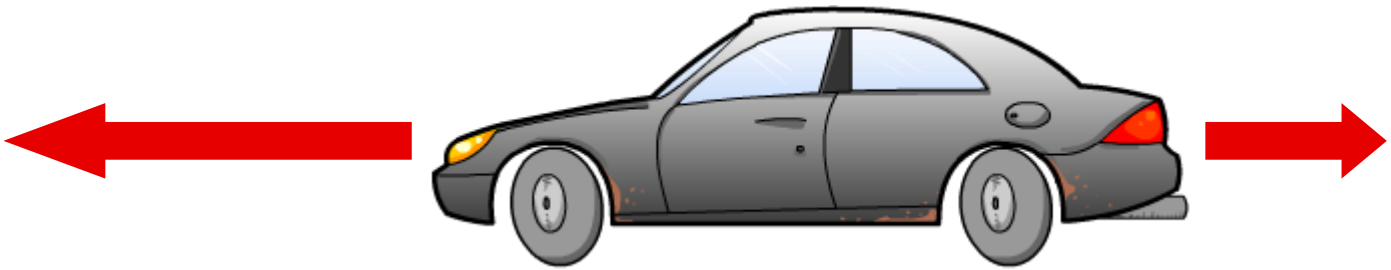


Forces and acceleration

An object will remain stationary or will move in the same direction at a constant speed, unless the forces acting on it are not balanced.



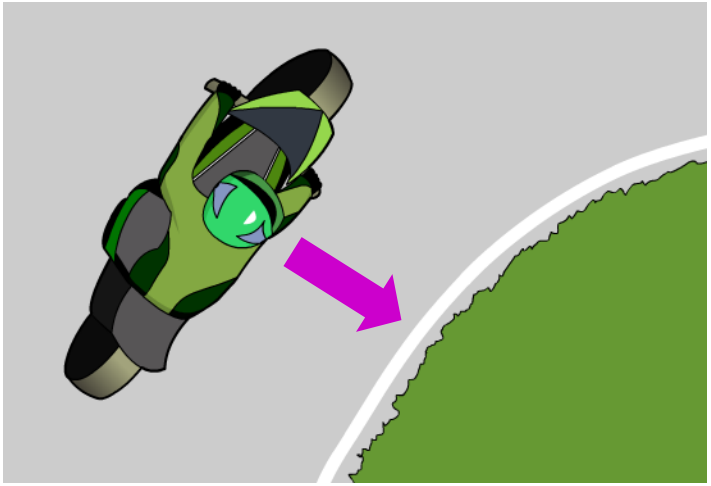
This will cause an acceleration in the direction of the stronger force. This can make an object slow down or speed up, or it can cause it to change **direction**.



Acceleration in a circle

A motorcycle drives around a corner at a constant speed. Its **direction** changes as it goes around the corner, so even though its speed is constant, it must be **acceleration**.

This acceleration must be at **right angles** (perpendicular) to the direction of movement as it turns the corner, otherwise its speed could not be constant.



Which way do you think the motorcycle is acceleration, towards the inside of the turn, or away from it?

Forces causing circular motion

Any object that moves in a circle must be accelerating towards the center of that circle. What causes this?

What equation do you know that links force and acceleration?

$$F = m \times a$$

Force and acceleration are both **vector** quantities, unlike mass, so according to this equation, their **directions** must be same.

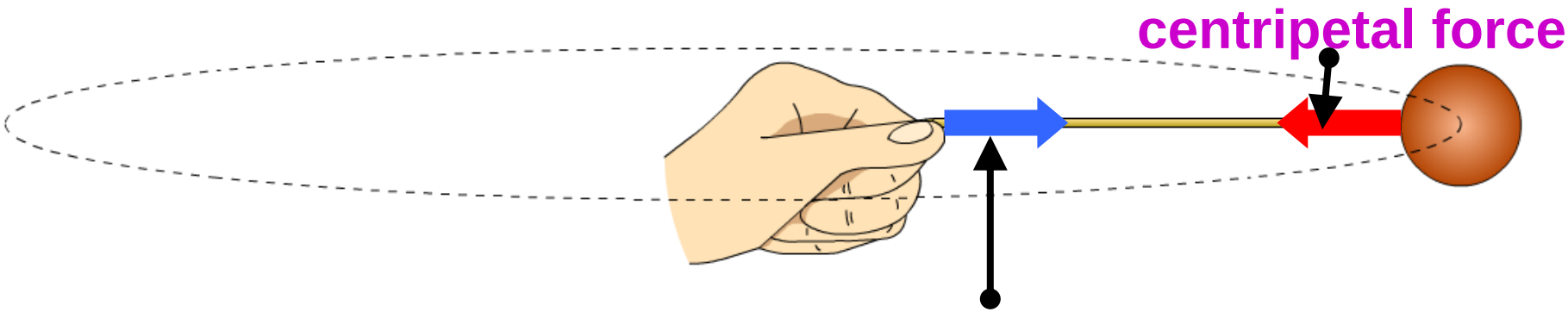
All circular motion must therefore be caused by a force acting towards the center of the circle.

This type of force is known as a **centripetal force**.

Centrifugal force or centripetal force?

Swing a mass around in a circle on the end of a string. Do you feel a force pulling your hand outwards? This is often called a "centrifugal force." You might have heard that centrifugal forces cause circular motion, but this is not good physics!

Consider what is happening in this case. The mass on the end of the string is the object that is performing circular motion, so it is the forces on **this** object that are important:



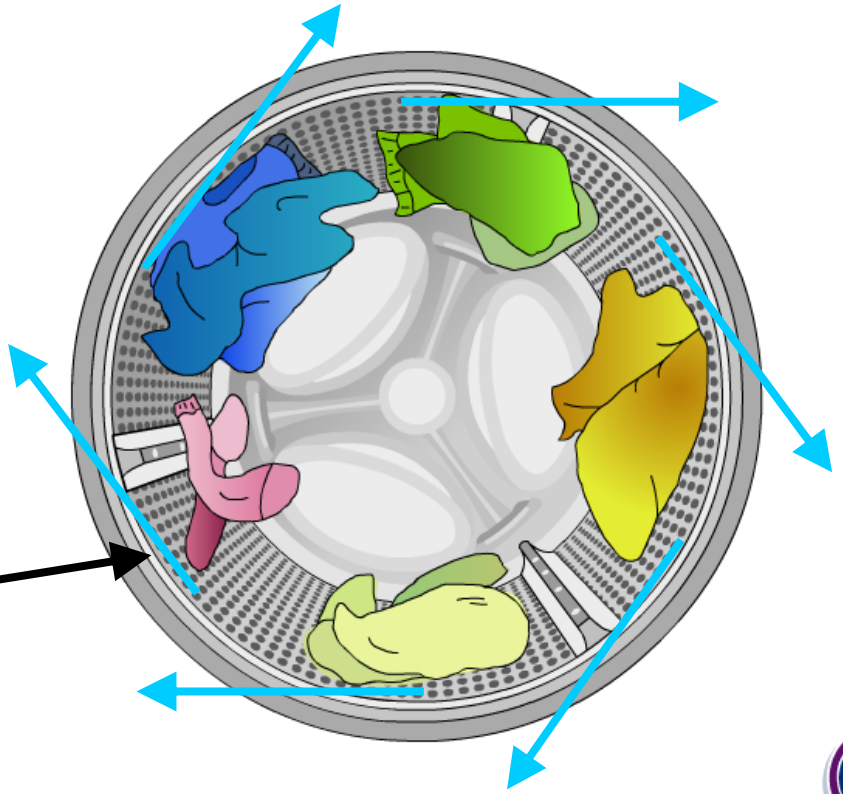
The force on your hand is a **reaction force**, which can be ignored when studying the motion of the mass.

Thinking about circular motion

It is important to think of circular motion as an object being **continuously prevented** from moving in a straight line, rather than as if the object is being flung outwards from the center.

A washing machine dries clothes by spinning them around very fast:

The sides of the drum provide the centripetal force that keeps the clothes moving in a circle, but water is free to escape in straight trajectories through the holes in the sides.



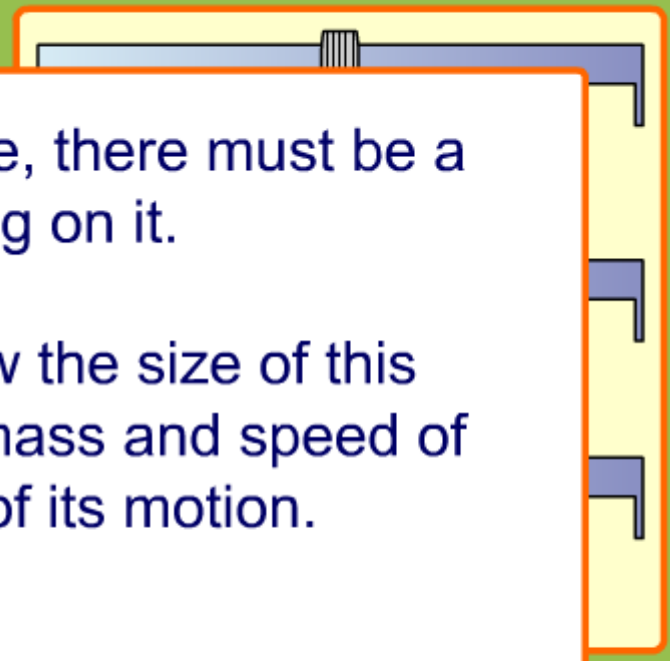
Examples of centripetal forces

Here are two more examples of circular motion caused by centripetal forces:

Can you figure out the direction of the force in each case, and describe the type of force involved?

Factors affecting centripetal forces

How strong is the centripetal force?



When an object moves in a circle, there must be a centripetal force acting on it.

Click **"start"** to investigate how the size of this force varies, depending on the mass and speed of the object, and the radius of its motion.

start

Factors affecting centripetal forces

How does the centripetal force depend on **mass**?

F = ma, so force is proportional to mass.

The **greater** the mass, the **larger** the centripetal force needed to maintain circular motion.

How does the centripetal force depend on **speed** and **radius**?

F = ma, so force is proportional to acceleration. If the truck is going faster, or if its radius is smaller, then it is changing direction more quickly, so its acceleration is greater.

The **greater** the speed, and the **smaller** the radius, the **larger** the centripetal force needed to maintain circular motion.

Understanding centripetal forces

Are these statements about centripetal forces true or false?

1.	All circular motion requires a centripetal force.	
2.	The centripetal force causing circular motion must always act outwards from the center.	
3.	The centripetal force on a rollercoaster car going round a vertical loop is **friction**.	
4.	The centripetal force on a car driving around a sharp bend on horizontal ground is **friction**.	
5.	The centripetal force on a bucket swinging in a circle on the end of a rope is **tension**.	
6.	The centripetal force on a planet orbiting a star is **gravity**.	

true false

?

solve

Centripetal Forces

$$F_c = \frac{mv^2}{r}$$

m is mass, measured in kg

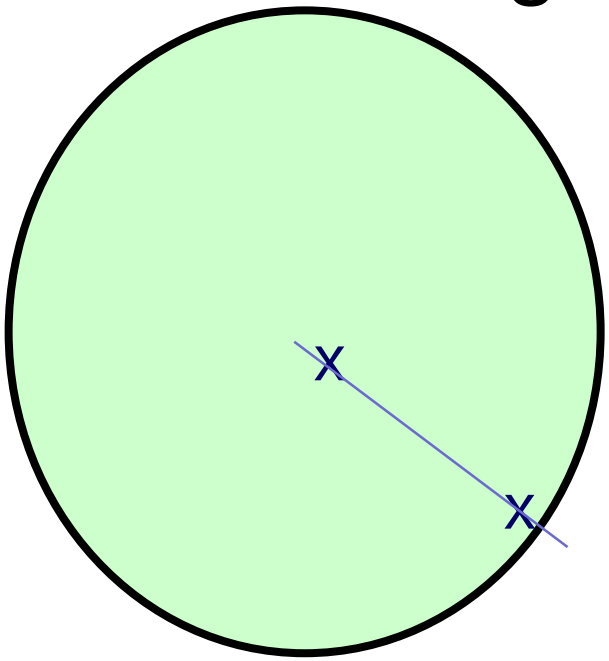
v is velocity, measured in m/s

r is radius of the circle, measured in m

F_c is centripetal force, measured in N

Merry-Go-Round

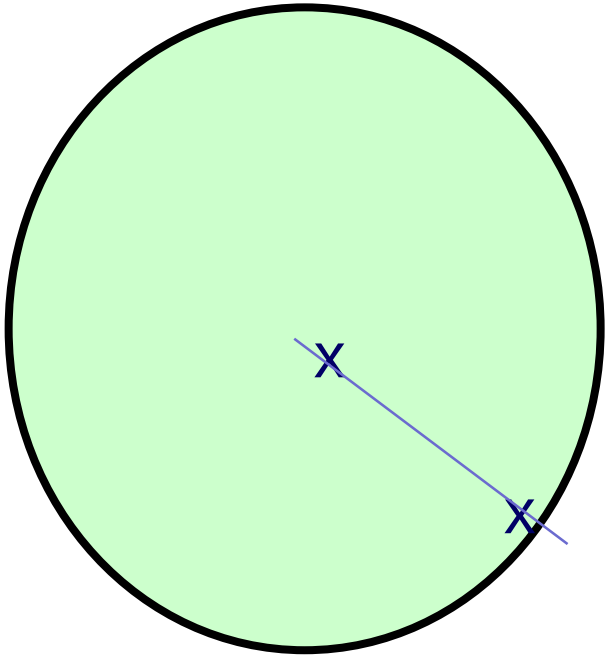
- Who crosses the finish line first, kid near middle or near the edge?



Tie!!! Both cross at same time and in the same time….

Merry-Go-Round

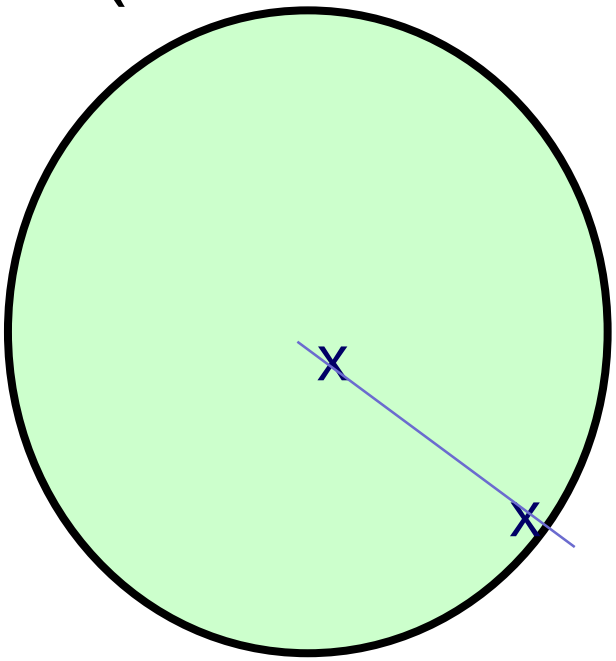
- Who goes faster, kid near middle or near the edge?



The kid on the edge! Bigger distance in same time….

Merry-Go-Round

- Who experiences the biggest centripetal force (the most “fun”)?



Kid near edge!

Torque

- Force that rotates an object
  - hold a mop near the mop head
  - then hold the mop at the opposite end
    - which is harder to hold horizontal?
      - holding at the opposite end… more torque