Motion

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How to Cite This Article

When you place a book on a table, why does the book stay there and not suddenly scoot off to the side? When you drop a rubber ball, why does it fall and then bounce? The answers to these questions belong to the science called *mechanics*, the branch of physics concerned with how and why objects move—that is, with the forces that cause objects to move and the principles that guide their movement. This knowledge has important applications in everything from building safe roads to launching satellites into space.

Force

A force is any push or pull that causes an object to accelerate, decelerate, stop, or change direction. Gravity and air resistance are two of a number of forces. These forces can be divided into two different classes. *Action-at-a-distance* forces are those that act without physical contact between objects. Gravity is such a force. It acts on objects even when there is no contact between them. When a ball is tossed in the air, for example, it is still affected by gravity. Other action-at-a-distance forces include magnetic and electric forces.

Contact forces act by direct contact between objects. Contact forces include *applied force*—force applied to an object by another object or by a person. If you push a chair across the floor, you are using applied force. *Frictional force* acts when an object moves across a surface, opposing the motion of the object. In the example of the chair, the floor exerts frictional force that opposes the direction of your push. *Air resistance* is really a type of frictional force that acts when objects move through air. A parachute makes use of air resistance. When the parachute opens, its wide surface encounters greater air resistance, which helps slow the descent of the person wearing the chute.

Other contact forces include *tensional force*, which is force transmitted through a taut rope, wire, cable, or string with an object at each end. If you move a heavy block of stone by tying a rope around it and pulling, you are using tensional force. You are not in contact with the block and cannot exert an applied force on it. Instead, you exert force on the rope, which transmits that force to the block. *Spring force* is exerted by a compressed or stretched spring on an object that is attached to the spring. It acts against the force that compressed the spring.

Each force is a vector quantity, as it has both magnitude and direction. When you push your chair across the floor, you can push gently or hard, and in whatever direction you choose. At the same time, other forces are acting on the chair. Frictional force acts against your push, and gravity pulls the chair down. Physicists measure force in units called *newtons*, named for the great 17th-century English scientist Sir Isaac Newton. The newton is a metric unit, defined as the force needed to cause a 1-kilogram (2.2-pound) object to accelerate at a rate of 1 meter (3.3 feet) per second per second.

When the magnitude and direction of all the forces acting on an object are balanced, the object will not move. It is then said to be at rest, or in a state of *equilibrium*. The object will move only when the forces acting on it are unbalanced. For example, suppose two teams are playing tug-of-war. One team pulls west with a force of 900 newtons. The other team pulls east with a force of 950 newtons. The *net force* is 50 newtons east.

Because forces are vector quantities, their effects can be visualized through the creation of vector diagrams and calculated through the process of vector addition. The length of a force vector represents the strength of the force; the arrow, its direction. The resultant shows the net force acting on an object.

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