



Chapter Five: Force

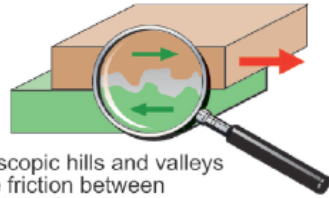
- **5.1 Forces**
- **5.2 Friction**
- **5.3 Forces and Equilibrium**



Chapter 5.2 Learning Goals

- Define friction.
- Identify causes of friction.
- Distinguish among various types of friction.

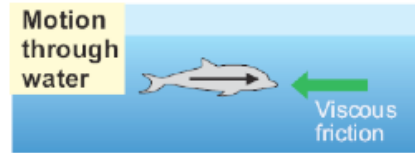
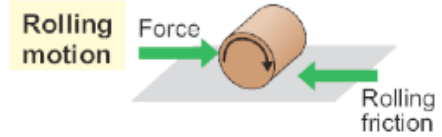
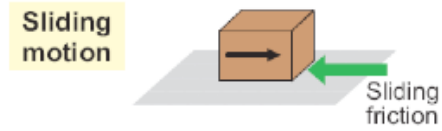
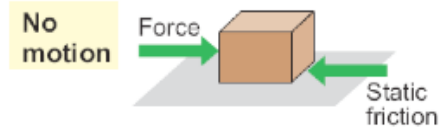
5.2 Friction



Microscopic hills and valleys cause friction between smooth surfaces.

- **Friction is a force that resists the motion of objects or surfaces.**
- **Many kinds of friction exist.**

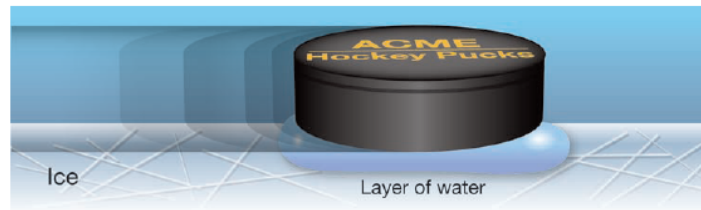
5.2 Friction





5.2 Friction and two surfaces

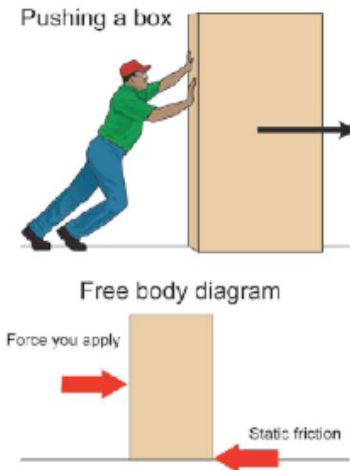
- Friction depends on both of the surfaces in contact.
- When the hockey puck slides on ice, a thin layer of water between the rubber and the ice allows the puck to slide easily.





5.2 Identifying friction forces

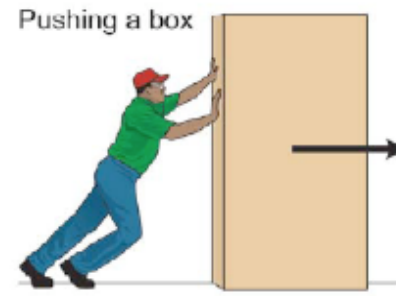
- Friction is a force, measured in newtons just like any other force.
- Static friction keeps an object at rest from moving.





5.2 Identifying friction forces

- Sliding friction is a force that resists the motion of an object moving across a surface.





5.2 A model for friction

- Friction depends on a material's properties such as roughness, how clean the surfaces are, and other factors.
- The greater the force squeezing two surfaces together, the greater the friction force.

It takes very little force to slide paper across a table.

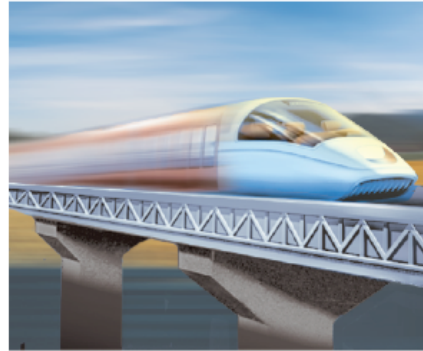


Adding a brick on top of the paper greatly increases the friction force.





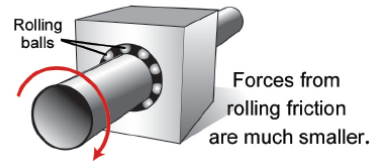
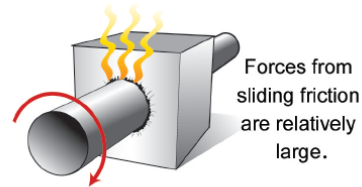
5.2 Reducing the force of friction



- Unless a force is constantly applied, friction will slow all motion to a stop eventually.
- It is impossible to completely get rid of friction, but it can be reduced.



5.2 Reducing the force of friction

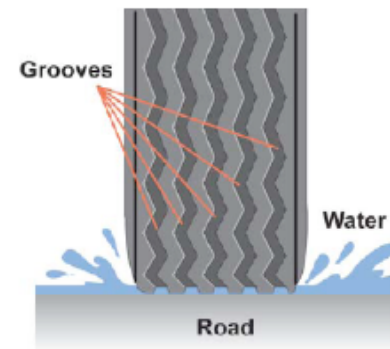


- The friction between a shaft (the long pole in the picture) and an outer part of a machine produces a lot of heat.
- Friction can be reduced by placing ball bearings between the shaft and the outer part.



5.2 Using friction

- Friction is also important to anyone driving a car.
- Grooved tire treads allow space for water to be channeled away from the road-tire contact point, allowing for more friction in wet conditions.





5.2 Using friction



- Shoes are designed to increase the friction between their soles and the ground.

How do you think these shoes increase friction?



5.2 Friction and energy

Why does rubbing your hands together make them warmer?



- Friction changes energy of motion into heat energy.



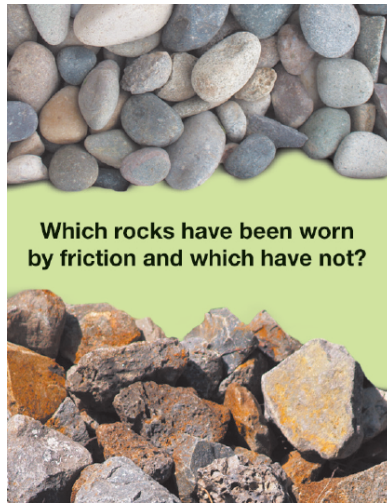
5.2 Friction and energy

- Friction is always present in any machine with moving parts.
- If the machine is small, or the forces are low, the amount of heat produced by friction may also be small.





5.2 Friction and energy



- Each time two moving surfaces touch each other, tiny bits of material are broken off by friction.
- Breaking off bits of material uses energy.