Chapter Two: Newton's Laws of Motion

Newton's laws of motion: Three statements describing the relations between the forces acting on a body and the motion of the body, first formulated by English physicist and mathematician Isaac Newton, which are the foundation of classical mechanics.

In his *Principia*, Newton reduced the basic principles of mechanics to three laws:

1. Newton's first law states that if a body is at rest or moving at a constant speed in a straight line, it will remain at rest or keep moving in a straight line at constant speed unless it is acted upon by a force.
2. **Newton's second law:**

   It states that the time rate of change of the momentum of a body is equal in both magnitude and direction to the force imposed on it. The momentum of a body is equal to the product of its mass and its velocity.

   Momentum, like velocity, is a vector quantity, having both magnitude and direction. A force applied to a body can change the magnitude of the momentum or its direction or both.

   Newton's second law is one of the most important in all of physics.

   For a body whose mass m is constant, it can be written in the form

   $\boldsymbol{F = ma}$**,**

   where F (force) and a (acceleration) are both vector quantities.
3. To every action there is always opposed an equal reaction. **Newton's third law: The law of action and reaction.** Newton's third law states that when two bodies interact, they apply forces to one another that are equal in magnitude and opposite in direction. The third law is also known as the law of action and reaction. For example, a book resting on a table applies a downward force equal to its weight on the table. According to the third law, the table applies an equal and opposite force to the book. This force occurs because the weight of the book causes the table to deform slightly so that it pushes back on the book like a coiled spring.

Newton's law of gravitation:

It states that any particle of matter in the universe attracts any other with a force varying directly as the product of the masses and inversely as the square of the distance between them.

In symbols, the magnitude of the attractive force F is equal to G (the gravitational constant($G=6.67\text{x}10^{-11}$ $N.m^2/kg^2$), multiplied by the product of the masses (m_1 and m_2) and divided by the square of the distance R:

$F = G(m_1m_2)/R^2$.

Newton's law of cooling states that *the rate of heat loss of a body is proportional to the difference in temperatures between the body and its surroundings*.As follow:

$Q=hA(T(t)-T_{env})$
Q=rate of heat transfer out of the body
H= heat transfer coefficient
A= surface area
T= temperature of the object
T(t) = time – dependent temperature
T_{env}= temperature of the environment

Newton's law of cooling results in a simple differential equation expressing temperature-difference as a function of time. The solution describes an exponential decrease of temperature-difference over time.

Simplified formula:
Newton's law of cooling can be simplified and stated as follow;
$dT/dt = r (T_{env}-T(t))$
Integrate
$T(t) = T_{env} +(T_o-T_{env})e^{-rt}$

Examples:

Ex.1: A force of 20 newtons acted upon a body of mass 8 Kg place on a horizontal surface. Calculate the acceleration.

Ex2: A force of 35 newtons acted on a body on a horizontal surface. The body moved with a constant acceleration of $3.5m/sec^2$. Calculate the mass of the body.

Ex.3: Two forces 5newtons and 3 newtons acted on a body of mas 2 Kg put on a horizontal surface. The two forces acted in opposite directions. Calculate the acceleration.

Ex. 4: two bodies of masses m_1=100Kg and m_2= 200kg . the distance between the center of the two bodies was 40m. Calculate the gravitational force between the two bodies.

Ex.5: calculate the gravitational force between the earth and the moon?

Ex.6: calculate the gravitational force between the electron and proton of Hydrogen atom.

Ex.7: What is the gravitational force between the Sun and the Earth?
The mass of the Sun = $2x\ 10^{30}$ Kg.
mass of the Earth = 6×10^{24} Kg
$G = 6.67 \times 10^{-11}\ N.m^2/kg^2$
The distance between the Sun and the Earth=1.5×10^{11} m.