Dynamics
Newton's Laws of Motion

Newton's 1st Law

A body will continue in its state of rest or move with uniform velocity unless a resultant force acts on it.

The tendency for bodies to resist changes in motion is called *inertia*

Mass is the property of a body which resists change in motion, i.e. a measure of inertia of a body

Linear Momentum and Impulse

The linear momentum of a moving object is defined as the product of its mass and its velocity.

$$p = mv$$

Linear momentum is a *vector* quantity and its direction follows the direction of the velocity.

Impulse of a force is defined as the product of the force and the time during which the force acts (time of impact).

Impulse of a resultant force = $p_{\text{final}} - p_{\text{initial}}$
= Area under a (resultant) force-time graph

Impulse is a vector quantity.

Problem solving for $F_{net} = ma$ questions

1. Draw free body diagram(s) with the forces acting on the body
2. Identify and indicate the acceleration direction
3. Form an equation of $F_{net} = ma$
4. If need to resolve the forces, form equations for each perpendicular component separately

Newton's 2nd Law

The rate of change of momentum of a body is directly proportional to the resultant force acting on it and the change takes place in the direction of the resultant force.

$$F_{\text{net}} \propto \frac{dp}{dt} \quad \Rightarrow \quad F_{\text{net}} = k\frac{dp}{dt}$$

If quantities are in SI units, $F_{\text{net}} = \frac{dp}{dt}$

Thus, force acting on a body is defined as the rate of change of momentum of the body.

If mass is constant, $F_{\text{net}} = ma$

If velocity is constant, $F_{net} = v\frac{dm}{dt}$

Direction of the acceleration or the change in momentum is in the same direction of the resultant force.

Newton's 3rd Law

If body A exerts a force (action) on body B, then body B exerts a force of the same kind, equal in magnitude, but in the opposite direction on body A.

Action-Reaction Pairs:

1. The two forces must be of the same kind
2. The two forces act on different bodies

Weight

Weight of a body is the gravitational force acting on the body.

Apparent Weightlessness

A body is said to be experiencing apparent weightlessness if the resultant force acting on it is its weight (mg) and its acceleration, a, is equal to g.

Conservation of Linear Momentum and Collisions

Principle of Conservation of Momentum:
The total momentum of a system of bodies remains constant provided no external resultant force acts on the system.

Type of Collision	Total Linear Momentum	Total Kinetic Energy	Remarks	Laws to Apply
Elastic	Conserved	Conserved		1. $\sum p_{initial} = \sum p_{final}$ 2. $u_1 - u_2 = v_2 - v_1$ or $\sum KE_{initial} = \sum KE_{final}$
Inelastic	Conserved	Not Conserved		$\sum p_{initial} = \sum p_{final}$
Completely Inelastic	Conserved	Not Conserved	bodies stick together after collision	$\sum p_{initial} = \sum p_{final}$