Name:_____Class:_____ Date: _____

Problem E

OVERCOMING FRICTION

PROBLEM

A bicyclist riding in the rain suddenly applies the brakes and slides to a stop. If the acceleration is –9.5 m/s^2, what is the coefficient of kinetic friction between the bicycle's rubber tires and the wet concrete?

SOLUTION

1. **DEFINE**

Given: $a_{net} = -9.5 \text{ m/s}^2$

$g = 9.81 \text{ m/s}^2$

Unknown: $\mu_k = ?$

2. **PLAN** **Choose the equation(s) or situation:** Use Newton's second law to describe the forces acting on the bicycle.

$$F_{net} = m\, a_{net} = -F_k$$

Use the definition of frictional force to express F_k in terms of the coefficient of friction.

$$F_k = \mu_k F_n = \mu_k (mg)$$

Rearrange the equation(s) to isolate the unknown(s):

$$m\, a_{net} = -\mu_k mg$$

$$\mu_k = -\frac{a_{net}}{g}$$

3. **CALCULATE** **Substitute the values into the equation(s) and solve:**

$$\mu_k = \frac{-(-9.5 \text{ m/s}^2)}{9.81 \text{ m/s}^2}$$

$$\mu_k = \boxed{0.97}$$

4. **CALCULATE** The coefficient of static friction for rubber and most surfaces is high. This is indicated by the value for rubber and wet concrete. Even under these conditions, μ_s is nearly 1.

ADDITIONAL PRACTICE

1. Blocks of ice are slid down a metal chute with an incline of 12.0° above the horizontal. The blocks undergo a constant acceleration of 1.22 m/s^2. What is the coefficient of kinetic friction between the ice and the chute?
2. **A force of 1760 N is required to start moving a bundle of wooden planks up a ramp. If the ramp's incline is 17° and the mass of the planks is 266 kg, what is the coefficient of static friction between the planks and the ramp?**

3. A bundle of bricks is pulled up a ramp to a construction site. The bundle has a mass of 5.1×10^2 kg, and the incline of the ramp is 14°. If the minimum force needed to move the bricks up the ramp is 4.1×10^3 N, what is the coefficient of static friction between the bricks and the ramp?

4. A force of 5.00 N to the left causes a 1.35 kg book to have a net acceleration of 0.76 m/s^2 to the left. What is the frictional force acting on the book?

5. A jar is slid horizontally across a smooth table. If the coefficient of kinetic friction between the jar and the table is 0.20, what is the magnitude of the jar's acceleration?

6. A skier is pulled by an applied force of 2.50×10^2 N up a slope with an incline of 18.0°. If the combined mass of the skier and skis is 65.0 kg and the net acceleration uphill is 0.44 m/s^2, what is the frictional force between the skis and the snow?

7. If the skier in problem 6 skis down the same hill, what will the skier's acceleration be?

8. A crate is pushed across a level floor by a force of 3.00×10^2 N exerted at an angle of 20.0° below the horizontal. The coefficient of kinetic friction between the crate and floor is 0.250. If the crate's velocity is constant, what is the magnitude of the normal force exerted on the crate by the floor? What is the mass of the crate?

9. A horse must exert a force of 590 N just to keep a sleigh from sliding down a snowcovered hill. The component of the sleigh's weight down the slope of the hill is 950 N, and the coefficient of static friction between the sleigh's runners and the snow is 0.095. What is the normal force exerted by the ground on the sleigh? What is the sleigh's mass if the slope of the hill is 14.0°?

10. A freight elevator accelerates upward at 1.20 m/s^2. A crate is lifted inside the elevator. In order to move the crate along the floor of the elevator, a worker must exert a force of 1.50×10^3 N at an angle of 10.0° below the horizontal on the upper corner of the crate. If the coefficient of static friction is 0.650, what is the normal force that the elevator floor exerts on the crate? What is the crate's mass?