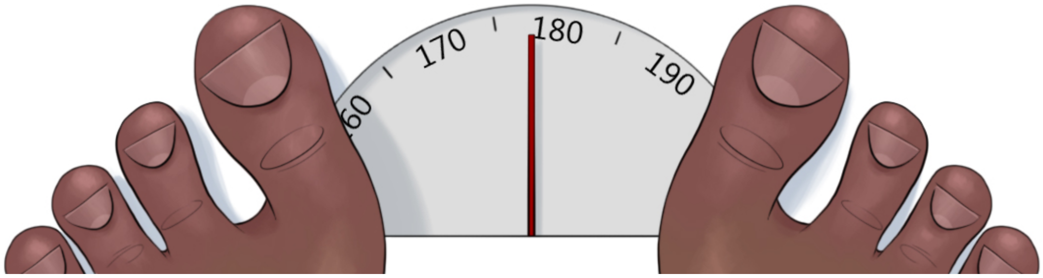


2.2: Forces

Identify forces acting on objects.

What exactly are forces?

What is it that causes motion to change? A simple answer would be that force is required to produce any change in motion. We all have certain ideas about what a force is. For the purpose of this course, we will define a force as an interaction between two objects that results in a push or a pull. There are two important aspects of this definition. First, there must be two objects involved in order for a force to be present. One object (called the agent of the force) does the pushing or pulling, and the other object (referred to as the object of the force) is being pushed or pulled. Second, there may be more than one type of interaction between objects. Forces only deal with interactions that result in a push or a pull.

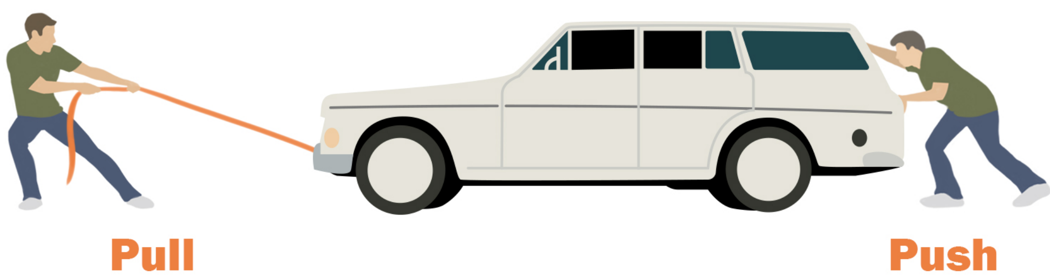


Fig. 2.4: Force is an interaction between two objects that results in a push or a pull.

Contact and Long-Range Forces

There are two types of forces—contact forces and long-range forces.

Contact forces occur when the interaction between two objects in direct contact (touching) results in a force.

Some common examples of contact forces include:

- **Friction (Ff)**—a contact force between a surface and an object; always parallel to the surface; opposes motion

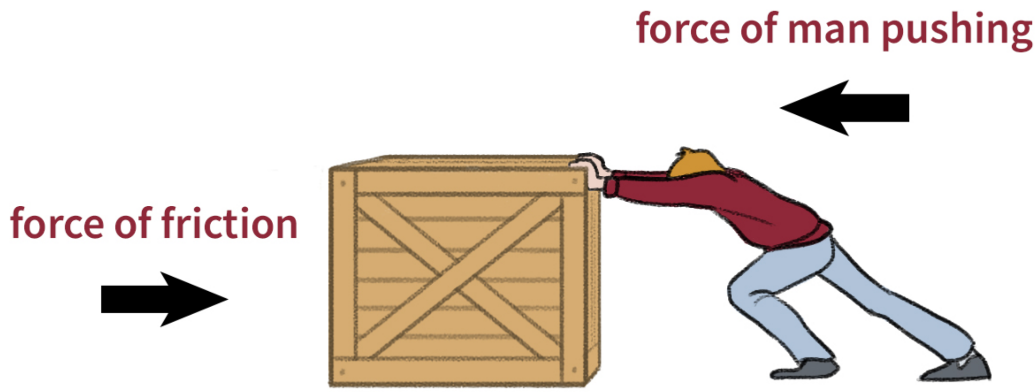


Fig. 2.5.

- **Normal force (FN)**—a contact force between a surface and an object; always perpendicular to the surface

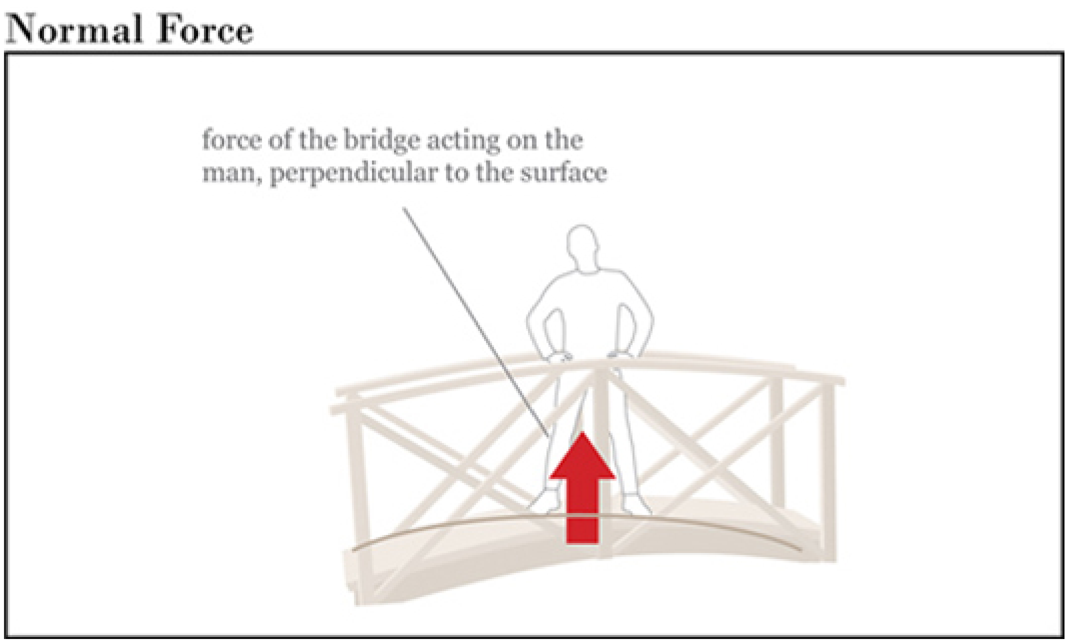


Fig. 2.6.

- **Tension (FT)**—pulling force along strings, ropes, cables, etc.

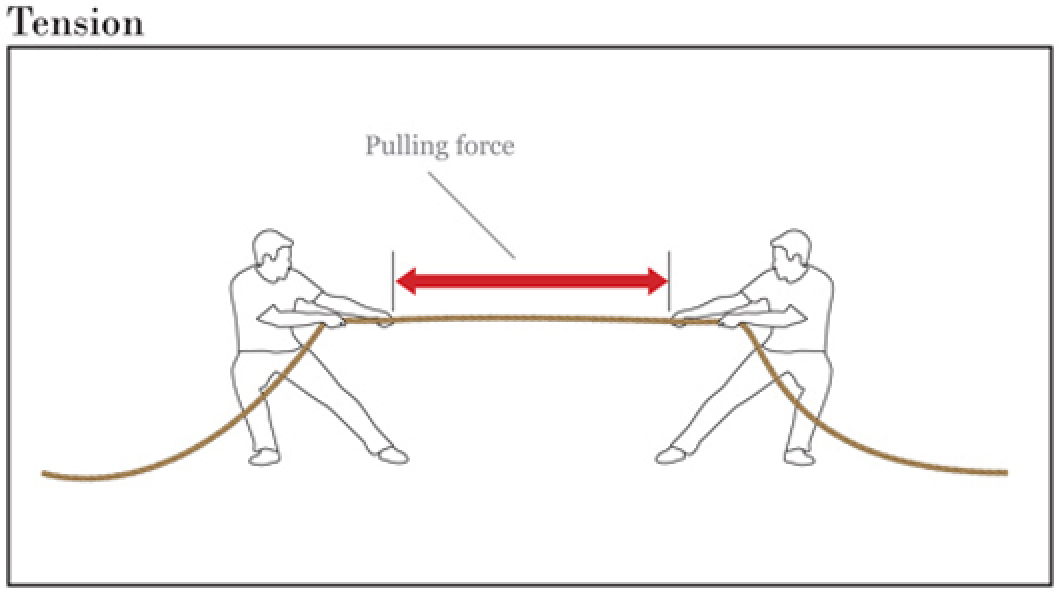


Fig. 2.7.

- **Spring Force (Fsp)**—the force a stretched or compressed spring exerts

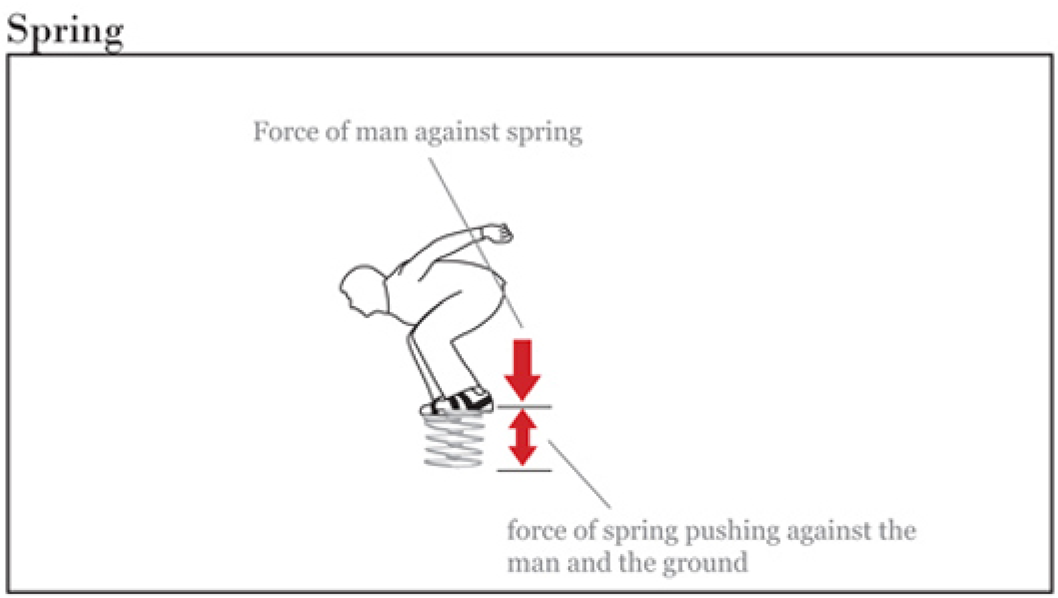


Fig. 2.8.

Long-range forces result when a force is exerted over a distance, without direct contact.

Some examples of long-range forces include:

- **Gravity (Fg)**—the force between any two objects with mass (usually the force between the earth and an object)
- **Electric force (FE)**—the force between any two objects with a net electric charge (discussed in more detail in lesson 7)
- **Magnetic force (FM)**—the force between two magnetic objects or between a magnet and iron compounds (discussed in more detail in

lesson 7)

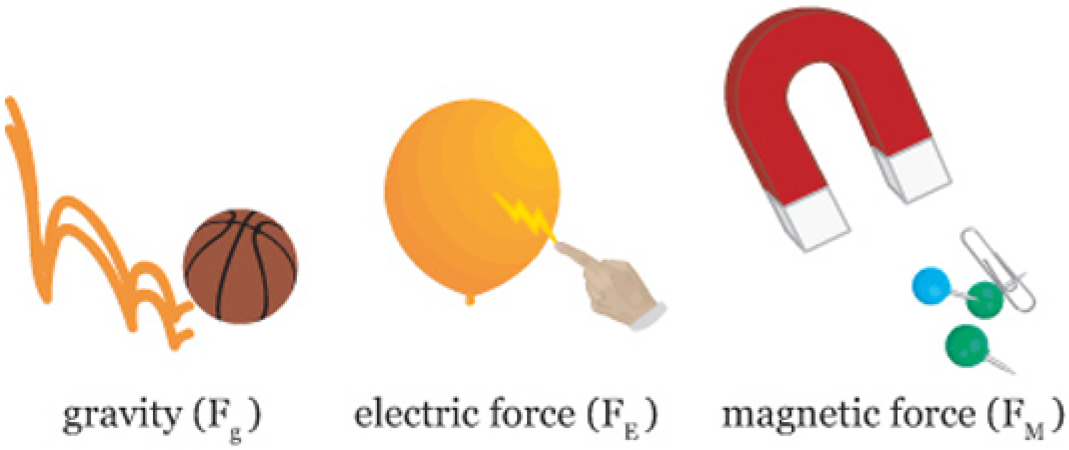


Fig. 2.9.

More about Gravity

The force of gravity is a common force that everyone has some experience with. There is a simple formula for calculating how much gravitational force is acting on an object. The force of gravity is equal to the mass of an object (in kilograms) times the gravitational field (measured in N/kg). The gravitational field is abbreviated with g, so the formula for the force of gravity is $Fg = mg$. For objects near Earth's surface, the gravitational field is approximately 10 N/kg. Finding the force of gravity for objects on Earth, then, simply requires multiplying the mass of an object by 10 N/kg. For example, a 25 kg object would have a force of gravity of 250 N on Earth.

Another common name for the force of gravity is the *weight* of an object. A typical student might have a mass of 60 kg. This student weighs 600 N. Technically, the newton is the proper unit for weight in the SI (metric) system. However, throughout the world people use the *kilogram* for metric weight. This is technically not correct because mass and weight are two different quantities! **For this course, we will stick to the strict use of mass (measured in kilograms) and weight (measured in newtons).**

Identifying the Forces Acting on an Object

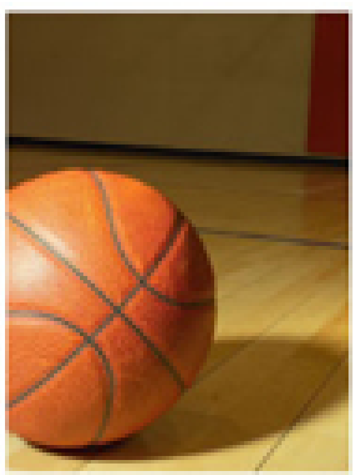
A good force to begin with is the force of gravity (Fg). The force of gravity is always present on Earth because all objects have mass. The direction is easy to remember as well. For objects at Earth's surface, gravity always pulls toward Earth (down). Another good reason for starting with the force of gravity is that *it is the only long-range force you need to worry about in this course*. That means that, in this course, any other forces acting on the object must be contact forces.

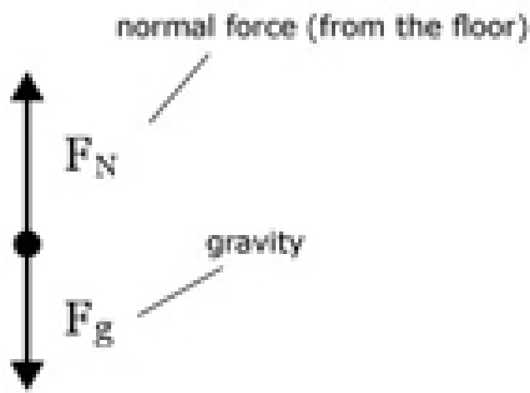
Contact forces should be easy to identify, too. Remember, they are in *contact* with the object (they are touching the object). You should look for things that the object touches. It must have direct contact to exert any kind of contact force.

If you are not sure you have identified all of the forces acting on an object you should remember Newton's first law: if the object is accelerating, decelerating, or changing direction (if it has constant speed), then there is a force acting on it.

How can you tell which forces are acting on an object? It is often helpful to draw a diagram to show all of the forces acting on an object. One such diagram is called a free-body diagram. A free-body diagram uses a dot to represent the object and arrows to represent the forces acting on that object. Arrows are good to use because they can show both the size and direction of the force. A free-body diagram will help you determine whether or not forces are balanced. Let's look at a couple of examples.

Example 2.1:

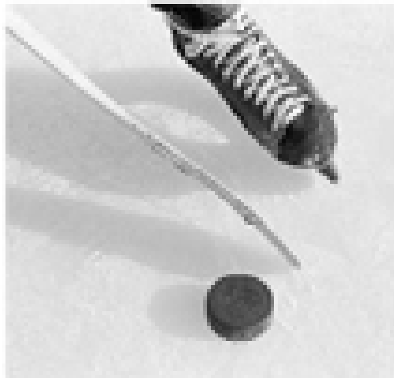


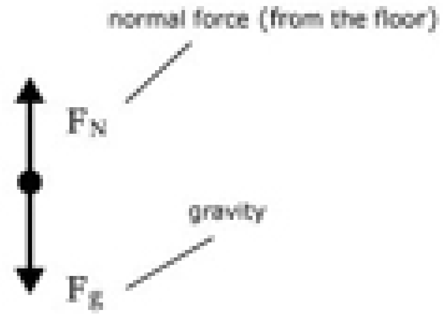


Suppose a basketball is at rest on the gym floor. This is how you would draw a free-body diagram for the basketball.

1. Draw a dot to represent the basketball.
2. Draw an arrow downward and label it F_g.
3. Ask yourself if the forces are balanced. (How do you know?)
4. What is the ball touching that could exert a force on it? (It touches the floor, which must push upward with enough force to exactly balance the force of gravity. This force is called the normal force.)
5. Draw the upward arrow and label it F_N.

Example 2.2:





A hockey puck is sliding across the ice at a constant velocity. Draw a free-body diagram for the hockey puck. (Assume that the ice does not cause friction.)

1. Draw a dot to represent the hockey puck.
2. Draw an arrow downward and label it Fg.
3. Ask yourself if the forces are balanced. (How do you know?)
4. What is the puck touching that could exert a force on it? (It touches the ice, which must push upward with enough force to exactly balance the force of gravity. This force is called the normal force.)
5. Draw the upward arrow and label it FN.

Did you notice the force diagrams look basically the same for a nonmoving basketball and for a hockey puck moving at constant velocity? This is because the forces are balanced for both objects. Remember that in both cases, there is no acceleration. This tells you that the forces must be balanced. Since only gravity and the normal force act on each object, we see that these forces must be the same size.