7-1The law of motion:

In the previous part, we focused on the science of describing motion such as displacement, velocity, and acceleration, without looking at its causes, and this science is called kinematics.

In this part of the course, we will study the cause of motion, which is an important physical quantity called force, which Newton developed three basic laws based on experimental observations. carried out more than three centuries ago. And the science that studies the relationship between the movement of the body and the force affecting it is from the sciences of classical mechanics, which is known as dynamics, and the word classic here indicates that we are dealing only with speeds that are much less than the speed of light and objects that are much larger than the atom.

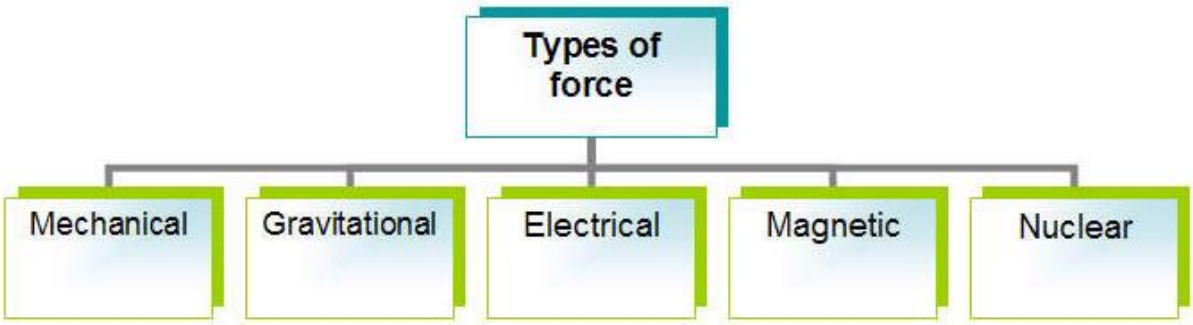
7-2The concept of force

In our daily life, we deal with many different types of forces that may affect moving objects, changing their speed, such as someone pushing or pulling a cart, or the force affecting static objects to keep them still, such as the book on the table or the pictures hanging on the wall. The effect of force is direct, contact force, such as pulling a spring or pushing a box, and the effect of force can be action-at-a-distance, such as repulsion or attraction of the poles of a magnet.

It is not always force needed to move object from one place to another but force is also existed when object do not move, for example when you read a book you exert force holding the book against the force of gravitation.

A body at rest is defined as being in equilibrium when the net force acting on it is zero. It is very important to know that when a body is at rest or when moving at constant speed, we say that the net force on the body is zero i.e. the body in equilibrium.

There are many types of force found in nature and they are either mechanical, gravitational, electrical, magnetic or nuclear. We will study in this course of the book the first and second type.



To study mechanical forces, we will begin by studying Newton's laws of motion.

7-3 Newton's laws of motion

Newton's first law, (**the law of equilibrium**) states that;

"An object at rest will remain at rest and an object in motion will remain in motion with a constant velocity unless acted on by a net external force".

Newton's second law, (**the law of acceleration**), states that;

"The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass".

Newton's third law, (**the law of action-reaction**), states that;

when two bodies interact, the force which body "A" exerts on body "B" (the action force) is equal in magnitude and opposite in direction to the force which body "B" exerts on body "A" (the reaction force).

Newton's first and second laws:

Newton's first law explains the case of bodies affected by a group of zero-sum forces, where the stationary body remains stationary and the moving body remains moving at a constant speed. As for Newton's second law, it is concerned with objects that are affected by an external force that causes them to move with an acceleration a or to change their speed if the objects are in motion. Here it should be noted that the second law contains the first law by applying that the acceleration is equal to zero $a = 0$.

$\sum \vec{f} = m\,\vec{a}$

where: m is the mass of the body and a is the acceleration of the body. Then the unit of the force is (Kg .m/s^2) which is called Newton (N).

$\sum \vec{f} = 0$ Newton's first law

$\sum \vec{f} = m\,\vec{a}$ Newton's second law

In the figure 7-1, if the mass increases by twice with the tension force constant, then the acceleration decreases by half.

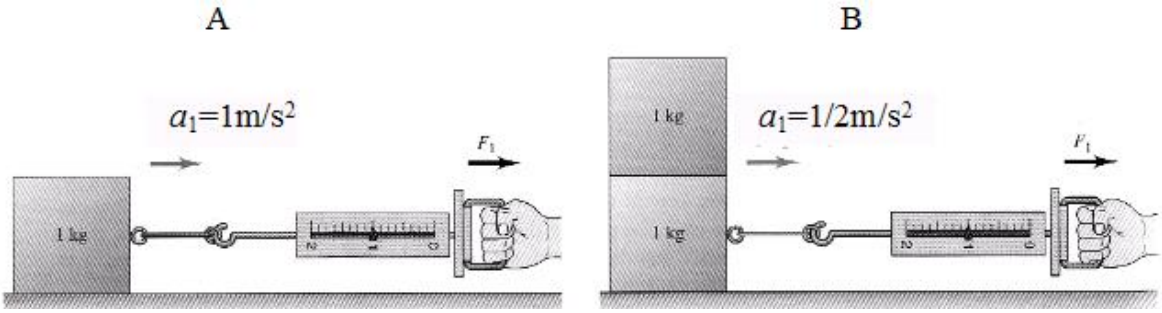


Figure 7-1

In the figure7-2, if the tension force is doubled, the acceleration will double

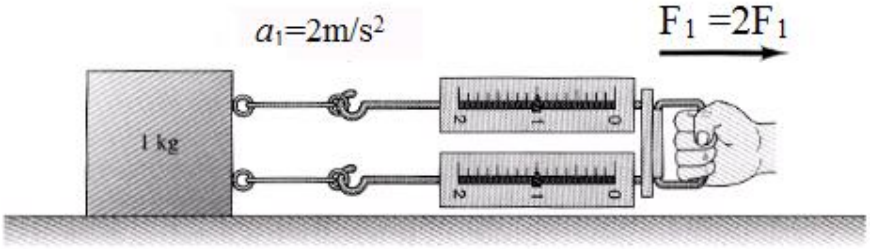
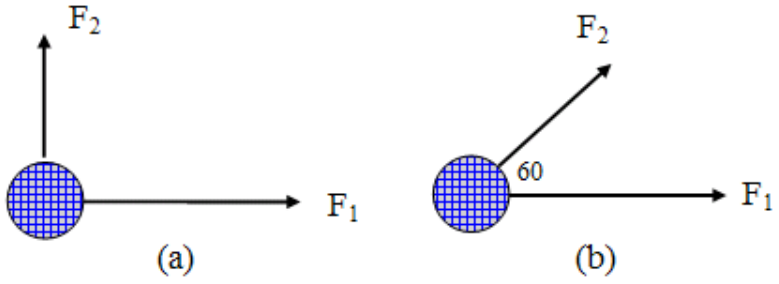


Figure 7-2

Example

Two forces, F1 and F2, act on a 5-kg mass. If F1 =20 N and F2 =15N, find the acceleration in (a) and (b) of the Figure



Solution:

(a) $\sum F = F_1 + F_2 = (20i + 15j)$ N

$\sum F = ma$ $\therefore 20i + 15j = 5\,a$

$a = (4i + 3j)$ m/s² or $a = 5$m/s²

(b) $F_{2x} = 15 \cos 60 = 7.5$ N

$F_{2y} = 15 \sin 60 = 13$ N

$F_2 = (7.5i + 13j)$ N

$\sum F = F_1 + F_2 = (27.5i + 13j) = \text{m}\ a = 5\ a$

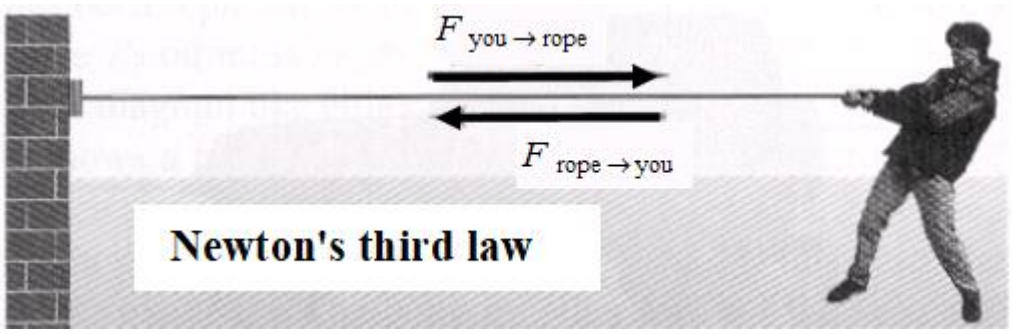
$a = (5.5i + 2.6j)$ m/s^2 or $a = 6.08$m/s^2

Newton's third law

Newton's third law is concerned with the mutual force between bodies, as if you forcefully influence an object, let it be a book you lift in your hand, the book in return affects the same amount of force on your hand and in the opposite direction.

$$F_{12} = -F_{21}$$

And the symbol F_{12} means the force affected by the first body as a result of the second body.



It is clear from the above figure the concept of Newton's third law of action and reaction, where the person pulls the wall with a rope, and in return, the rope pulls the person as a reaction.