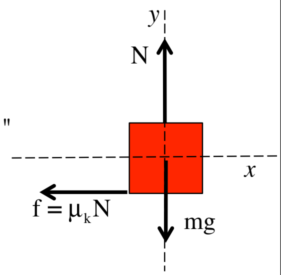
Problem 5.38

A car moves at 50 mi/hr stops in the rain.

a.) What is the minimum stopping distance on the road (when wet) if the coefficient of friction between the road and tires is .1?

A f.b.d. for the car as it is stopping is shown to the right with N.S.L. presented for both axes shown below. Notice I've written the frictional force both as "f" and as "$\mu_k N$". I've done this because when I sum the forces along that line, I prefer to put "$\mu_k N$" into the expression straight away, thereby circumventing the need for a substitution later. I also do the "normal direction" first as we need its magnitude to determine the magnitude of the frictional force (and remember, "N" isn't *always* "mg!"). So, in this case:



$$\underline{\sum F_x :}$$

$$N - mg = ma_y$$

$$\Rightarrow \quad N = mg$$

Summing up the forces in the *x-direction*, then substituting in for "N," we get:

$$\underline{\sum F_x :}$$

$$\mu_k N = ma$$

$$\Rightarrow \quad \mu_k (mg) = ma$$

$$\Rightarrow \quad a = \mu_k g$$

$$= (.100)(9.80 \text{ m/s}^2)$$

$$= .980 \text{ m/s}^2$$

After some unit conversion, and noting that the acceleration is negative, we can use:

$$(v_2)^2 = \cancelto{0}{(v_1)^2} + 2a(\Delta x)$$

$$\Rightarrow \quad \Delta x = -\frac{(v_2)^2}{2a}$$

$$= -\frac{\left[(50.0 \text{ mi/hr})\left(\frac{(1.00 \text{ hr})}{(3.60\text{x}10^3 \text{ s})}\right)\frac{(1.61\text{x}10^3 \text{ m})}{(1.00 \text{ mi})}\right]^2}{2(-.980 \text{ m/s}^2)}$$

$$= 255 \text{ m}$$

b.) If the coefficient of friction had been .600, then what?

Combining our N.S.L. findings with our kinematics expression, we get:

$$\cancelto{0}{(v_2)^2} = (v_1)^2 + 2a(\Delta x)$$

$$\Rightarrow \quad \Delta x = -\frac{(v_2)^2}{2(-\mu_k g)}$$

$$= \frac{\left[(50.0 \text{ mi/hr})\left(\frac{(1.00 \text{ hr})}{(3.60\text{x}10^3 \text{ s})}\right)\frac{(1.61\text{x}10^3 \text{ m})}{(1.00 \text{ mi})}\right]^2}{2(.600)(9.80 \text{ m/s}^2)}$$

$$= 42.5 \text{ m}$$