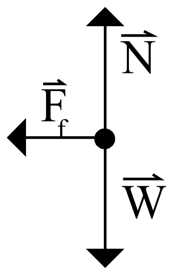
Chapter 5 Problem 54 [†]



Given
$\mu_k = 0.71$
$\Delta x = 47\ m$
$v_f = 25\ km/h = 6.94\ m/s$

Solution
Find the initial speed of the car.

From the free-body diagram given above and using Newton's 2^{nd} law gives

$$\Sigma \vec{F} = m\vec{a}$$

$$\vec{F}_f + \vec{W} + \vec{N} = m\vec{a}$$

Choose the coordinate system so that the x axis is in the horizontal direction. The acceleration will also be in the x direction. Writing out the equation in unit vector notation gives

$$-\mu_k N\hat{i} - mg\hat{j} + N\hat{j} = ma\hat{i}$$

The x-component of this equation is

$$-\mu_k N = ma \tag{1}$$

and the y-component of this equation is

$$-mg + N = 0 \tag{2}$$

From equation (2) we see that the normal force is mg. Substitute this into equation (1) and solve for the acceleration.

$$-\mu_k(mg) = ma$$

$$a = -\mu_k g = -(0.71)(9.8\ m/s^2) = 6.96\ m/s^2$$

Now that we have the acceleration, the following kinematic equation can be used to find the initial velocity.

$$v_f^2 - v_i^2 = 2a\Delta x$$

$$v_i^2 = v_f^2 - 2a\Delta x$$

$$v_i = \sqrt{v_f^2 - 2a\Delta x} = \sqrt{(6.94\ m/s)^2 - 2(-6.96\ m/s^2)(47\ m)} = 26.5\ m/s$$

In terms of km/h this is $95.4\ km/h$. Converting this to miles per hour gives $59.4\ mi/h$.

[†]Problem from Essential University Physics, Wolfson