

There are four fundamental forces

At the microscopic level, friction results from interactions between the protons and electrons in atoms and molecules. Magnetic force also results from atomic phenomena. These forces are classified as *electromagnetic forces*. The electromagnetic force is one of four fundamental forces in nature. The other three fundamental forces are gravitational force, the strong nuclear force, and the weak nuclear force. All four fundamental forces are field forces.

The strong and weak nuclear forces have very small ranges, so their effects are not directly observable. The electromagnetic and gravitational forces act over long ranges. Thus, any force you can observe at the macroscopic level is either due to gravitational or electromagnetic forces.

The strong nuclear force is the strongest of all four fundamental forces. Gravity is the weakest. Although the force due to gravity holds the planets, stars, and galaxies together, its effect on subatomic particles is negligible. This explains why electric and magnetic effects can easily overcome gravity. For example, a bar magnet has the ability to lift another magnet off a desk.

SECTION REVIEW

1. Draw a free-body diagram for each of the following objects:
 - a. a projectile accelerating downward in the presence of air resistance
 - b. a crate being pushed across a flat surface at a constant speed
2. A bag of sugar has a mass of 2.26 kg.
 - a. What is its weight in newtons on the moon, where the acceleration due to gravity is one-sixth that on Earth?
 - b. What is its weight on Jupiter, where the acceleration due to gravity is 2.64 times that on Earth?
3. A 2.0 kg block on an incline at a 60.0° angle is held in equilibrium by a horizontal force.
 - a. Determine the magnitude of this horizontal force. (Disregard friction.)
 - b. Determine the magnitude of the normal force on the block.
4. A 55 kg ice skater is at rest on a flat skating rink. A 198 N horizontal force is needed to set the skater in motion. However, after the skater is in motion, a horizontal force of 175 N keeps the skater moving at a constant velocity. Find the coefficients of static and kinetic friction between the skates and the ice.
5. **Critical Thinking** The force of air resistance acting on a certain falling object is roughly proportional to the square of the object's velocity and is directed upward. If the object falls fast enough, will the force of air resistance eventually exceed the weight of the object and cause the object to move upward? Explain.