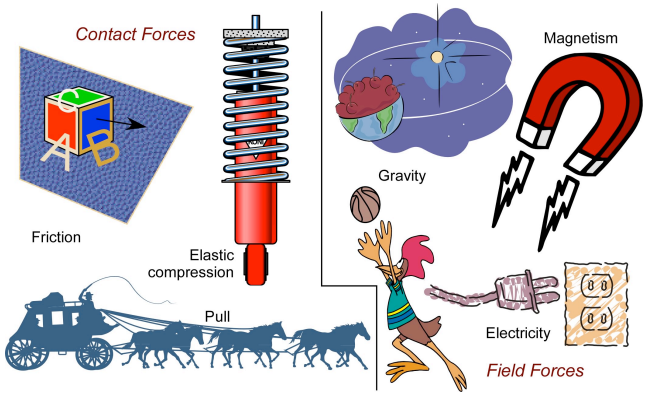
Sorting out the Forces

People often think of force as something you apply using your muscles. When you push or pull on an object, you apply a force on it. You also apply force when you throw a baseball or kick a soccer ball, or sit on a soccer ball.



Therefore, a force is simply a push or a pull that can be applied in a number of ways. When you apply a force on an object, its shape can change, as it might when you sit on a soccer ball, or on a sofa, or when you squeeze an orange. These are soft objects; but even rigid objects, such as a wall or a car, can be deformed (have their shape changed) if enough force is applied, such as with a sledgehammer or in an collision with another car. Forces might cause *deformations (change in shape)*. Forces might cause *motion* – if you push or pull on a box, it may move. If you pull the box on a rough surface, you will need more force to move it than on a smooth surface. These forces are examples of **contact forces** – they arise from physical contact between the applier of the force (called the agent) and the receiver of the force (called the receiver).

Field forces (or **non-contact forces**) are another class of forces. These forces do not involve physical contact between the agent and the receiver, but act through space. The force of gravity, namely the gravitational attraction between two masses such as the earth and you, or the sun and the planets, or between stars, is one such force. Another is the electric force, often observed as static electricity, which causes objects that are similarly charged to repel each other (and oppositely charged ones to attract). Yet another is the attraction between magnets and steel.

While it is convenient to classify forces as field forces and contact forces, on a microscopic level the distinction is not so clear. For example, the force of friction might seem like a contact force, but it is caused by repulsive forces between electric charges, which are field forces. For our course, we will treat friction as a contact force.

The Four Fundamental Forces in Nature

It might seem like there are a lot of forces in nature – gravitational force, friction forces, electric forces, magnetic forces, push and pull forces, elastic forces …the list is not short. This list highlights the *macroscopic descriptions of phenomena.* These descriptions are useful in designing, say, roller coasters, furniture, bridges, or highways. However, the atomic origins of these forces can be traced to just **four fundamental forces**:

1. The gravitational force, which describes the attraction between objects, is based on the mass of each object and the distance between them, and holds galaxies, stars, and planets together.
2. The electromagnetic force, which describes the attraction and repulsion between objects due to the charge on each object and the distance between them, and is responsible for the binding of atoms and molecules.
3. The nuclear strong force, the which is responsible for the binding of neutrons and protons into nuclei.
4. The nuclear weak force, which is a short-range nuclear force that produces instability in certain nuclei.

Strengths:

Each of these forces is described by a constant, a number, which gives the "strength" of this force. The strengths of these forces may be ranked using these constants. Ranked from strongest to weakest: nuclear strong, electromagnetic, nuclear weak and gravitational.

Ranges:

The strong and weak forces have very short ranges since they occur only within atoms. These invisible forces keep things together, but are hard to observe except in the research laboratory. In everyday life, the forces that impact us noticeably are the two long-range forces: gravity and the electromagnetic force. While the gravitational force may be "weakest," when one factors in the large masses involved (such as that of planets or stars), the gravitational force becomes a dominant force in everyday life. Close behind is the electromagnetic force, which causes static, gives us electrical power, makes cell-phones work, and makes for the conveniences of modern-day life.

Forces are present everywhere on Earth and throughout the universe. Understanding how forces effect you and everything around you reveals the 'magic' behind the wonders of nature.