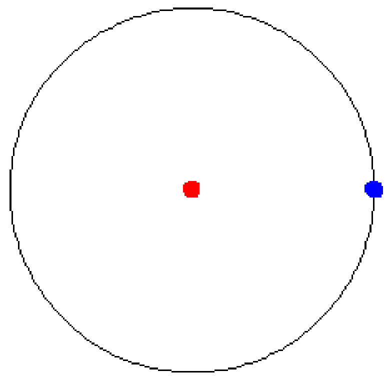
Circular Motion

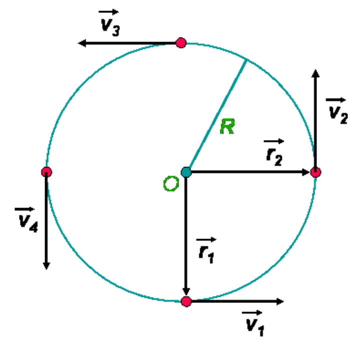
Speed/Velocity in a Circle



Consider an object moving in a circle around a specific origin. The DISTANCE the object covers in ONE REVOLUTION is called the CIRCUMFERENCE. The TIME that it takes to cover this distance is called the PERIOD.

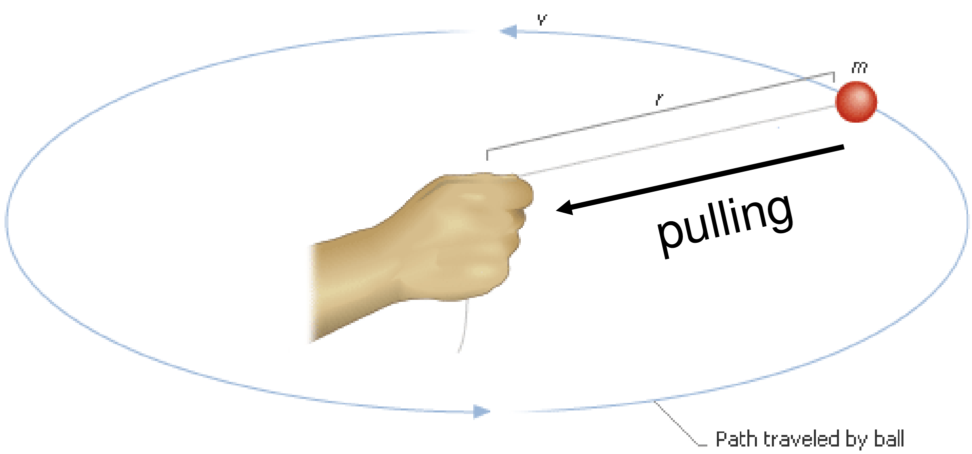
$$\bar{s}_{circle} = \frac{d}{T} = \frac{2\pi r}{T}$$

Speed is the MAGNITUDE of the velocity. And while the speed may be constant, the VELOCITY is NOT. Since velocity is a vector with BOTH magnitude AND direction, we see that the direction of the velocity is ALWAYS changing.



We call this velocity, TANGENTIAL velocity as its direction is draw TANGENT to the circle.

Circular Motion & N.S.L



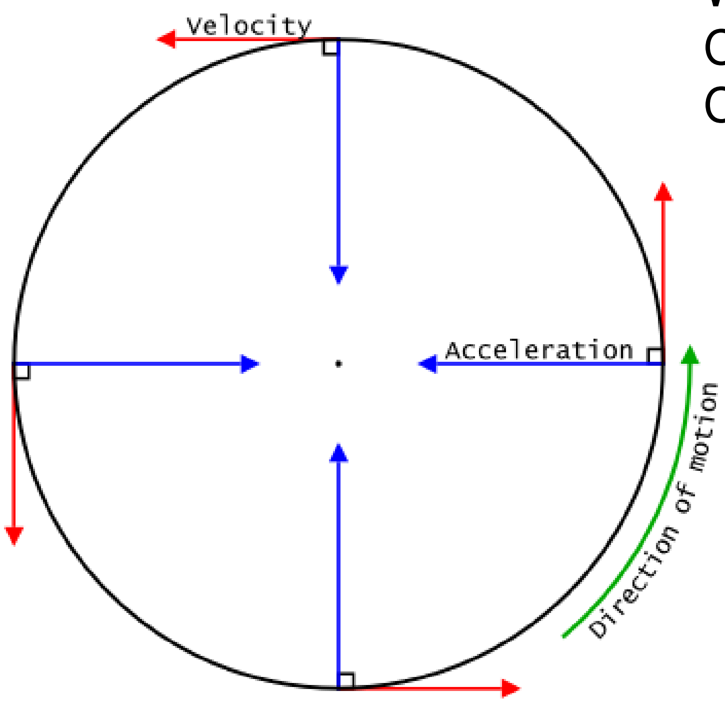
Let's recall some important facts!

1. Velocity is a VECTOR
2. Vectors have magnitude AND Direction
3. Acceleration is defined as the RATE of CHANGE of VELOCITY!
4. According to Newton's second Law. The acceleration is DIRECTLY proportional to the force. $F_{net} \alpha$ acc

What can we conclude?

•If it is moving in a circle, the DIRECTION of the velocity is changing
•If the velocity is changing, we have an acceleration
•Since we are PULLING towards the CENTER of the CIRCLE, we are applying a NET FORCE towards the CENTER.
•Since we have a NET FORCE we MUST have an ACCELERATION.

Centripetal Acceleration



We define this inward acceleration as the CENTRIPETAL ACCELERATION. Centripetal means "**CENTER SEEKING**".

So for an object traveling in a counter-clockwise path. The velocity would be drawn TANGENT to the circle and the acceleration would be drawn TOWARDS the CENTER.

To find the MAGNITUDES of each we have:

$$v_c = \frac{2\pi r}{T} \qquad a_c = \frac{v^2}{r}$$

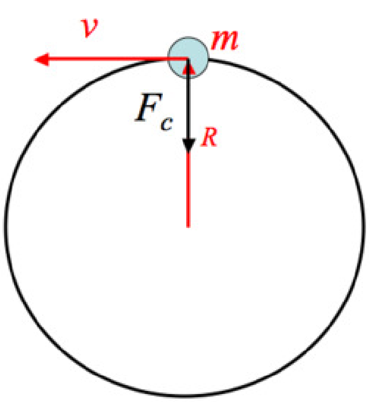
Circular Motion and N.S.L

Recall that according to Newton's Second Law, the acceleration is directly proportional to the Force. If this is true:

$$F_{NET} = ma \quad a_c = \frac{v^2}{r}$$

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

$$F_c = Centripetal\ Force$$



Since the acceleration and the force are directly related, the force must ALSO point towards the center. This is called CENTRIPETAL FORCE.

NOTE: The centripetal force is a NET FORCE. It could be represented by one or more forces. So NEVER draw it in an F.B.D.

Example

A Ferris wheel with a diameter of 18.0 meters rotates 4 times in 1 minute. a) Calculate the velocity of the Ferris wheel. b) Calculate the centripetal acceleration of the Ferris wheel at a point along the outside. c) Calculate the centripetal force a 40 kg child experiences.

$$v_c = \frac{2\pi r}{T} = \frac{2(3.14)9}{15} =$$ **3.77 m/s**

$$a_c = \frac{v^2}{r} \rightarrow \frac{v^2}{9} =$$ **1.58 m/s/s**

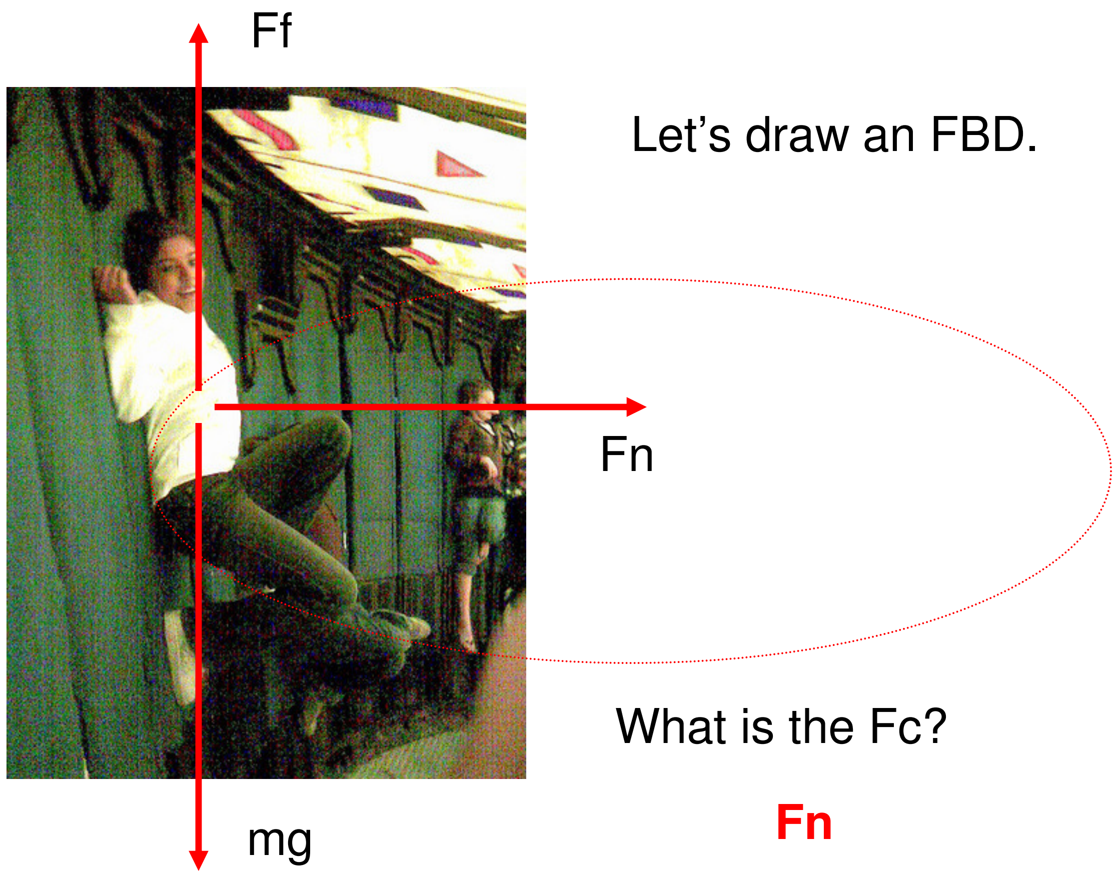
$$F_c = \frac{mv^2}{r} \rightarrow \frac{(40)v^2}{9} =$$ **63.17 N**

$$or \quad F_c = ma_c \rightarrow (40)(a_c) =$$ **63.17 N**

Centripetal Force and F.B.D's

The centripetal force is ANY force(s) which point toward the CENTER of the CIRCLE.

Gravitron the ride



Let's draw an FBD.

What is the Fc?

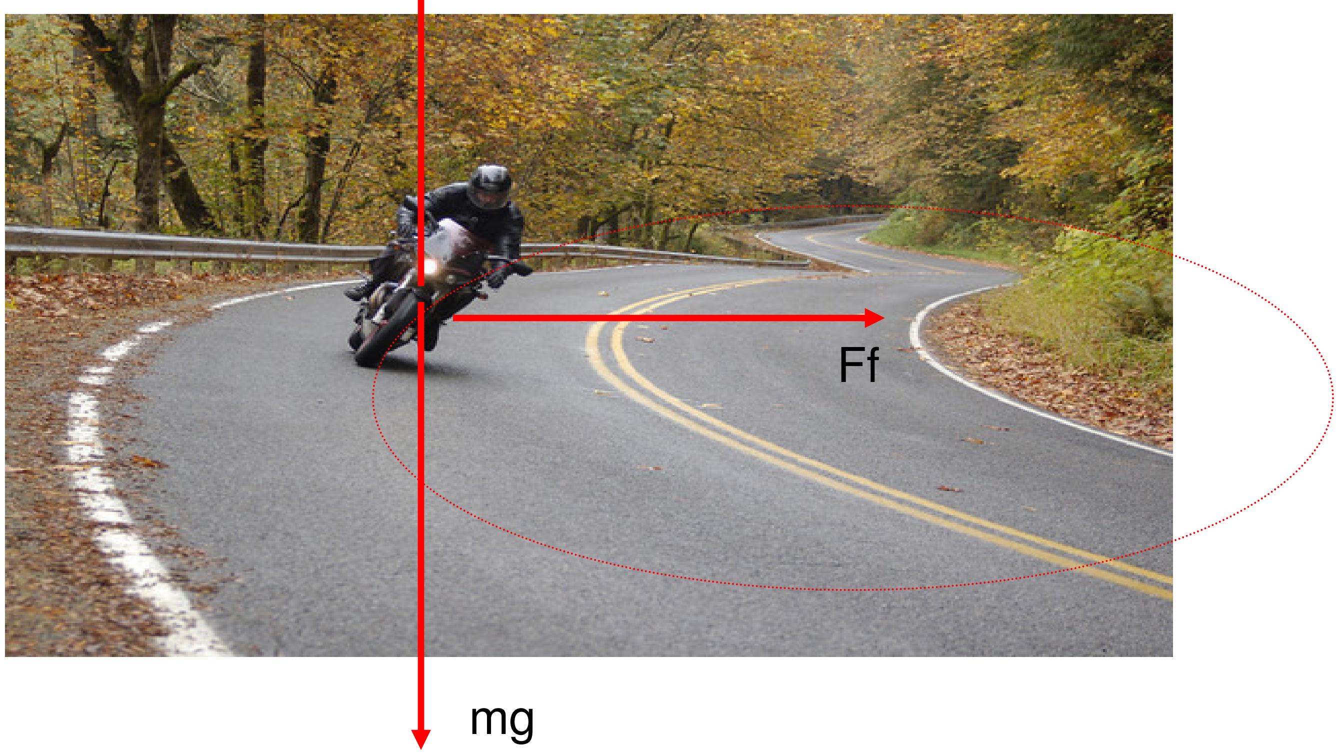
Fn

Centripetal Force and F.B.D's

Rounding a curve

Fn

Let's draw an FBD.

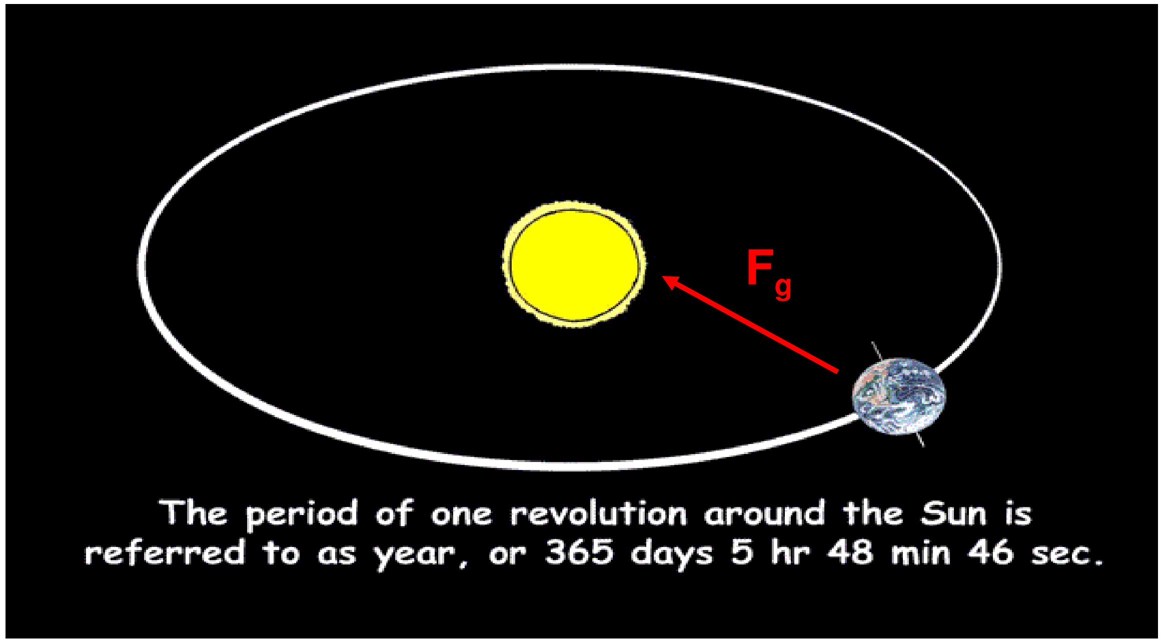


What is the Fc?

Ff

Centripetal Force and F.B.D's

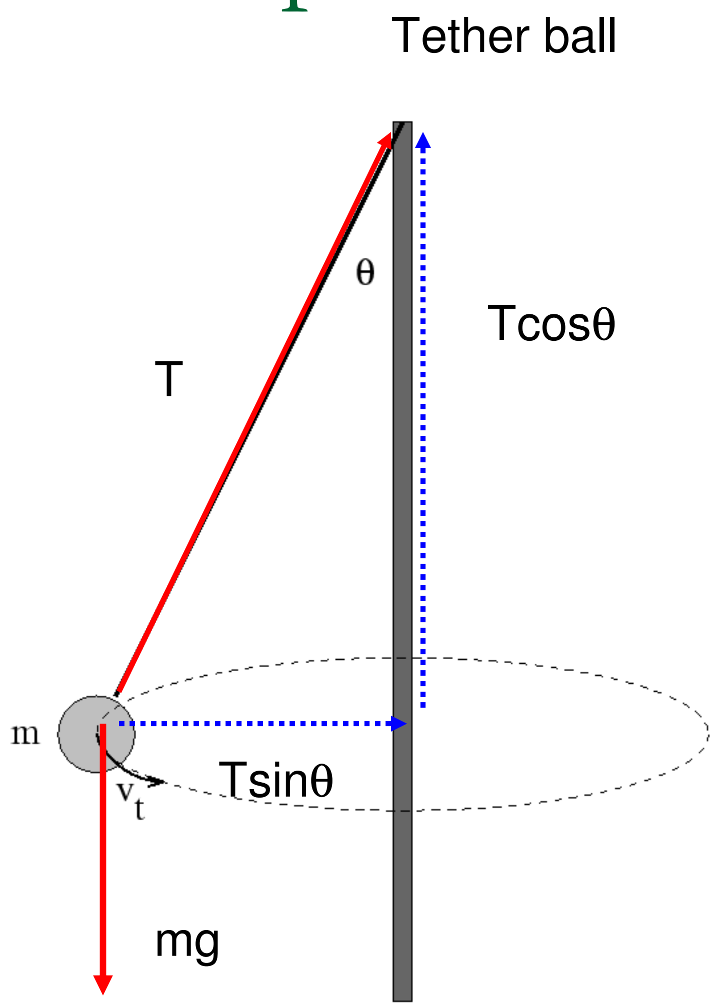
The earth in orbit around the sun



What is the Fc?

Fg

Centripetal Force and F.B.D's



What is the Fc?

Tsinθ