

3.2 Types of forces

Forces can be placed into two categories:

- 1) Action-at-a-distance forces.
- 2) Contact forces.

1) **Action-at-a-distance forces** are forces between two interacting bodies that are **not** in mechanical contact with each other.

Electrostatic, magnetic and gravitational forces belong to this category.

A familiar example of forces at a distance is the interaction between two magnets or a magnet and a paper clip. Weight is another example.



An action at a distance force is set up by the presence of a field causing such a force. A paper clip will be attracted by a magnet if it falls in the magnetic field created by that magnet. The gravitational field of the Earth is responsible for the attractive pull exerted on any object placed in that field. Similarly the electric field of a charge is responsible for the attractive or repulsive force exerted on another charge placed in that field.



Weight is an 'action' at a distance force

2) **Contact forces** are forces between interacting bodies that are in mechanical contact with each other, such as a pull or push one exerts with a hand. Examples of contact forces are normal forces, tensional forces, frictional forces, drag forces, and up-thrust forces.

a) **Normal Forces:** The normal force is the support force exerted upon an object which is in contact with another object as the upward push exerted on a book by a table. In general, we call a force F a "push" if it acts away from the object exerting it. The normal force acts perpendicularly to the surface exerting this force; hence, the term *normal* is used. The normal push by the road on a car prevents the latter from sinking down the asphalt or the soil. The normal push from the snow on the skates of a skier prevents him/her from sinking in the snow. A ladder leaning on a vertical wall is acted upon by two normal forces, the vertical normal push exerted by the ground and the horizontal normal push exerted by the wall.



b) **Tensional forces:** Tension is used for forces exerted on or by ropes, strings, springs or other similar objects that can be used to **pull** other objects. A pull is a force that acts towards the object exerting it. Tension is responsible for holding a hanging lamp from falling down. Tension is also responsible for holding an elevator in its motion or in its state of rest. A tensional force in a string or spring is directed along the string or the spring.



Note that springs can be used to pull or push objects while strings can only be used to pull objects; the force exerted by a spring is always referred to as tension.

c) **Frictional forces:** These forces tend to oppose or prevent surfaces from sliding across each other. Friction depends on the nature of the two surfaces in contact and on the degree to which the two surfaces are pressed together.



Friction is responsible for holding a nail in a wall, for moving up on an electric walkway, for braking, for a racing car to accelerate and to cross a curve without slipping, and for walking, hiking, biking and rock climbing. In the example of the ladder, the frictional force exerted by the floor is responsible for keeping it from slipping. These types of friction are referred to as 'dry friction'.

d) **Resistance forces, or drag:** These are a special type of frictional forces called 'viscous or wet friction', that tend to oppose the motion of objects in fluids (liquids or gases), or the motion of fluids relative to other objects. Resistance forces are exerted by the fluid on the moving object.



Although drag forces can be ignored when their magnitudes are small enough compared to other acting forces, these forces may develop drastically with increasing speed and large contact areas; for instance, a parachuter benefits from drag forces to fall at a relatively safe speed.

e) **Up-thrust:** This is the upward force which acts on objects immersed in a fluid (liquid or gas). This force acts only in the presence of gravity, and it acts by the fluid on the object. Up-thrust causes wood to float in water, helium and hot-air balloons to float in air, and objects to weigh less when immersed in water.



Note that in very simple situations, many forces may be involved. Think for instance of the forces that are involved when you push a trolley.

In one sense, the above classification of contact forces and action at a distance forces is an arbitrary one. So-called contact forces between two bodies, are actually caused by electric action-at-a-distance forces acting between very small particles (atoms and molecules and their constituent particles) of these bodies. However, they are still significantly different in their quantitative behavior to be classified separately. The main difference is as follows: when objects, between which measurable action-at-a-distance forces are acting, approach each other, the magnitude of the force increases continuously and gradually with decreasing distance. On the other hand, when objects between which contact forces are acting are made to touch each other, the magnitude of the force changes abruptly from zero (or immeasurably small values) to a non-zero measurable value at the point(s) of contact.

Fundamental types of forces

Scientists believe that there are three fundamental types of forces in nature:

- a) Gravity: soon to be discussed.
- b) The electroweak forces: All of the forces we deal with in this course - with the exception of gravity - belong to this kind of force. Examples are "contact" forces, electrical and magnetic forces.
- c) The strong forces: These are associated with the binding of the particles in the nuclei of atoms.



3.3 The weight of a body

The weight of a body is the force exerted on that body by the Earth due to what is known as the gravitational attraction of the Earth. In simpler words, weight is the pull of gravity. The force of

I say you're upside down!