Sample: Physics - Mechanical Problems

Problem 6.3

A baseball player slides into third base with an initial speed of $4.4\mathrm{m/s}$.

Part A

If the coefficient of kinetic friction between the player and the ground is 0.48, how far does the player slide before coming to rest?

Express your answer using two significant figures.

$\Delta x =$ reset shortcuts help m

Solution:

Given:

$v_i = 4.4$ m/s,

$v_f = 0$ (final speed)

$\mu = 0.48$,

$d = \Delta x = ?$

The equation of motion is

$$-F = ma$$

The force of kinetic friction is given by

$$F = \mu N$$

where μ is coefficient of kinetic friction, and N is the normal force that presses the sliding object to the surface.

If the object is sliding on a level surface, N=mg,

where g is the gravity acceleration constant (9.81 m/s^2).

Thus,

$$-\mu mg = ma$$
$$a = -\mu g$$

The distance is

$$d = \frac{{v_f}^2 - {v_i}^2}{2a} = \frac{{v_f}^2 - {v_i}^2}{-2\mu g} = \frac{-4.4^2}{-2 \cdot 0.48 \cdot 9.81} = 2.06 = 2.1 \text{ m}$$

Answer. $\Delta x = 2.1$ m.

Problem 6.12

IP A 45-kg crate is placed on an inclined ramp. When the angle the ramp makes with the horizontal is increased to 27° , the crate begins to slide downward.

Part A

What is the coefficient of static friction between the crate and the ramp?

Express your answer using two significant figures.

$\mu_s =$ reset shortcuts help

Solution:

Given:

$m = 45$ kg,

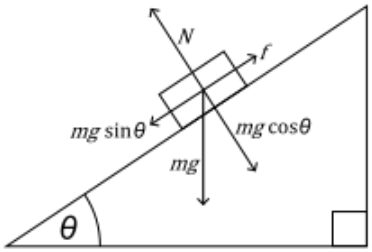
$\theta = 27°$,

$\mu_s = ?$,

The coefficient of static friction looks like

$$\mu_s = \frac{F_{smax}}{N}$$

The maximum force of static friction is used because static friction has a whole range from zero newtons up to the maximum force of static friction.



The friction force is

$$F_{smax} = mg \sin\theta$$

The normal force N is

$$N = mg \cos\theta$$

Thus,

$$\mu_s = \frac{F_{smax}}{N} = \frac{mg \sin\theta}{mg \cos\theta} = \tan\theta$$

$$\mu_s = \tan 27° = 0.51$$

Answer. $\mu_s = 0.51$

Part B

At what angle does the crate begin to slide if its mass is doubled?

Express your answer using two significant figures.

Solution:

The coefficient of static friction does not depend on the object's mass.

$$\mu_s = \tan\theta$$

Thus,

$$\theta' = \tan^{-1}\mu_s = \tan^{-1} 0.51 = 27°$$

Answer. $\theta' = 27°$.

Problem 6.14

A person places a cup of coffee on the roof of her car while she dashes back into the house for a forgotten item. When she returns to the car, she hops in and takes off with the coffee cup still on the roof.

Part A

If the coefficient of static friction between the coffee cup and the roof of the car is 0.24, what is the maximum acceleration the car can have without causing the cup to slide? Ignore the effects of air resistance.

Express your answer using two significant figures.

$a =$ [$\sqrt{\square}$ $\alpha\beta$ $\Sigma\Delta$ reset shortcuts help] $\mathrm{m/s^2}$

Solution:

Given:

$\mu_s = 0.24,$

$a = ?$

The coefficient of static friction is

$$\mu_s = \frac{F_{smax}}{N}$$

The force is

$$F_{smax} = ma$$

If the object is sliding on a level surface, N=mg, where g is the gravity acceleration constant (9.81 $\mathrm{m/s^2}$).

Thus,

$$ma = \mu_s mg$$

The acceleration is

$$a = \mu_s g = 0.24 \cdot 9.81 = 2.354 = 2.4\ \mathrm{m/s^2}$$

Answer. $a = 2.4\ \mathrm{m/s^2}$.

Part B

What is the smallest amount of time in which the person can accelerate the car from rest to $14\,\mathrm{m/s}$ and still keep the coffee cup on the roof?

Express your answer using two significant figures.

Solution:

Given:

$v_i = 0$ m/s, (initial speed)

$v_f = 14$ (final speed),

$a = 2.4\ \mathrm{m/s^2}$,

$t = ?$

The time is

$$t = \frac{v_f - v_i}{a} = \frac{14 - 0}{2.4} = 5.8\ s$$

Answer. $t = 5.8\ s$