

Friction and Gravity

Reading Preview

Key Concepts

- What factors determine the strength of the friction force between two surfaces?
- What factors affect the gravitational force between two objects?
- Why do objects accelerate during free fall?

Key Terms

- friction • static friction
- sliding friction
- rolling friction • fluid friction
- gravity • mass • weight
- free fall • air resistance
- terminal velocity • projectile



Target Reading Skill

Comparing and Contrasting As you read, compare and contrast friction and gravity by completing a table like the one below.

	Friction	Gravity
Effect on motion	Opposes motion	
Depends on		
Measured in		

Lab zone

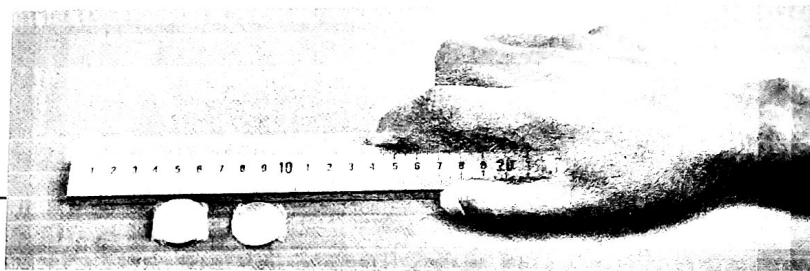
Discover Activity

Which Lands First?

1. Stack three quarters. Wrap tape around the quarters to hold them tightly together. Place the stack of quarters next to a single quarter near the edge of a desk.
2. Put a ruler flat on the desk behind the coins. Line it up parallel to the edge of the desk and just touching the coins.
3. Keeping the ruler parallel to the edge of the desk, push the coins over the edge at the same time. Observe how long the coins take to land.

Think It Over

Predicting Did you see a difference in the time the coins took to fall? Use what you observed to predict whether a golf ball will fall more quickly than a table tennis ball. Will a pencil fall more quickly than a book? How can you test your predictions?



What happens when you jump on a sled on the side of a snow-covered hill? You can predict that the sled will slide down the hill. Now think about what happens at the bottom of the hill. Does the sled keep sliding? You can predict that the sled will slow down and stop.

Why does the sled's motion change on the side of the hill and then again at the bottom? In each case, unbalanced forces act on the sled. The force of gravity causes the sled to accelerate down the hill. The force of friction eventually causes the sled to stop. These two forces affect many motions on Earth.

◀ Friction and gravity both act on the sled.

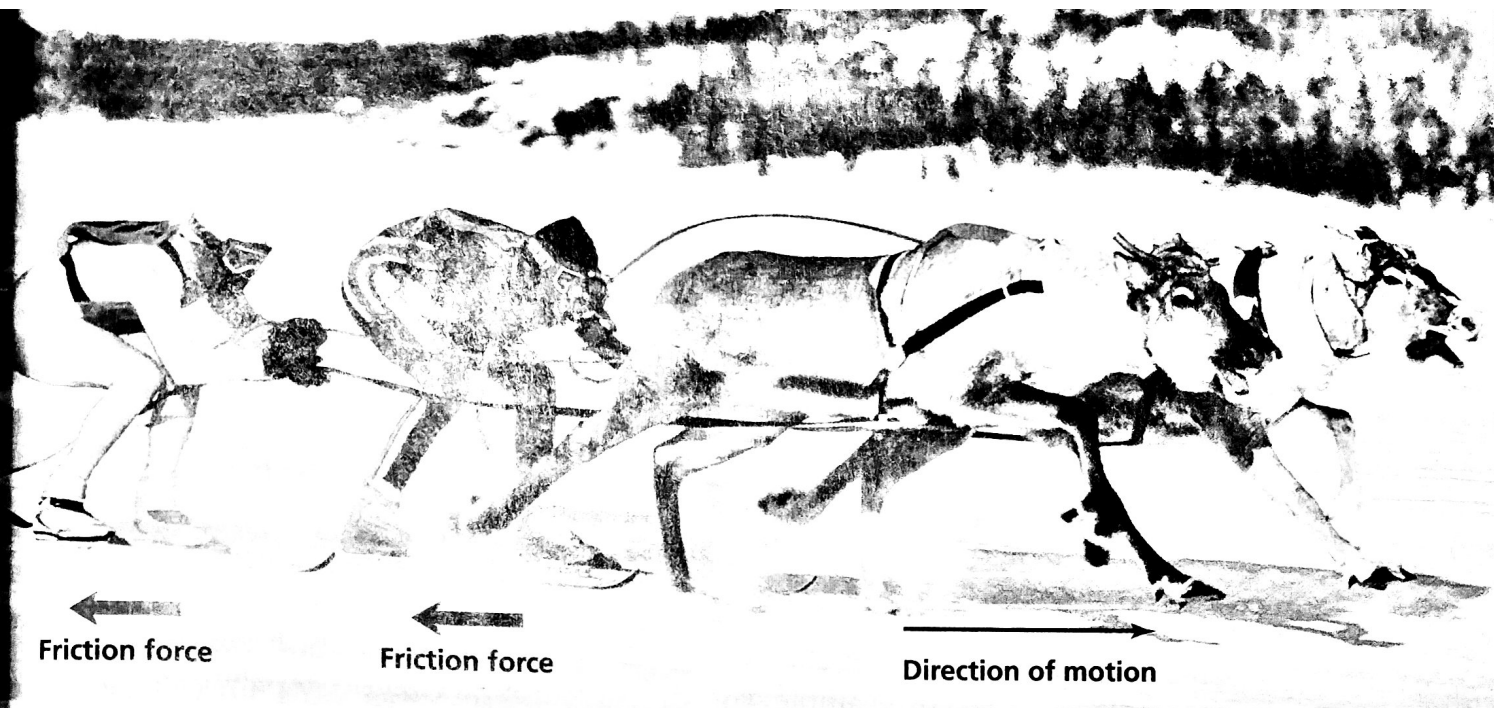


FIGURE 4

Friction and Smooth Surfaces The smooth surfaces of the skis make for a fast ride for these Finnish skiers. *Relating Diagrams and Photos* How does the direction of friction compare to the direction of motion?

Friction

When a sled moves across snow, the bottom of the sled rubs against the surface of the snow. In the same way, the skin of a firefighter's hands rubs against the polished metal pole during the slide down the pole. The force that two surfaces exert on each other when they rub against each other is called **friction**.

The Causes of Friction In general, smooth surfaces produce less friction than rough surfaces. **The strength of the force of friction depends on two factors: how hard the surfaces push together and the types of surfaces involved.** The skiers in Figure 4 get a fast ride because there is very little friction between their skis and the snow. The reindeer would not be able to pull them easily over a rough surface such as sand. Friction also increases if surfaces push hard against each other. If you rub your hands together forcefully, there is more friction than if you rub your hands together lightly.

A snow-packed surface or a metal firehouse pole may seem quite smooth. But, as you can see in Figure 5, even the smoothest objects have irregular, bumpy surfaces. When the irregularities of one surface come into contact with those of another surface, friction occurs. Friction acts in a direction opposite to the direction of the object's motion. Without friction, a moving object might not stop until it strikes another object.



FIGURE 5

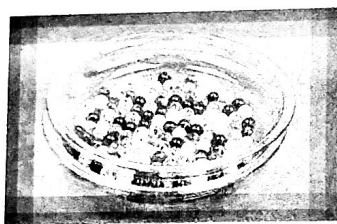
A Smooth Surface?

If you look at the polished surface of an aluminum alloy under a powerful microscope, you'll find that it is actually quite rough.

Spinning Plates

You can compare rolling friction to sliding friction.

1. Stack two identical pie plates together. Try to spin the top plate.
2. Now separate the plates and fill the bottom of one pie plate loosely with marbles.



3. Place the second plate in the plate with marbles.
4. Try to spin the top plate again. Observe the results.

Drawing Conclusions What applications can you think of for the rolling friction modeled in this activity?

Static Friction Four types of friction are shown in Figure 6. The friction that acts on objects that are not moving is called **static friction**. Because of static friction, you must use extra force to start the motion of stationary objects. For example, think about what happens when you try to push a heavy desk across a floor. If you push on the desk with a force less than the force of static friction between the desk and the floor, the desk will not move. To make the desk move, you must exert a force greater than the force of static friction. Once the desk is moving, there is no longer any static friction. However, there is another type of friction—sliding friction.

Sliding Friction Sliding friction occurs when two solid surfaces slide over each other. Sliding friction can be useful. For example, you can spread sand on an icy path to improve your footing. Ballet dancers apply a sticky powder to the soles of their ballet slippers so they won't slip on the dance floor. And when you stop a bicycle with hand brakes, rubber pads slide against the tire surfaces, causing the wheels to slow and eventually stop. On the other hand, sliding friction is a problem if you fall off your bike and skin your knee!

Rolling Friction When an object rolls across a surface, **rolling friction** occurs. Rolling friction is easier to overcome than sliding friction for similar materials. This type of friction is important to engineers who design certain products. For example, skates, skateboards, and bicycles need wheels that move freely. So engineers use ball bearings to reduce the friction between the wheels and the rest of the product. These ball bearings are small, smooth steel balls that reduce friction by rolling between moving parts.

Fluid Friction Fluids, such as water, oil, or air, are materials that flow easily. **Fluid friction** occurs when a solid object moves through a fluid. Like rolling friction, fluid friction is easier to overcome than sliding friction. This is why the parts of machines that must slide over each other are often bathed in oil. In this way, the solid parts move through the fluid instead of sliding against each other. When you ride a bike, fluid friction occurs between you and the air. Cyclists often wear streamlined helmets and specially designed clothing to reduce fluid friction.

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Reading
Checkpoint

What are two ways in which friction can be useful?

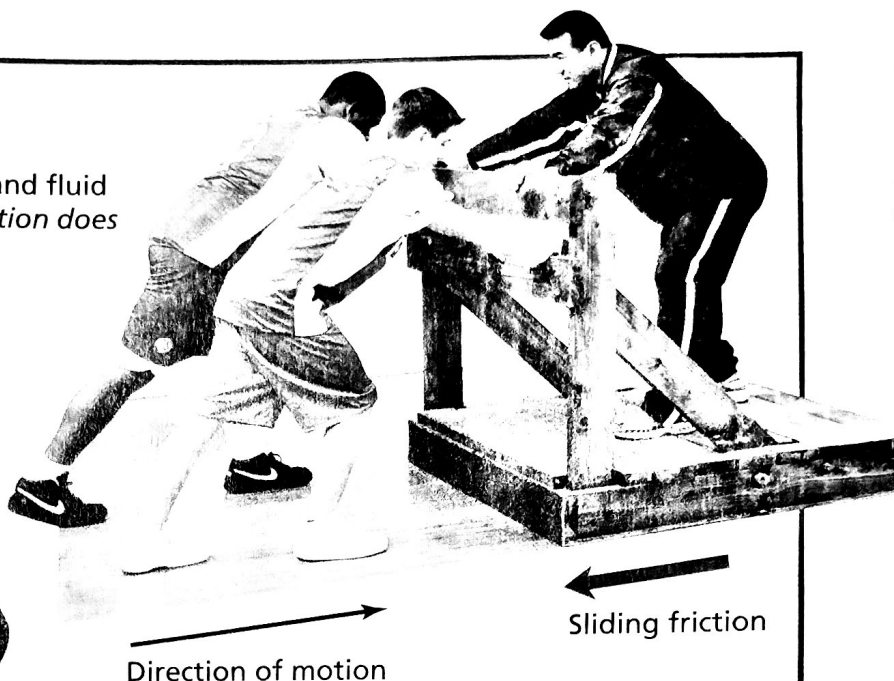
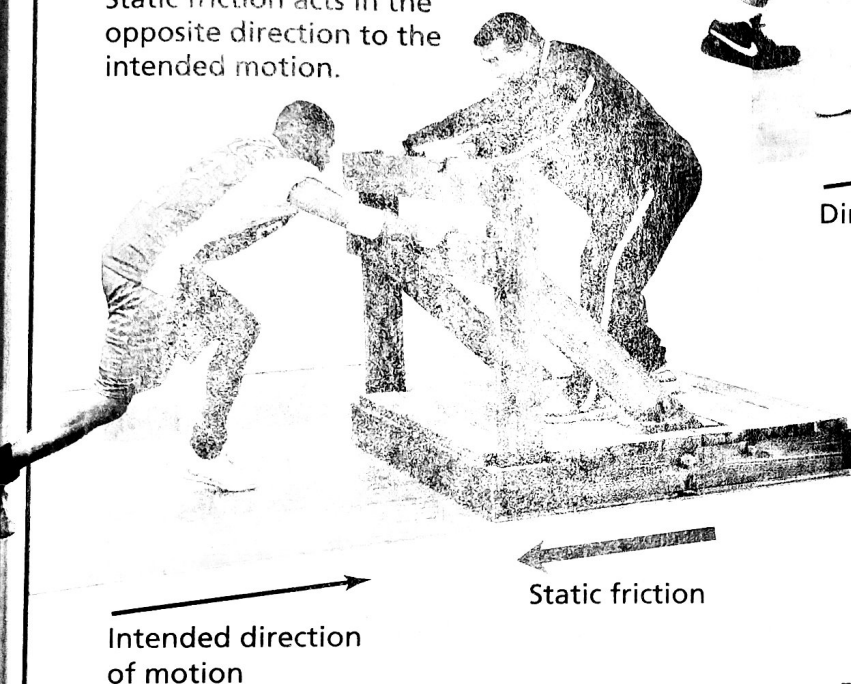
FIGURE 6

Types of Friction

Types of friction include static, sliding, rolling, and fluid friction. *Making Generalizations* In what direction does friction act compared to an object's motion?

Static Friction ▼

To make the sled move, the athlete first has to overcome the force of static friction. Static friction acts in the opposite direction to the intended motion.

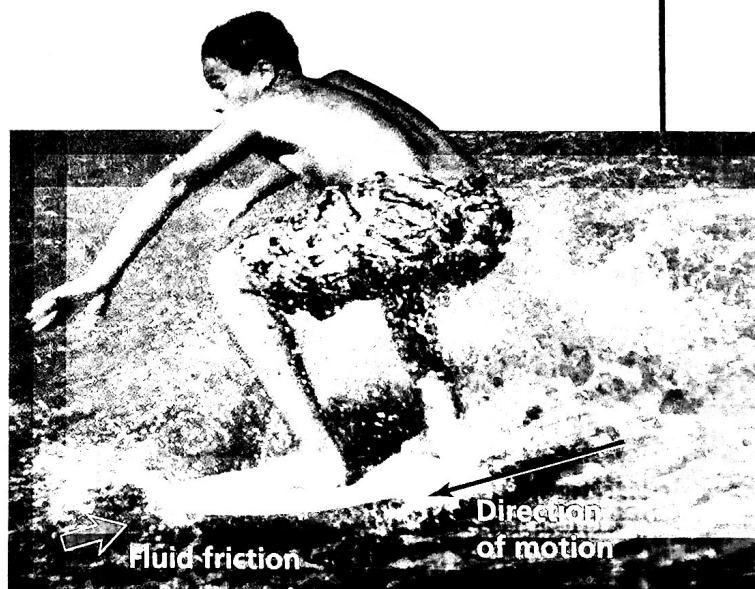
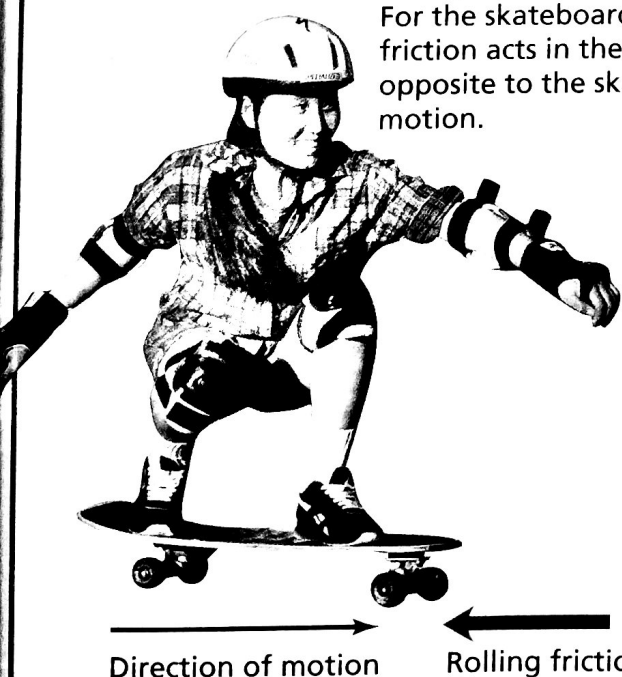


Sliding Friction ▲

Once the sled is moving, it slides over the floor. Sliding friction acts between the sled and the floor in the opposite direction to the sled's motion.

Rolling Friction ▼

Rolling friction occurs when an object rolls over a surface. For the skateboarder, rolling friction acts in the direction opposite to the skateboard's motion.



Fluid Friction ▲

When an object pushes fluid aside, friction occurs. The surfer must overcome the fluid friction of the water.