

## 15.1: The Four Forces of Nature

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There are four fundamental forces in Nature:

- *Gravitational force.* The gravitational force is a force between any two bodies due to their mass. The gravitational force is the force responsible for keeping you attached to the floor at this moment: the Earth's mass is pulling you down toward its center, and your mass is attracting the Earth upward toward you. Without the gravitational force, you would be floating freely around the room.

The gravitational force is always attractive, and it is the weakest of the four forces. Gravity is described in more detail in Chapter 51.

- *Electromagnetic force.* The electromagnetic force is responsible for the attraction and repulsion of electric charges, and is also responsible for the magnetic force.

Most forces you encounter in everyday life (besides gravity) are electromagnetic in nature. When you push on something with your hand, for example, you are not really in direct contact with it: the outermost electrons of the atoms at the surface of the object are being electrically repelled by the outermost electrons in the atoms at the surface of your hand. Similarly, when you're standing on the floor, you're actually hovering a small distance above the floor: the outermost electrons at the bottom of your shoes are electrically repelling the outermost electrons at the top of the floor.

The classical theory of the electromagnetic force is given by *Maxwell's equations*, which you'll study in General Physics II. The most modern and comprehensive theory of the electromagnetic force is the theory of *quantum electrodynamics*, which you can learn about in a graduate course in physics.

- *Strong nuclear force.* The strong nuclear force is the force that holds together protons and neutrons in the atomic nucleus, and overpowers the electromagnetic mutual repulsion of the nuclear protons. It is also responsible for *nuclear fusion*, which is the process that causes the Sun to shine and is also present in the detonation of a hydrogen bomb.
- *Weak nuclear force.* The weak nuclear force is responsible for a process called  *$\beta$  decay*, in which a neutron in the atomic nucleus decays into a proton and an electron, and the electron escapes from the atom.

Every force we encounter in Nature is ultimately due to one of these four forces.

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