

Physics 1112 Homework #4 Study Problems Solutions

#5.35 [Stopping Distance] The car is moving to the right ($\rightarrow$) while slowing down, so its acceleration is to the left ($\leftarrow$). Since the car skids, the friction force is kinetic friction.

(a) Free-body diagram shown at the right:

Newton's 2nd Law: $\sum \vec{F} = m\vec{a}$

+y: $N - mg = ma_y = 0 \Rightarrow N = mg$

+x: $-f = ma_x$

Kinetic friction: $f = \mu_k N = \mu_k mg$

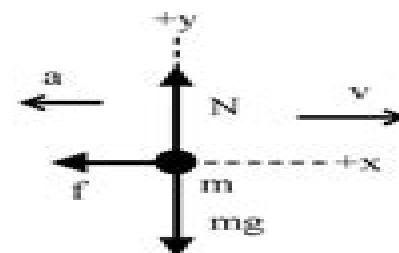
$\Rightarrow a_x = -f/m = -\mu_k g$

Find the stopping distance using the motion equation: $v_x^2 = v_{x0}^2 + 2a_x x = 0$

$$\Rightarrow x = -\frac{v_{x0}^2}{2a_x} = -\frac{v_{x0}^2}{2(-\mu_k g)} = \frac{v_{x0}^2}{2\mu_k g} = \frac{(28.7 \text{ m/s})^2}{2(0.80)(9.80 \text{ m/s}^2)} = 52.5 \text{ m}$$

(b) Use the previous result to solve for: $v_{x0} = \sqrt{2\mu_k g x} = \sqrt{2(0.25)(9.80 \text{ m/s}^2)(52.5 \text{ m})} = 16.0 \text{ m/s}$

$$= 16.0 \text{ m/s} \left(\frac{1 \text{ mi}}{1609 \text{ m}} \right) \left(\frac{3600 \text{ s}}{1 \text{ h}} \right) = 36 \text{ mi/h}$$



#1. [Box on Truck] (a) Free-body diagram for the box (assuming acceleration is $\rightarrow$ North):

What is the maximum acceleration such that the box doesn't slide?

+y: $N - mg = 0 \Rightarrow N = mg$

+x: $f_s = ma$ Static friction: $f_s \leq \mu_s N = \mu_s mg$

$$\Rightarrow a = \frac{f_s}{m} \leq \frac{\mu_s mg}{m} = \mu_s g = (0.30)(9.8 \text{ m/s}^2) = 2.94 \text{ m/s}^2$$

The box doesn't slide but accelerates with the truck at: $2.20 \text{ m/s}^2 \rightarrow$ North.

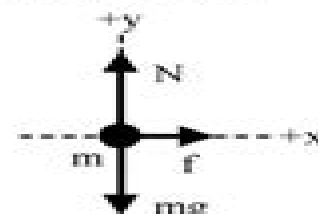
The friction force on the box is: $f_s = ma = (40.0 \text{ kg})(2.20 \text{ m/s}^2) = 88 \text{ N} \rightarrow$ North

(b) Since the truck's acceleration is $> 2.94 \text{ m/s}^2$, the box slides on the truck. Now the box is accelerated by kinetic friction: $f_k = \mu_k N = \mu_k mg$ with acceleration $a = f_k/m = \mu_k g = (0.20)(9.8 \text{ m/s}^2) = 1.96 \text{ m/s}^2$.

Now the box's acceleration is: $1.96 \text{ m/s}^2 \leftarrow$ South. (In the free-body diagram, f now points $\leftarrow$.)

The box's acceleration is South, in the same direction the truck is accelerating (South), but opposite to the direction the truck is moving (North) as it slows down.

The friction force on the box is: $f_k = \mu_k mg = (0.20)(40.0 \text{ kg})(9.8 \text{ m/s}^2) = 78 \text{ N} \leftarrow$ South



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