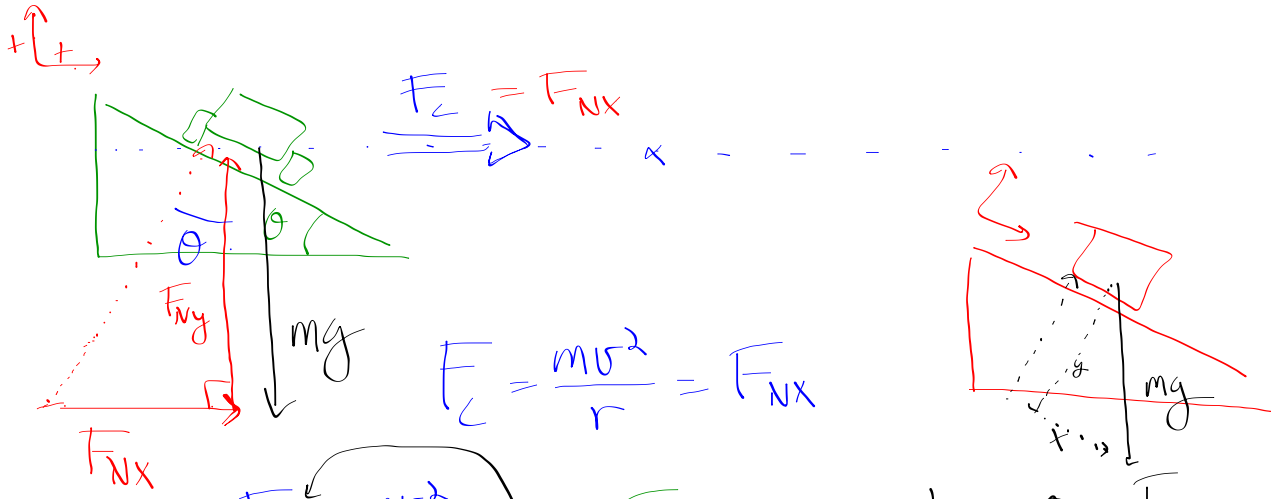
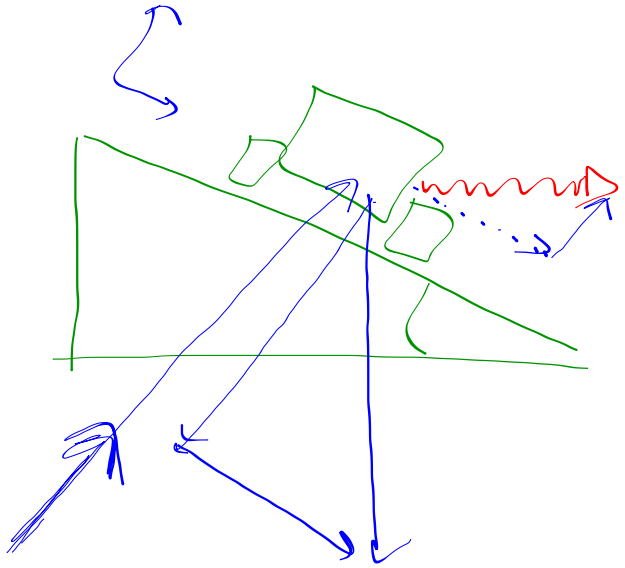
16. What must a curve with a radius of 60.0 m be banked at (i.e. what is the banking angle) for a car traveling at 60 km/h? Remember, banked curves are designed so that for a given speed, NO fricition would be require to safely get around the corner. (Although not required, a more interesting, and difficult problem, would be to determine what the coefficient of static friction needs to be for a car not to skid when traveling at 90 km/h around this same curve, banked at the angle you determine in solving this problem).

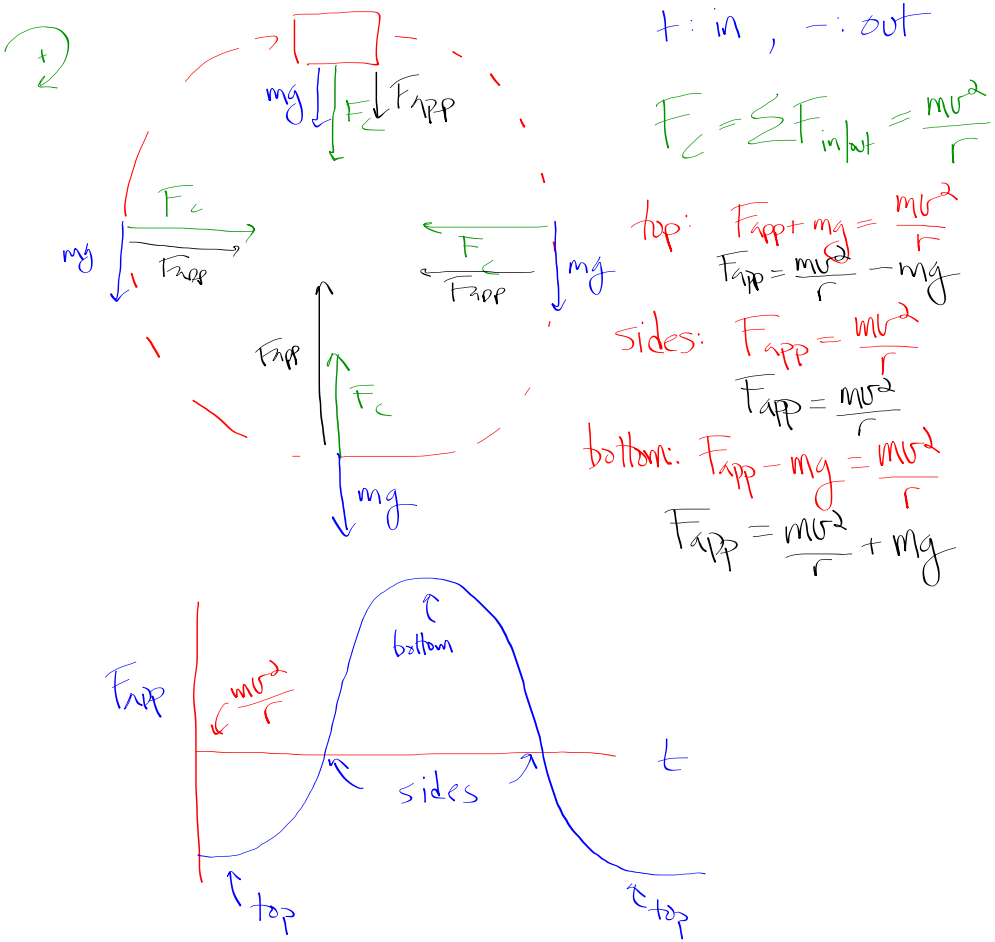


$$\theta = \tan^{-1}\frac{v^2}{r \cdot g}$$

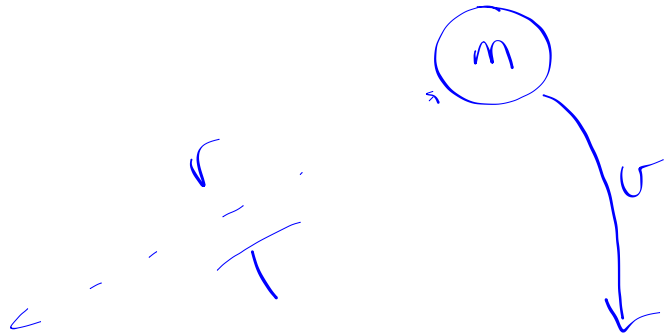


Vertical Circular Motion:

To maintain a constant centripetal (towards the center!) force, we must account for the fact that the direction of the gravitational force is always the same. Therefore, whatever other forces that are providing the centripetal force must be constantly changing in both direction AND magnitude.



EXAMPLE 1: A 7.0 kg mass at the end of a 116.0 cm string is spun in a vertical circle. The mass moves with a speed of 4.5 m/sec. What is the tension in the string when the mass is at the top of its travel? At the bottom?



top: $T = \frac{mv^2}{r} - mg$

$= \frac{(7)(4.5)^2}{1.16} - (7)(9.8)$

$= 53.6\ N$

bottom: $T = \frac{mv^2}{r} + mg$

$= \frac{(7)(4.5)^2}{(1.16)} + (7)(9.8)$

$= 190.8\ N$

EXAMPLE 2: A 4.0 lb object is swung in a vertical circle having a radius of 2.3 feet. At what speed will the string just begin to go slack? Where is the object along its circular path when the string first goes slack?

↳ at the top

$T = 0$

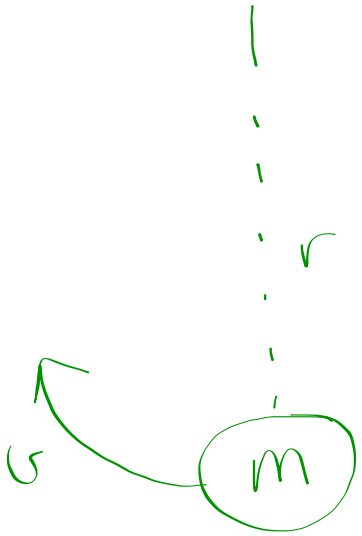
top: $T = \frac{mv^2}{r} - mg$

$0 = \frac{v^2}{r} - g$

$v = \sqrt{g \cdot r}$

EXAMPLE 3: For the previous problem, if the string breaks at 110.0 lbs, at what speed will the string break?

$T = 110$ lbs . . .



$$T = \frac{mv^2}{r} + mg$$

EXAMPLE 4: An airplane finds itself at the bottom of a circular dive having a radius of 1390 meters. The plane is traveling at 245 m/s.
a) What is the apparent weight of a 70-kg person when at the bottom of the dive?
b) How many g's does the person experience at this moment?

apparent weight: what a scale reads

$F_N = F_{app}$

$1g = 9.8\ m/s^2$

$F_{app} = F_N$ = apparent weight

$$g's = \frac{\text{acceleration in } m/s^2}{9.8}$$

EXAMPLE 6: A 590-gram rolling ball on a track attempts to do a loop-d-loop. If the loop has a radius of 80.0 centimeters, what minimum speed must the ball have?

Hint: Minimum speed is the speed at which gravity will apply all of the force necessary to keep the ball in uniform circular motion. This will occur when Fapp = 0 at the top of the loop. (Any slower than that and the force of gravity will be greater than the necessary centripetal force, and the ball will fall out of uniform circular motion!)