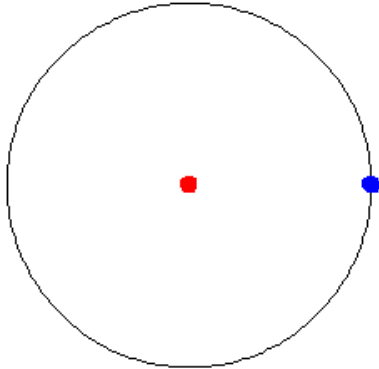

Circular Motion



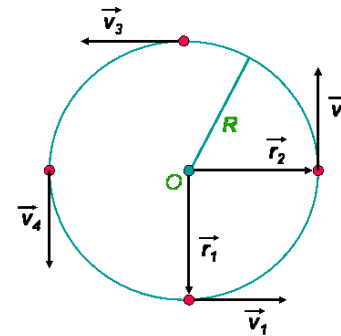
Speed/Velocity in a Circle



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**.

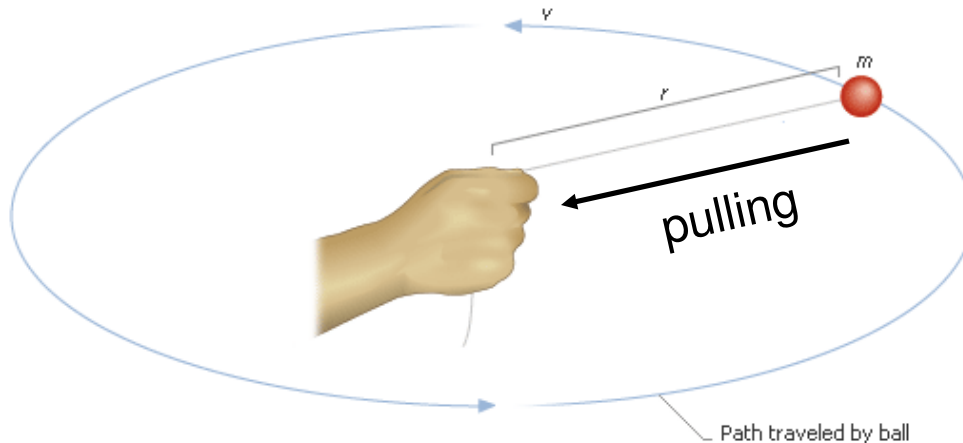
$$\bar{s}_{circle} = \frac{d}{T} = \frac{2\pi r}{T}$$

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



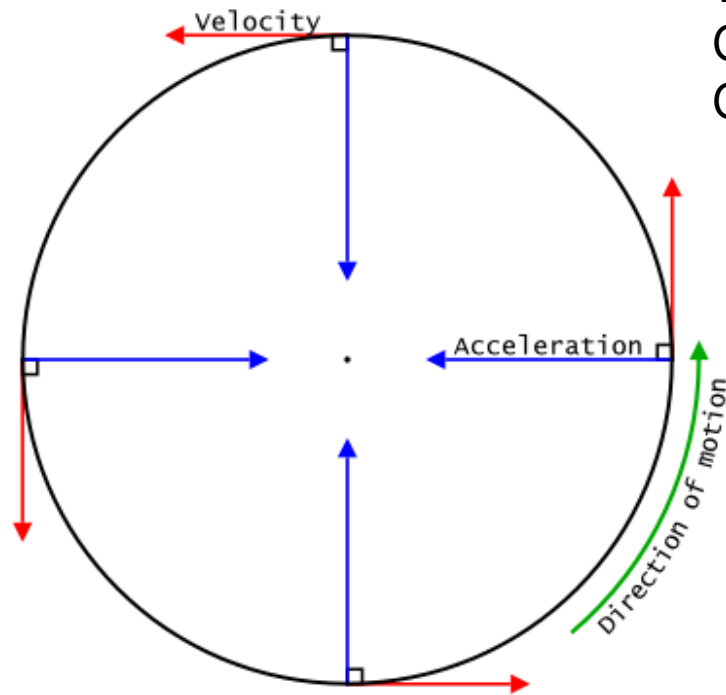
Let's recall some important facts!

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. $F_{\text{net}} \propto \text{acc}$

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:

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

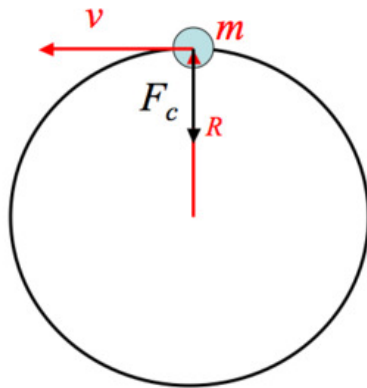
Circular Motion and N.S.L

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

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

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

$$F_c = \textit{Centripetal Force}$$



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.

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

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

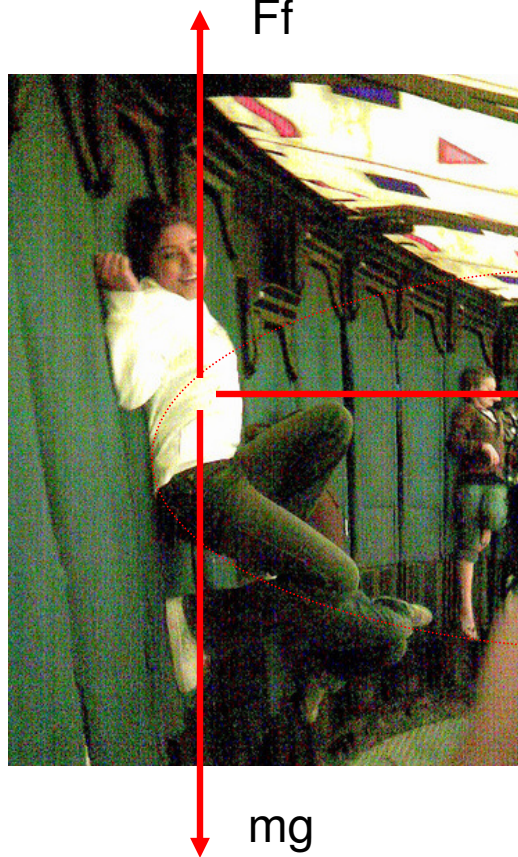
$$F_c = \frac{mv^2}{r} \rightarrow \frac{(40)v^2}{9} = \mathbf{63.17 \text{ N}}$$

$$\text{or } F_c = ma_c \rightarrow (40)(a_c) = \mathbf{63.17 \text{ N}}$$

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.

F_n

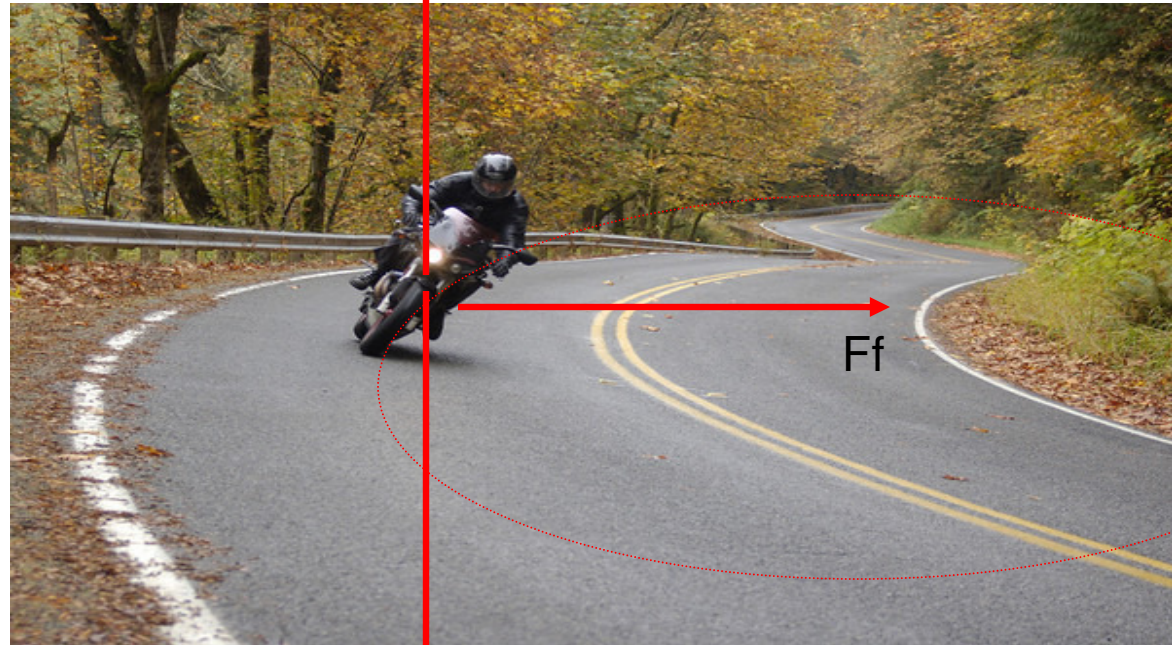
What is the F_c ?

F_n

Centripetal Force and F.B.D's

Rounding a curve

Let's draw an FBD.



F_n

F_f

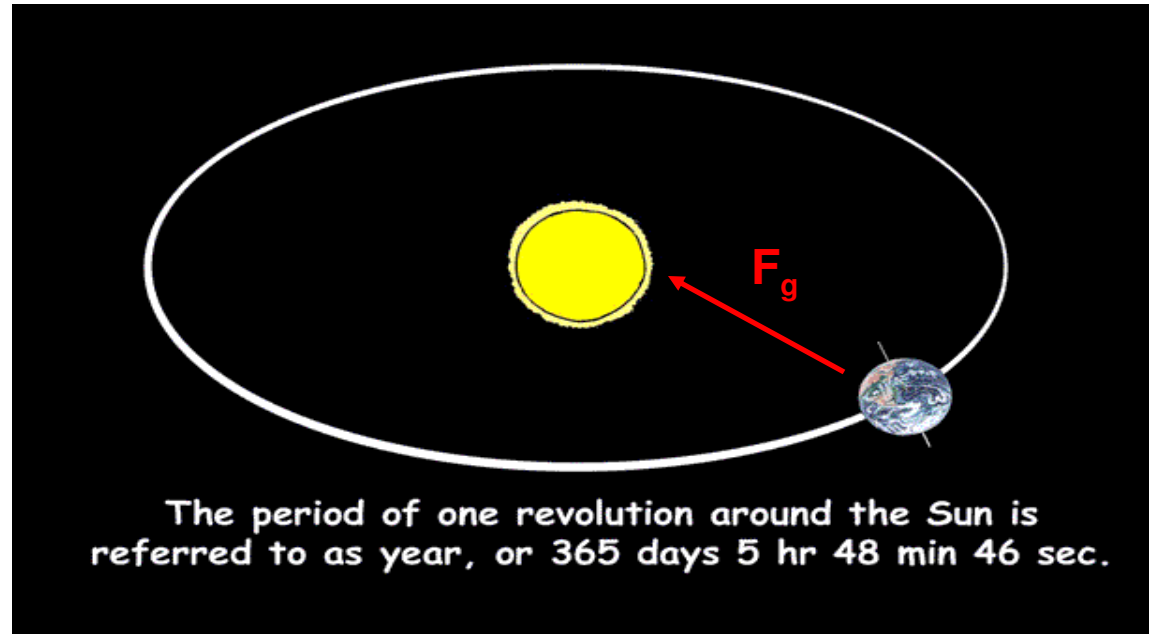
mg

What is the F_c ?

F_f

Centripetal Force and F.B.D's

The earth in orbit around the sun

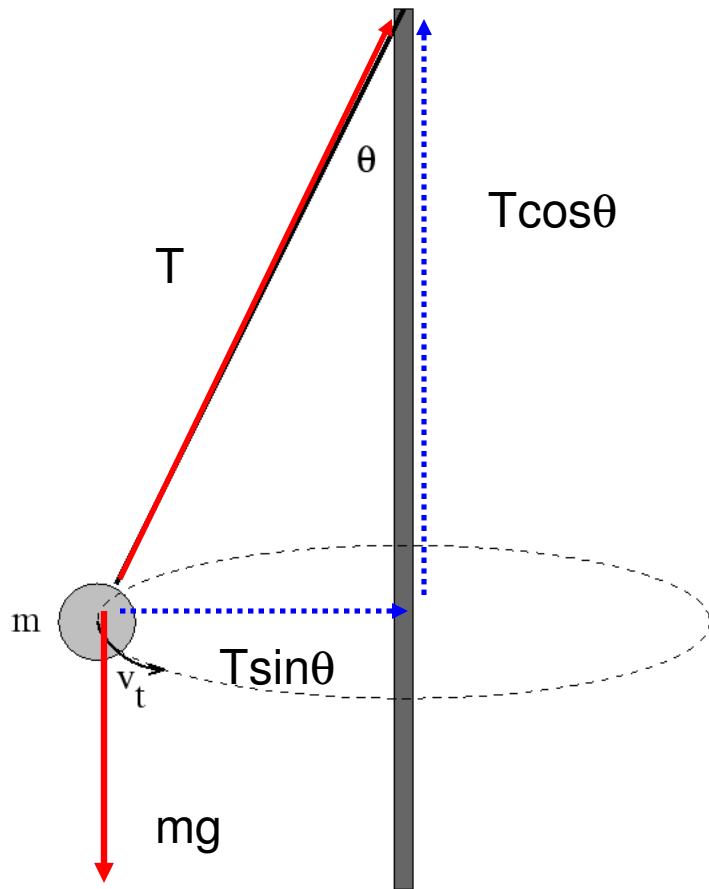


What is the F_c ?

F_g

Centripetal Force and F.B.D's

Tether ball



What is the F_c ?

$T \sin \theta$