Introduction to Classical Mechanics

Classical mechanics is the branch of physics that deals with the motion of macroscopic objects under the influence of forces. It was developed primarily by Isaac Newton in the 17th century and remains the foundation for understanding everyday physical phenomena.

Newton's Three Laws of Motion

First Law - Law of Inertia

An object at rest stays at rest, and an object in motion stays in motion at constant velocity, unless acted upon by a net external force.

Example: A hockey puck sliding on frictionless ice will continue moving in a straight line at the same speed indefinitely.

Second Law - F = ma

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

$$F = m * a$$

Where:
F = net force (Newtons)
m = mass (kilograms)
a = acceleration (m/s^2)

Example: Pushing a 10 kg box with a force of 50 N produces an acceleration of 5 m/s^2.

Third Law - Action and Reaction

For every action, there is an equal and opposite reaction. When object A exerts a force on object B, object B simultaneously exerts a force equal in magnitude but opposite in direction on object A.

Example: A rocket expels gas downward (action), and the gas pushes the rocket upward (reaction).

Energy and Work

Work is done when a force moves an object through a distance:

$$W = F * d * \cos(theta)$$

Kinetic Energy is the energy of motion:

$$KE = (1/2) * m * v^2$$

Potential Energy (gravitational) is stored energy due to height:

$$PE = m * g * h$$

The Work-Energy Theorem states that the net work done on an object equals its change in kinetic energy:

$$W_{net} = \text{delta } KE = KE_{final} - KE_{initial}$$

Conservation of Momentum

Momentum (p) is defined as the product of mass and velocity:

$$p = m * v$$

In an isolated system (no external forces), the total momentum before a collision equals the total momentum after:

$$m1*v1_i + m2*v2_i = m1*v1_f + m2*v2_f$$

This principle is used to analyse collisions, explosions, and rocket propulsion.

Key Formulas Summary

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v = u + a*t
s = u*t + (1/2)*a*t^2
v^2 = u^2 + 2*a*s
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F = m * a

W = F * d * cos(theta)

KE = (1/2) * m * v^2

PE = m * g * h

p = m * v

Impulse J = F * delta_t = delta_p