

Introduction to Dynamics

Introduction to Dynamics

The study of forces and motion of bodies

1. What is Dynamics?

Aspect	Definition
Scope	Examines <i>why</i> objects move (cause and effect) rather than just <i>how</i> they move.
Subfields	• Kinematics – description of motion (position, velocity, acceleration). • Kinetics – relation between motion and forces/moments.
Contrast	Statics deals with bodies at rest or in uniform motion (net force = 0). Dynamics handles accelerating bodies (net force ≠ 0).

2. Fundamental Principles

Principle	Statement	Typical Equation
Newton's First Law (Inertia)	A body remains at rest or moves with constant velocity unless acted upon by a net external force.	$\sum \mathbf{F} = 0 \Rightarrow \mathbf{v} = \text{constant}$
Newton's Second Law	The rate of change of linear momentum equals the applied net force.	$\sum \mathbf{F} = m \mathbf{a}$
Newton's Third Law	For every action there is an equal and opposite reaction.	$\mathbf{F}_{AB} = -\mathbf{F}_{BA}$
Work-Energy Principle	The work done by all forces equals the change in kinetic energy.	$W_{\text{net}} = \Delta K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$
Impulse-Momentum Principle	Impulse applied to a body equals the change in its linear momentum.	$\mathbf{J} = \int \mathbf{F} dt = \Delta \mathbf{p}$
Angular Momentum	Rate of change of angular momentum equals the applied moment (torque).	$\sum \mathbf{M} = \frac{d\mathbf{L}}{dt}$

Introduction to Dynamics

3. Types of Motion

Motion	Description	Key Quantities
Translational	All points of the body move along parallel paths.	Linear displacement (s), velocity ($\mathbf{v}$), acceleration ($\mathbf{a}$)
Rotational	Motion about a fixed axis; every point follows a circular path.	Angular displacement (θ), angular velocity (ω), angular acceleration (α)
General Plane Motion	Combination of translation of a reference point and rotation about that point.	Velocity of any point: $\mathbf{v}_P = \mathbf{v}_O + \boldsymbol{\omega} \times \mathbf{r}_{OP}$
Three? Dimensional Motion	Simultaneous translation and rotation in space.	Use vector forms of ($\mathbf{v}$, $\mathbf{a}$, $\boldsymbol{\omega}$, $\boldsymbol{\alpha}$) and inertia tensor ($\mathbf{I}$).

4. Kinematics Review (Essential for Dynamics)

1. Position ? Velocity

$$[\mathbf{v}(t) = \frac{d\mathbf{r}}{dt}]$$

2. Velocity ? Acceleration

$$[\mathbf{a}(t) = \frac{d\mathbf{v}}{dt} = \frac{d^2\mathbf{r}}{dt^2}]$$

3. Constant Acceleration Equations (1?D