Surface tension

Surface tension is the force that acts on the surface of a liquid, causing it to contract and minimize its surface area, due to the cohesive forces between the liquid molecules.

This results in the liquid resisting external force and forming shapes like droplets or films.

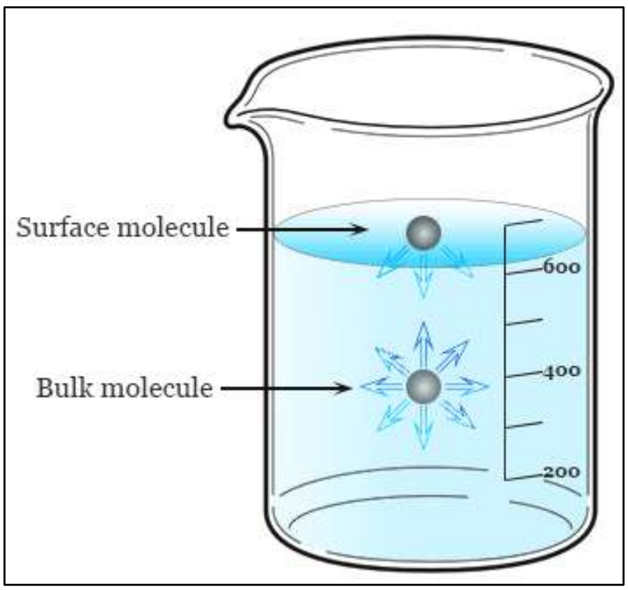

Figure: Show Surface tension of liquid.

Viscosity

Viscosity is a measure of a fluid's resistance to flow. It describes how thick or sticky a liquid is, and how easily it can flow under an applied force. A fluid with high viscosity resists motion (like honey or glycerin), while a fluid with low viscosity flows more easily (like water or alcohol).

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Newton's first law of motion:

An object will remain at rest or in uniform motion in a straight line unless acted on by an external, unbalanced force.

Uniform motion in a straight line means that the velocity is constant. An object at rest has a constant velocity of zero. An external force is an applied force, one applied on or to the object or system. There are also internal forces. For example, suppose the object is an automobile and you are a passenger traveling inside. You can push (apply a force) on the floor or the dashboard, but this has no effect on the car's velocity because your push is an internal force. Because of the ever-present forces of friction and gravity on the Earth, it is difficult to observe an object in a state of uniform motion. But in free space, where there is no friction and negligible gravitational attraction, an object initially in motion maintains a constant velocity. For example, after being projected on its way, an interplanetary spacecraft approximates this condition quite well. Upon going out of the solar system where there is negligible gravitational influence, as two Voyager spacecraft have done , a spacecraft will travel with a constant velocity until an external, unbalanced force alters this velocity.

Quiz 1: Which of the following statements is correct? (a) It is possible for an object to have motion in the absence of forces on the object. (b) It is possible to have forces on an object in the absence of motion of the object. (c) Neither statement (a) nor statement (b) is correct. (d) Both statements (a) and (b) are correct.

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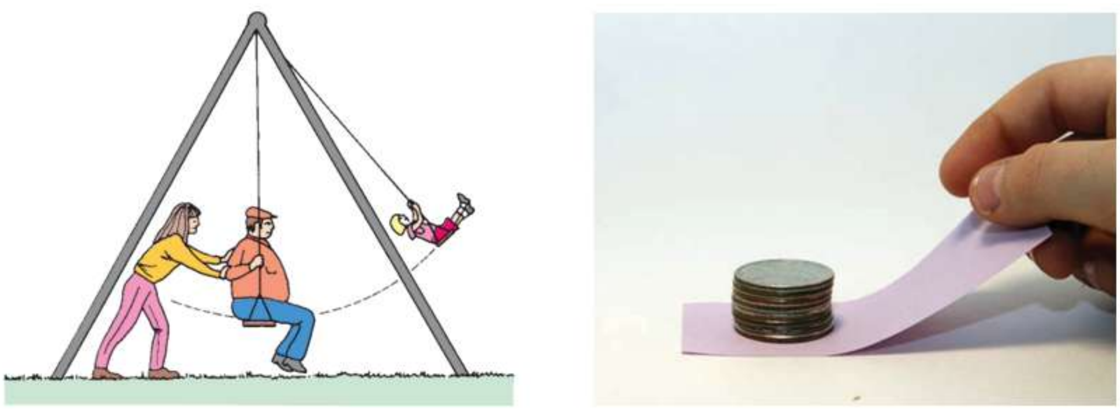
Motion and Inertia

Galileo also introduced another important concept. It appeared that objects had a property of maintaining a state of motion; there was a resistance to changes in motion. Similarly, if an object was at rest, it seemed to "want" to remain at rest. Galileo called this property inertia. Inertia is the natural tendency of an object to remain in a state of rest or in uniform motion in a straight line. Newton went one step further and related the concept of inertia to something that could be measured: mass. Mass is a measure of inertia. The greater the mass of an object, the greater its inertia, and vice versa.



(a) (b)

Figure: Mass and inertia (a) An external, applied force is necessary to set an object in motion. The man has more mass and more inertia than the child and hence has more resistance to motion. (b) Because of inertia, it is possible to remove the paper strip from beneath the stack of quarters without toppling it, by giving the paper a quick jerk.

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Newton’s Second Law of motion

Newton’s Second Law of motion establishes the relationship between the force acting on a body and the acceleration caused by this force.This law summarizes experiments and observations on bodies moving under the action of external forces. Qualitatively, a force is any push or pull exerted on a body, such as the push of the wind on a sail boat, or the pull of your hand on a doorknob. It is intuitively obvious that such a push or pull has a direction as well as a magnitude in fact, force is a vector quantity, and it can be represented graphically by an arrow. An external force acting on a body gives it an acceleration that is in the direction of the force and has a magnitude directly proportional to the magnitude of the force and inversely proportional to the mass of the body:

$$F=ma$$

$$\sum F_x = ma_x \qquad \sum F_y = ma_y \qquad \sum F_z = ma_z$$

System	Force	Mass	Acceleration
SI	newton (N)	kilogram (kg)	m/s^2

Quiz :An object experiences no acceleration. Which of the following cannot be true for the object? (a) A single force acts on the object. (b) No forces act on the object. (c) Forces act on the object, but the forces cancel.

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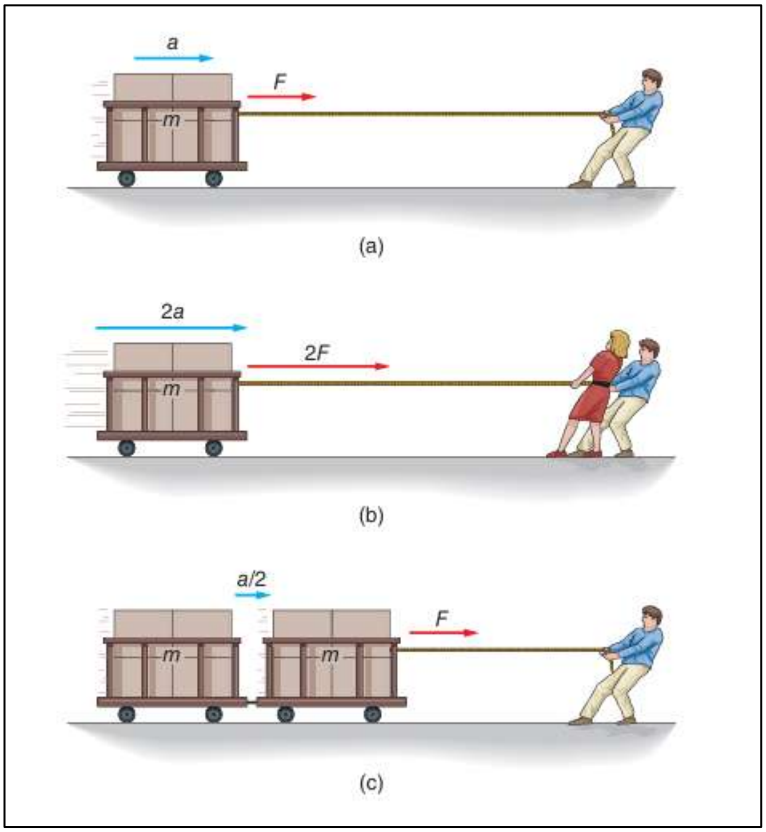

Figure: Force, Mass, and acceleration (a) An unbalanced force F acting on a mass m produces an acceleration a. (b) If the mass remains the same and the force is doubled, then the acceleration is doubled. (c) If the mass is doubled and the force remains the same, then the acceleration is reduced by one-half. The friction of the cars is neglected in all cases.

The Gravitational Force and Weight

Gravitational force, often referred to as weight when applied to an object, is the force exerted by the Earth (or another planet, moon, etc.) on an object due to gravity. The weight of an object is the force with which it is attracted toward the center of the Earth.

$$\vec{\mathbf{F}}_g = m\vec{\mathbf{g}} \tag{5.5}$$

Therefore, the weight of an object, being defined as the magnitude of $\vec{\mathbf{F}}_g$, is given by

$$F_g = mg \tag{5.6}$$

Mass is the amount of matter an object contains (and a measure of inertia). Weight is related to the force of gravity (that is, related to the gravitational force acting on a mass or object).

EXAMPLE 2 The racing car *Spirit of America* (see Fig. 5.6), which set a world record for speed on the Salt Flats of Utah, had a mass of 4100 kg, and its jet engine could develop up to 68000 N of thrust. What acceleration could this car achieve?

SOLUTION: According to Newton's Second Law, a horizontal force of magnitude 68000 N produces an acceleration

$$a = \frac{F}{m} = \frac{68000\ \text{N}}{4100\ \text{kg}} = 17\ \text{m/s}^2 \tag{5.7}$$

EXAMPLE 3 Some small animals—locusts, beetles, and fleas—attain very large accelerations while starting a jump. The rat flea attains an acceleration of about $2.0 \times 10^3\ \text{m/s}^2$. Calculate what force the hind legs of the flea must exert on the body while pushing it off with this acceleration. The mass of the flea is about 6.0×10^{-11} kg; neglect the mass of the legs.

SOLUTION: According to Newton's Second Law, the magnitude of the force is

$$F = ma = 6.0 \times 10^{-11}\ \text{kg} \times 2.0 \times 10^3\ \text{m/s}^2 = 1.2 \times 10^{-7}\ \text{N}$$

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Newton's Third Law of moition

When you push with your hand against a body, such as a wall, the body pushes back at you. Thus, the mutual interaction of your hand and the wall involves two normal forces: the "action" force of the hand on the wall and the "reaction" force of the wall on the hand . These forces are said to form an action–reaction pair.

Newton's Third Law gives the quantitative relationship between the action force and the reaction force: Whenever a body exerts a force on another body, the latter exerts a force of equal magnitude and opposite direction on the former.

Thus, although action and reaction are forces of equal magnitudes and of opposite directions, their effects do not cancel because they act on different bodies.

If two objects interact, the force $\vec{F}_{12}$ exerted by object 1 on object 2 is equal in magnitude and opposite in direction to the force $\vec{F}_{21}$ exerted by object 2 on object 1:

$$\vec{F}_{12} = -\vec{F}_{21} \qquad (5.7)$$

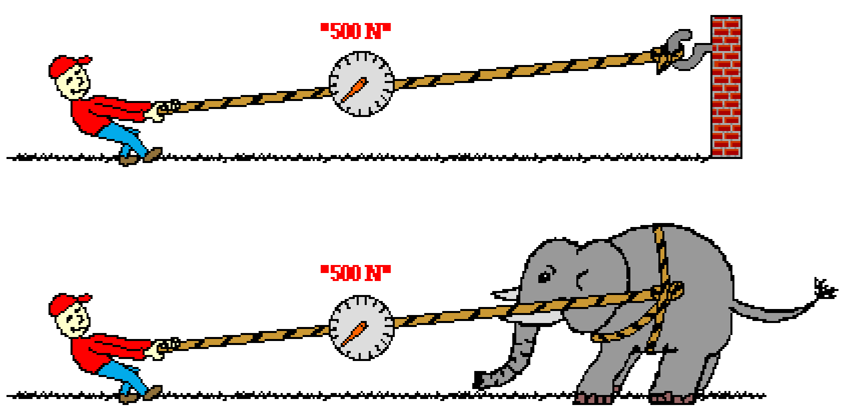

Figure : Show the same force in each case.

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The Normal Force

When a body presses against a surface, the surface (even a seemingly rigid one) deforms and pushes on the body with a normal force the surface.

$$F = ma = mg \tag{5.15}$$

We will denote the weight by the vector symbol **w**. According to Eq. (5.15), the magnitude of the weight is

$$w = mg \tag{5.16}$$

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