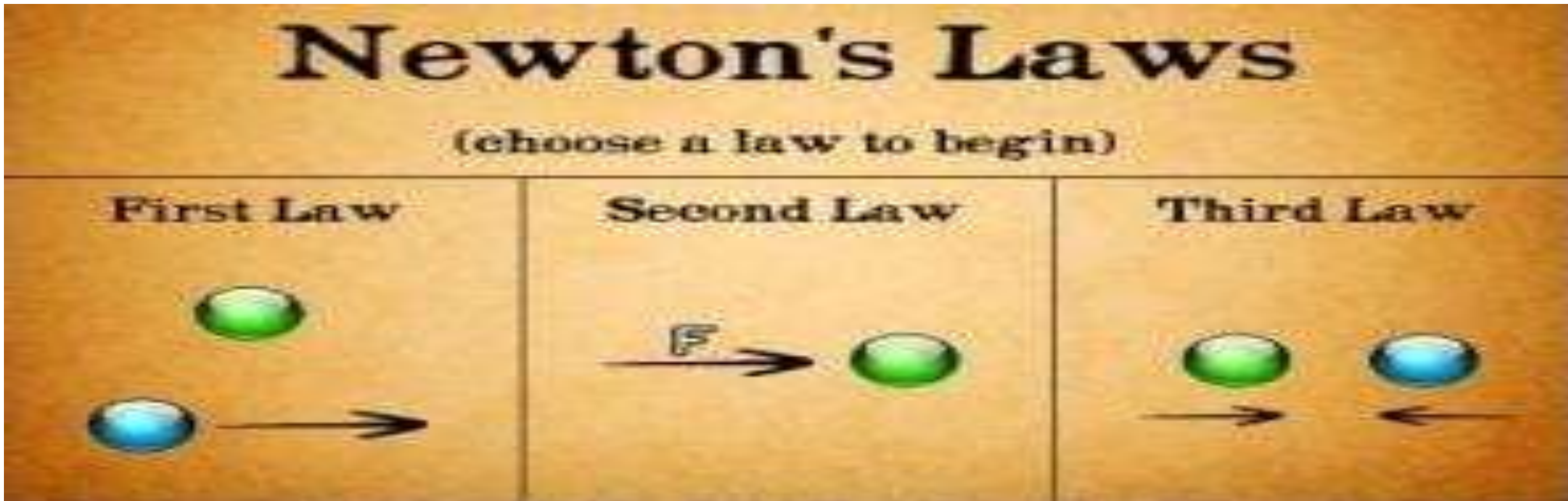
AL-MUSTAQBAL UNIVERSITY
Babylon– Iraq

Department of Bio Medical Engineering



Subject Physics.

Class 1

Lecture 3 ((Newton's Laws of Motion))

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Introduction

- In physics, we come across various motions of a body. What causes the motion of an object? The answer is a force. What stops an object under motion? The answer is Force. Thus, in general Force and Motion are like two sides of a coin. Example: the interdependence of force and motion is seen in throwing a ball and catching a ball. Let us first understand the meaning of force and motion individually and then the relation between them. Newton's laws of motion describe the behavior of objects in motion and how they interact with one another. The laws provide a framework for understanding how forces affect an object's motion, and can be used to predict and explain the behavior of objects in real-world situations. Together, forces and Newton's laws of motion provide a fundamental understanding of the physical world and are used in a variety of applications, including engineering, physics research, and everyday life.

In this article, we will discuss the laws concerned with explaining the movement of objects, Newton's laws and their applications in our lives. We will also shed light on the other most famous laws developed by Isaac Newton

- In physics, force is defined as any influence that causes an object to undergo a change in motion or acceleration. Force is a vector quantity, meaning that it has both magnitude and direction. The standard unit of force in the International System of Units (SI) is the newton (N), which is defined as the amount of force required to accelerate a mass of one kilogram at a rate of one meter per second squared.

Newton's Laws of Motion

Newton’s 1st Law (The Law of Inertia):

- If no force acts on an object, then the speed and direction of itsmotion do not change.

- **Inertia:** The tendency of an object to resist changes in its state of motion. In other words, it is a property of matter through which it remains in a state of rest or in motion that does not change unless it is acted upon by an external force. A tendency to not move or change. The first law states that all things have inertia. The greater the mass of an object, the greater its force (and the more difficult it is to change its

- if the object is at rest, it remains at rest (velocity = 0).If the object is in motion, it continues to move in a straight line with the same velocity.
- An object is in **translational equilibrium** if the net force on it is zero and vice versa.

$\Sigma F = 0$ ⟷ **Translational Equilibrium**

Newton’s Second Law of Motion

states that the acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass. In other words, the greater the force applied to an object, the greater its acceleration will be, and the greater the object's mass, the less its acceleration will be for a given force.

Mathematically: $\mathbf{a} = \frac{\mathbf{F}_{\text{net}}}{m}$ or $\mathbf{F}_{\text{net}} = m\mathbf{a}$

$\mathbf{F}_{\text{net}} = m\mathbf{a}$ This is the workhorse of mechanics

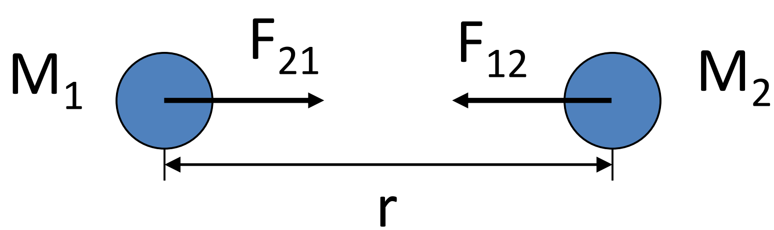
Application of Newton's Second Law of Motion 1- Weight: The magnitude of the earth's gravitational force to the body and it is measured in N and is given by the following formula:

$$W = m \cdot g$$

2- Law of Gravitation: Any two objects in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

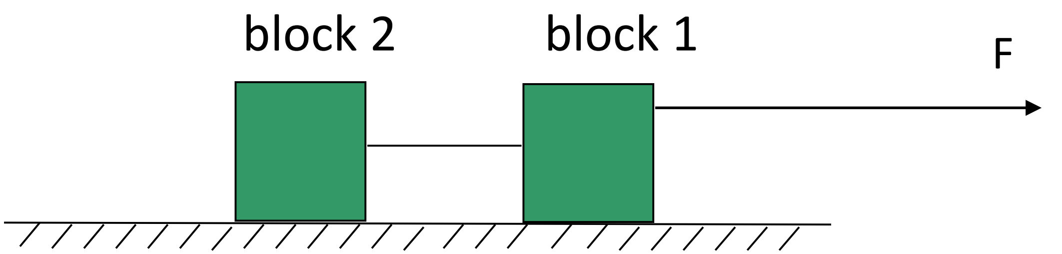
$$F = \frac{GM_1M_2}{r^2}$$

r is the distance between the two masses M_1 and M_2 and $G = 6.67\times10^{-11}$ Nm^2/kg^2.



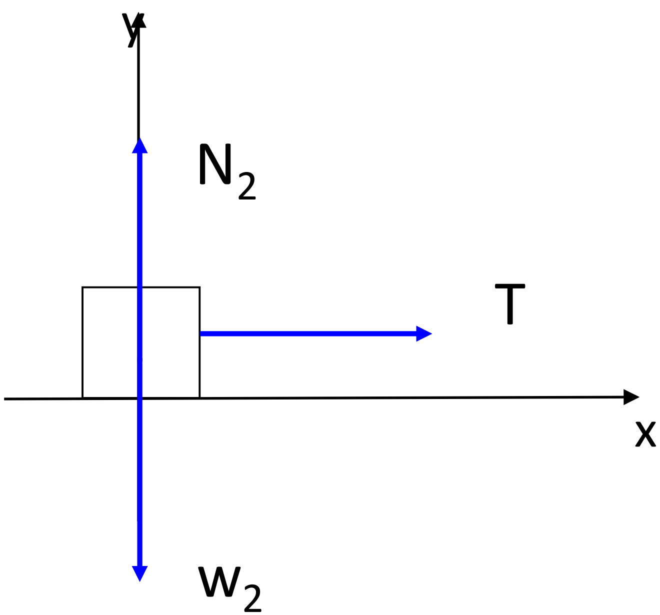
$$\mathbf{F}_{21} = -\mathbf{F}_{12}.$$

Example: A force of 10.0 N is applied to the right on block 1. Assume a frictionless surface. The masses are $m_1 = 3.00$ kg and $m_2 = 1.00$ kg. Find the tension in the cord connecting the two blocks as shown.

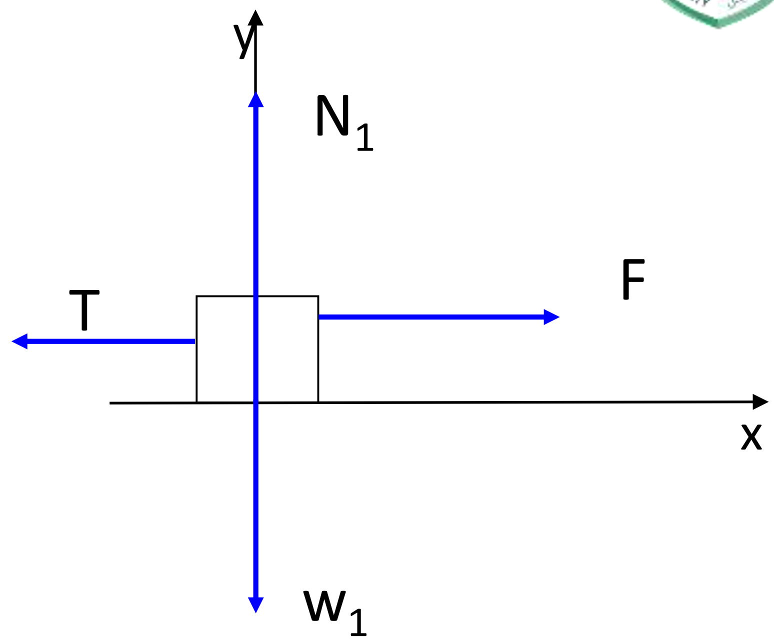


Assume that the rope stays taut so that both blocks have the same acceleration.

FBD for block 2:



FBD for block 1:



Apply Newton's 2nd Law to each block:

$$\sum F_x = T = m_2 a$$

$$\sum F_y = N_2 - w_2 = 0$$

$$\sum F_x = F - T = m_1 a$$

$$\sum F_y = N_1 - w_1 = 0$$

Example continued:

$$F - T = m_1 a \quad (1)$$

$$T = m_2 a \quad (2)$$

These two equations contain the unknowns: *a* and *T*.

To solve for T, a must be eliminated. Solve for a in (2) and substitute in (1).

$$F - T = m_1 a = m_1\left(\frac{T}{m_2}\right)$$

$$F = m_1\left(\frac{T}{m_2}\right) + T = \left(1 + \frac{m_1}{m_2}\right)T$$

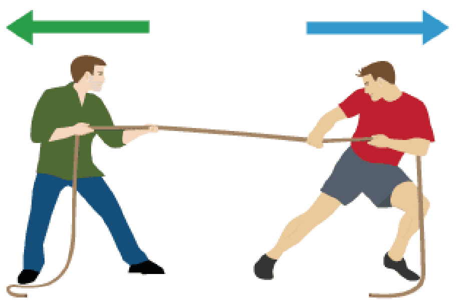
$$T = \frac{F}{\left(1 + \frac{m_1}{m_2}\right)} = \frac{10\ \mathrm{N}}{\left(1 + \frac{3\ \mathrm{kg}}{1\ \mathrm{kg}}\right)} = 2.5\ \mathrm{N}$$

Newton’s Third Law of Motion

For every action there is a reaction force that is equal in magnitude and opposite in direction.

When 2 bodies interact, the forces on the bodies, due to each other, are always equal in magnitude and opposite in direction.

In other words, forces come in pairs.



Mathematically: $\mathbf{F}_{21} = -\mathbf{F}_{12}.$

$\mathbf{F}_{21}$ designates the force on object 2 due to object 1.

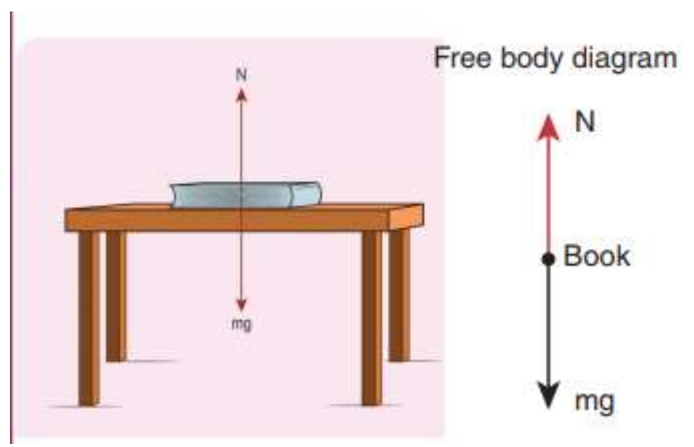
Application of Newton's third Law of Motion

1- The reaction force on the surface of the bodies (normal force)

A- Force from a solid surface which keeps object from falling through

B- Direction: always perpendicular to the surface

C - Magnitude: depends on situation

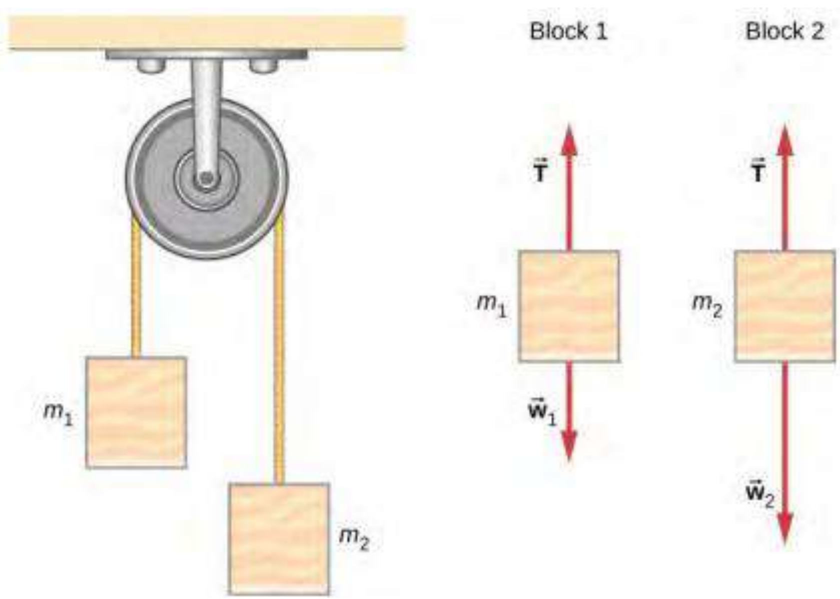


2- Tensile strength in a rope(T)

A- A taut rope exerts forces on whatever holds its ends

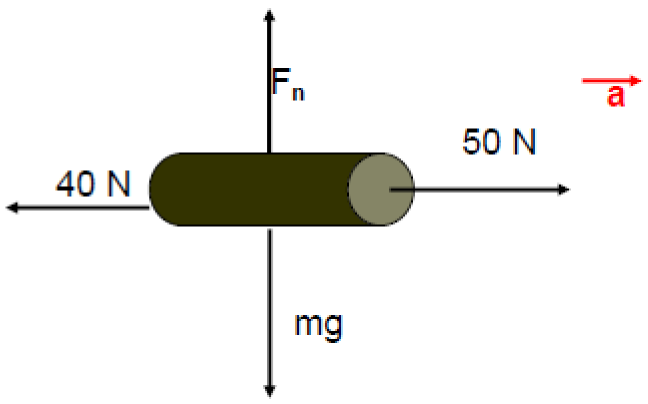
B- Direction: always along the cord (rope, cable, string ……) and away from the object

C- Magnitude: depend on situation



Example:

A 50 N applied force drags an 8.16 kg log to the right across a horizontal surface. What is the acceleration of the log if the force of friction is 40.0 N?



$$F_{NET} = ma$$

$$F_a - F_f = ma$$

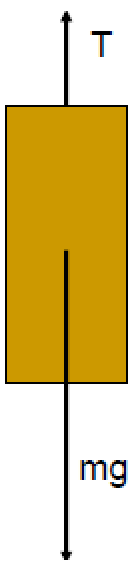
$$50 - 40 = 8.16a$$

$$10 = 8.16a$$

$a =$ 1.23 m/s/s

Example:

An elevator with a mass of 2000 kg rises with an acceleration of 1.0 m/s2. What is the tension in the supporting cable?



$$F_{NET} = ma$$

$$\boxed{T - mg = ma}$$ ← Equation of Motion

$$T = ma + mg$$

$$T = (2000)(1) + (2000)(9.8)$$

$$T = \text{21,600 N}$$

H.W

Q1 __________ **is a push or a pull.**

A- motion B- velocity C- acceleration D- force

Q2- ball is thrown straight up in the air. According to Newton's first law of motion, what is the reason for the ball falling back to Earth?

A) A force has acted on it.

B) It is accelerating in the same direction as Earth's gravitational force on it.

C) The change in the ball's acceleration is proportional to the force acting on it.

D) The ball exerts a force on the air surrounding it.

Q3- Newton's first law of motion states that __________.

A) an object will remain at rest or keep moving with a constant velocity unless a force acts on it

B) acceleration is calculated by dividing the force exerted on an object by the mass of the object

C) when a force acts on an object, its acceleration is in the same direction as the force

D) when a force is applied on an object, there is an equal force applied by the object in the opposite direction