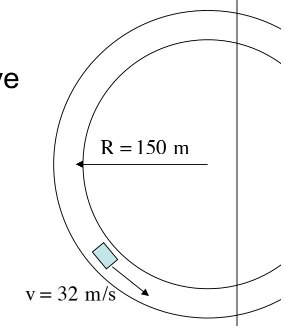
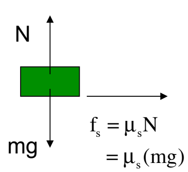
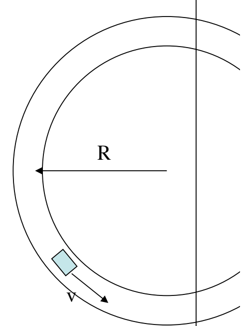
Problem 7.23

A truck can just make it around a 150 m curve moving at 32 m/s. What would its maximum speed be if the radius had been 75 m.

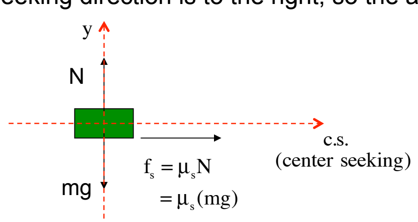


Looking at the car from the front, our f.b.d. looks like:





The center-seeking direction is to the right, so the axes look like:



Newton's Second Law yields:

$$\sum F_y$$
$$N - mg = ma_y$$
$$\Rightarrow N = mg$$

$$\sum F_{c.s.}$$
$$\mu_s N = ma_{c.s.}$$
$$\Rightarrow \mu_s (mg) = m\left(\frac{v^2}{R}\right)$$
$$\Rightarrow v = \sqrt{\mu_s g R}$$

We aren't given the coefficient of friction, but we do know that when R=150 meters, the maximum velocity is 32 m/s. Using that to determine the coefficient of friction yields:

$$v = \sqrt{\mu_s \quad g \quad R}$$
$$(32 \text{ m/s}) = \sqrt{\mu_s (9.8 \text{ m/s}^2)(150 \text{ m})}$$
$$\Rightarrow \mu_s = .697$$

With the coefficient of friction, the maximum velocity for a curve radius of 75 meters becomes:

$$v = \sqrt{\mu_s \quad g \quad R}$$
$$= \sqrt{(.697)(9.8 \text{ m/s}^2)(75 \text{ m})}$$
$$\Rightarrow v_{max} = 22.6 \text{ m/s}$$

Interesting note: Because the radii are in a ratio of 2 to 1, that doesn't mean the velocities will be in that ratio. The problem is in the fact that the velocity is proportional to the square root of R, not R itself!