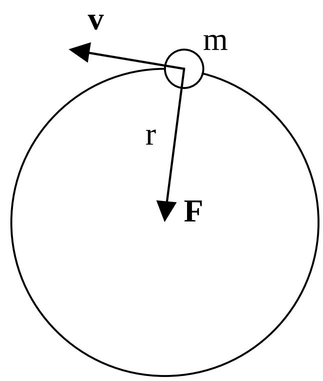
CHAPTER 6 CIRCULAR MOTION

CENTRIPETAL FORCE

The force **F** necessary to keep a body in uniform circular motion is defined as the centripetal force. The magnitude of the force is $F = m v^2/r$ and it is directed to the center of rotation. If F were not present object *m* would move along it's velocity vector **v**.

F can be produced by gravitational attraction, a string, or a roadbed pushing on a tire.

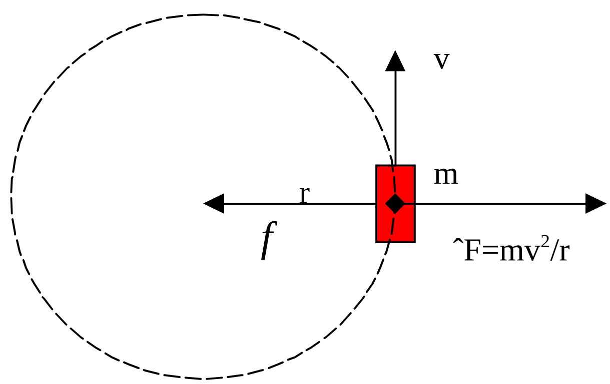


EXIT RAMP (see examples 6-4 and 6-5)

A curved exit ramp is normally inclined to facilitate a higher speed of exit with no slippage. Consider a car of mass m moving with velocity v along a curved path of radius R. There is static friction μ_k between the tire and road. This frictional force $f = \mu_k N$ must oppose the outward $m v^2/r$ force. Then the maximum velocity before slippage is

$$mv^2/r = f = \mu_k N = \mu_k mg$$

$$\boxed{v_{max} = (r \; g \, \mu_k)^{1/2}}$$



If the exit ramp is inclined the forces opposing slippage can be increased.

$$mv^2/r = N \sin\theta + f \cos\theta$$

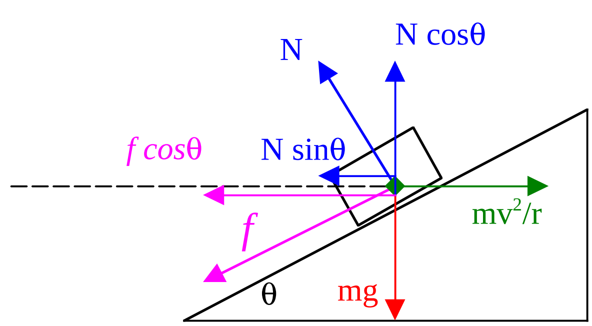
$$mg = N \cos\theta$$

We can determine the banking angle under extreme conditions $f = 0$ (ice!!), thus not relying on frictional forces.

$$m\, v^2/r = N \sin\theta$$

$$m\, g = N \cos\theta$$

$$\boxed{\tan\theta = v^2/r\, g \quad \text{or} \quad v_{max} = (r\, g \tan \theta)^{1/2}}$$



LOOP-THE-LOOP (see example 6-7)

Consider a pilot making a vertical loop in an airplane at speed constant speed v. What forces does he aircraft experience? How does he avoid a stall at position A?

Let P be the force of lift on the aircraft wing (the same as the normal force on the pilot in example 6-7). Zero net force insures uniform motion at each location. P changes direction to balance the weight and centripetal force.

A: $P + mg = mv^2/r$ à $P = mv^2/r - mg$ (lightest)

B: $P = ((mv^2/r)^2 + (mg)^2)^{1/2}$

C: $P = mv^2/r + mg$ à $P = mv^2/r + mg$ (heaviest)

D: $P = ((mv^2/r)^2 + (mg)^2)^{1/2}$

A stall condition occurs If P=0 (freefall) at the top (A).

Then $mv^2/r = mg$

$v > (rg)^{1/2}$ or stall