More Circular Motion

- Emphasis here is on the idea the centripetal force is a net force. It is not a particular "type" of force like tension or friction. So, centripetal force may be provided by one force or a sum of different forces.

- So, do not ever, ever label Fc in a free body diagram. Identify whatever force types are acting like F_T or F_f or Fn or Fg or Fq (later in electrostatic problems).

- Must provide individual net force statements.

ex. $\underline{Fnet}_{y, x} = \overset{ma_c}{Fc}$ tells reader direction of net force and Fc

$F_{net\ y} = Fg + F_T$ tells reader what forces are combining to provide Fc

- Define the equations in the set up... as sometimes you will need to modify an equation by inserting a negative sign for directions (kind of like in connected systems unit).

- In addition the FBD, must also include a visualization of the object within the plane of rotation. This picture at the very least should include the direction of the motion (speed) with the forces acting radially inward.
  > If possible, these can be in the same picture

Application Problems Involving Centripetal Force

Centripetal force is not a "new" force; it is a net force.

It is a name used to indicate the net force is causing circular motion.

Centripetal force in a problem may be caused by one or more of the following forces:

friction	**normal**	**magnetic**
weight/gravitational	**electrostatic**	**tension**

key: 1. identify the plane of the motion
2. identify the forces acting in the plane of motion
3. calculate the net force acting in the plane of motion

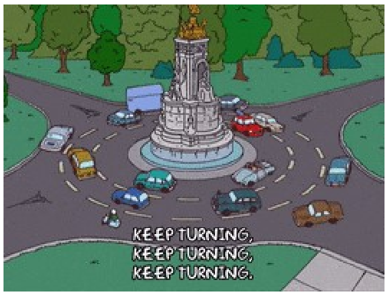
Ex. 1. Horizontal Circles:

A person of 60.0 kg is suspended on the side of a spinning carnival ride and, suppose, the floor has been dropped during the spinning. The person feels to be stuck to the wall as the wall rotates. The radius of the ride is 6.8 m. The person completes one revolution in 5.3 s . Draw an FBD.

a) What is the tangential speed of the person
b) What is the coefficient of static friction for clothes on ride wall?

Ex 2. Horizontal Circles :

A car is driving through a roundabout along a level road with no embankment. While in one lane of radius 25.0 m, they travel at 13.9 m/s. They then change to an outer lane that is a radius or 28.0 m, but maintain the same speed. How much did the coefficient of friction change by? Draw a FBD.



Static Friction prevents skidding

$0 \leq \mu_s \leq \mu_{s\,max}$

Ex. 3: Vertical Circles:

A 1.35 kg bucket of water is spun in a vertical circle . The radius of the circle is held constant at 0.950 m.

a) What is the applied force at the top of the circle if the bucket was moving at 4.00 m/s? Draw a FBD.

b) What is the applied force at the bottom of the circle if the bucket was moving at 4.00 m/s? Draw a FBD.

c) What is the applied force exactly midway between the top and the bottom of the loop if the bucket was moving at 4.00 m/s? Draw a FBD.

Ex 1)

$m = 60.0\ \text{kg}$

$r = 6.8\ \text{m}$

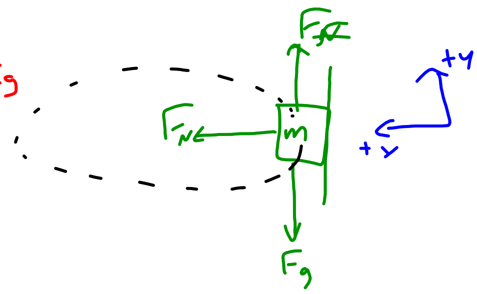
$T = 5.3\ \text{s}$

$\vec{a}_y = 0\ \text{m/s}^2$

$\vec{g} = 9.81\ \text{m/s}^2$ [down]

$v = ?$

$\mu_s = ?$



a) $$F_{Net,x} = F_N = ma_c = \frac{mv^2}{r}$$

$$v = \frac{2\pi r}{T} = \frac{2\pi(6.8\ \text{m})}{5.3\ \text{s}} = 8.0614\ \text{m/s}$$

$$\boxed{v = 8.1\ \text{m/s}}$$

b) $$F_f = \mu_s F_N \rightarrow \mu_s = \frac{F_f}{F_N}$$

$$F_{Net,y} = F_f - F_g = ma_y = 0\ \text{N}$$

$$\therefore F_f = F_g$$

$$\mu_s = \frac{\cancel{m}g}{(\cancel{m}v^2/r)} = \frac{gr}{v^2}$$

$$= \frac{(9.81\ \text{m/s}^2)(6.8\ \text{m})}{(8.0614\ \text{m/s})^2} = \boxed{1.0}$$

Ex 2

$r_1 = 25.0\ m$

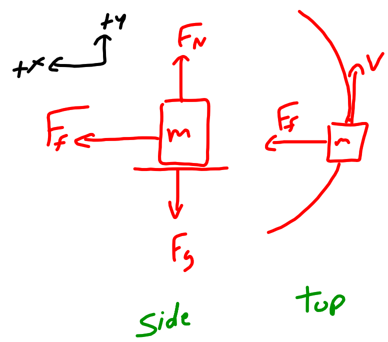
$r_2 = 28.0\ m$

$v = 13.9\ m/s$

$\vec{a}_y = 0\ m/s^2$

$\vec{g} = 9.81\ m/s^2\ [down]$

$\Delta\mu_s = ?$



$$F_{net,x} = F_f = ma_c = \frac{mv^2}{r}$$

$$F_{net,y} = F_N - F_g = ma_y = 0\ N$$

$$F_N = F_g$$

$$F_f = \mu_s F_N = \mu_s mg$$

$$\frac{\cancel{m}v^2}{r} = \mu_s \cancel{m}g$$

$$\mu_s = \frac{v^2}{rg}$$

$$\Delta\mu_s = \mu_{s1} - \mu_{s2} = \frac{v^2}{r_1 g} - \frac{v^2}{r_2 g}$$

$$\mu_s = \frac{v^2}{g}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$= \frac{(13.9\ m/s)^2}{(9.81\ m/s^2)}\left(\frac{1}{25.0\ m} - \frac{1}{28.0\ m}\right)$$

$$= 0.0844 = \boxed{0.084}$$

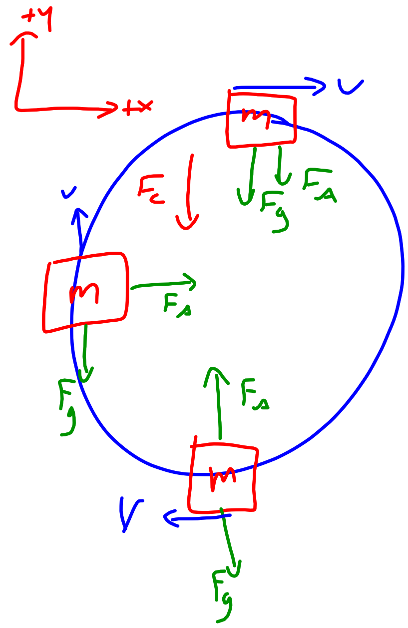
Ex 3)

$m = 1.35\ kg$

$V = 4.00\ m/s$

$r = 0.950\ m$

$\vec{g} = 9.81\ m/s^2$ [down]



a) $F_{Net,y} = \left(-F_g - F_A = -F_c = -ma_c\right) \times -1$

$F_g + F_A = ma_c$

$F_A = ma_c - F_g \longrightarrow ma_c - mg$

$= \frac{mv^2}{r} - mg \qquad = m(a_c - g)$

$= m\left(\frac{v^2}{r} - g\right)$

$= (135\ kg)\left(\frac{(4.00\ m/s)^2}{0.950\ m} - 9.81\ m/s^2\right)$

$= 9.49\ N = \boxed{9.5\ N}$

b) 360 N

c) 227 N