Table 1 Units of Mass, Acceleration, and Force

System	Mass	Acceleration	Force
SI	kg	m/s^2	$N = kg \cdot m/s^2$
cgs	g	cm/s^2	$dyne = g \cdot cm/s^2$
Avoirdupois	slug	ft/s^2	$lb = slug \cdot ft/s^2$

Did you know?

The symbol for the pound, lb, comes from *libra,* the Latin word for "pound," a unit of measure that has been used since medieval times to measure weight.

terms and units you use every day to talk about weight are really units of force that can be converted to newtons. For example, a $\frac{1}{4}$ lb stick of margarine has a weight equivalent to a force of about 1 N, as shown in the following conversions:

$$1 \text{ lb} = 4.448 \text{ N}$$
$$1 \text{ N} = 0.225 \text{ lb}$$

Forces can act through contact or at a distance

If you pull on a spring, the spring stretches. If you pull on a wagon, the wagon moves. When a football is caught, its motion is stopped. These pushes and pulls are examples of *contact forces,* which are so named because they result from physical contact between two objects. Contact forces are usually easy to identify when you analyze a situation.

Another class of forces—called *field forces*—does not involve physical contact between two objects. One example of this kind of force is gravitational force. Whenever an object falls to Earth, the object is accelerated by Earth's gravity. In other words, Earth exerts a force on the object even when Earth is not in immediate physical contact with the object.

Another common example of a field force is the attraction or repulsion between electric charges. You can observe this force by rubbing a balloon against your hair and then observing how little pieces of paper appear to jump up and cling to the balloon's surface, as shown in **Figure 2.** The paper is pulled by the balloon's electric field.

The theory of fields was developed as a tool to explain how objects could exert force on each other without touching. According to this theory, masses create gravitational fields in the space around them. An object falls to Earth because of the interaction between the object's mass and Earth's gravitational field. Similarly, charged objects create electromagnetic fields.

The distinction between contact forces and field forces is useful when dealing with forces that we observe at the macroscopic level. (*Macroscopic* refers to the realm of phenomena that are visible to the naked eye.) As we will see later, all macroscopic contact forces are actually due to microscopic field forces. For instance, contact forces in a collision are due to electric fields between atoms and molecules. In fact, every force can be categorized as one of four fundamental field forces.

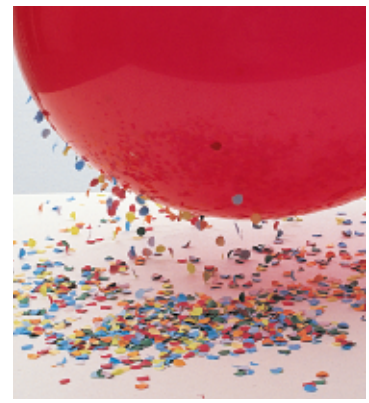

Figure 2
The electric field around the rubbed balloon exerts an attractive electric force on the pieces of paper.