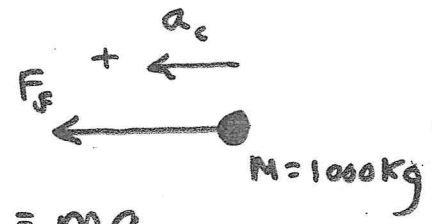
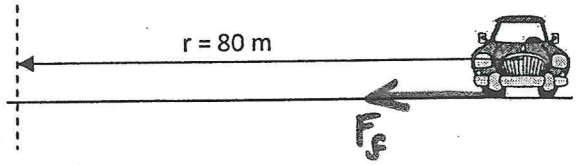
Centripetal Force Examples

1. A 1000kg car enters a **level** curve at 20m/s. If the curve has a radius of 80m. What centripetal force must be supplied by friction to keep the car from skidding? What is supplying the centripetal force?





$\Sigma F = ma_c$

$F_f = ma_c$

$F_f = m\left(\frac{v^2}{r}\right) = (1000)\left(\frac{20^2}{80}\right)$

$\boxed{F_f = 5000N}$

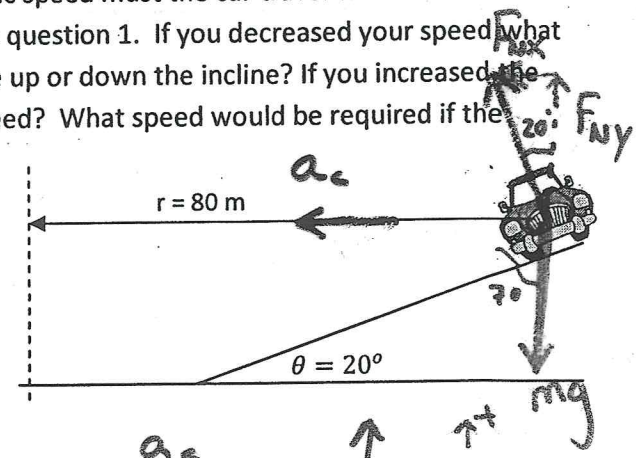
(Friction is supplying the centripetal force)

2. The same 1000kg car travels around a **frictionless, banked curve** having a radius of 80m. If the banking is 20° to the horizontal, at what specific speed must the car travel to maintain a constant radius? Compare this to the speed in question 1. If you decreased your speed what would happen to your radius (would you move up or down the incline? If you increased the bank angle what happens to the maximum speed? What speed would be required if the frictionless bank were at 90°?

$r = 80m$ $\mu = 0$

$\theta = 20°$ $v = ?$

$m = 1000$ kg



y-direction

$\Sigma F_y = m\cancel{a_y}^{0}$

$\Sigma F_y = \emptyset$

$F_{NY} - mg = 0$

$F_{NY} = mg$

① $\boxed{F_N \cos\theta = mg}$

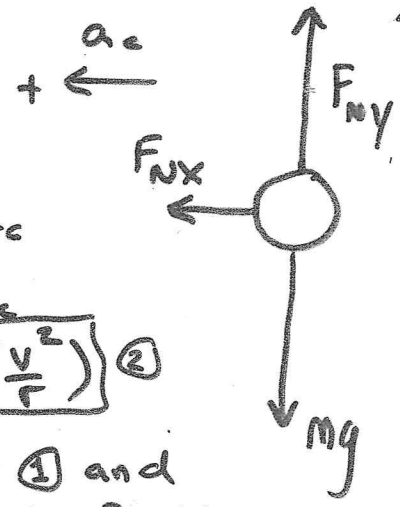
radial dir

$\Sigma F = ma_c$

$F_{NX} = ma_c$

$\boxed{F_N \sin\theta = m\left(\frac{v^2}{r}\right)}$ ②

solve F or F_N in ① and sub into ②. Solve for v.



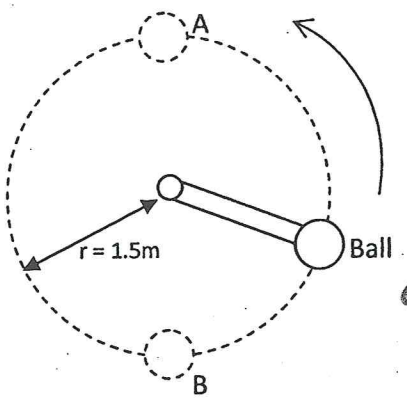
[break apart the normal force]

F_{NX} - radial direction

constant

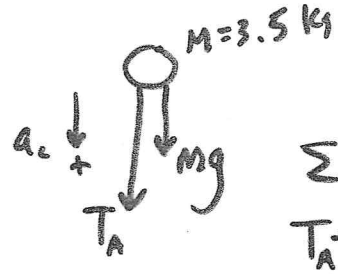
$$\Sigma F = \frac{mv^2}{r}$$

3. A 3.5kg steel ball is swung at a constant speed in a **vertical circle** of radius 1.5m, on the end of a light, rigid steel rod (see figure). **Predict** where the tension would be the greatest (point A or B). If the ball has a frequency of 1.0 Hz. Calculate the tension in the rod due to the mass at the top (A) and bottom (B) positions. Compare to your prediction.



$m = 3.5\ kg$
$f = 1\ Hz$
$r = 1.5\ m$

@ Pt. A



$\Sigma F = ma_c$

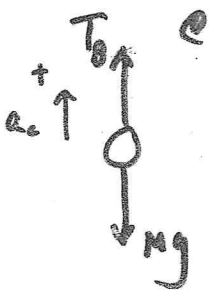
$T_A + mg = m\,4\pi^2 r f^2$

$$\boxed{T_A = m4\pi^2 r f^2 - mg}$$

Tension @ A is reduced because mg is being subtracted

$T_A \doteq$

@ Pt B



$\Sigma F = ma_c$

$T_B - mg = m\,4\pi^2 r f^2$

$$\boxed{T_B = m4\pi^2 r f^2 + mg}$$

T_B at pt. B is greater because mg is added.

$T_B \doteq$

solve for f where $T_A = 0$ (no tension at top)