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Title: Work Power And Energy

WORK, ENERGY AND POWER

Concept of Work

When a force $\vec{F}$ causes a displacement $\vec{s}$, the work done is given by:

$$W = \vec{F} \cdot \vec{s} = Fs\cos\theta$$

Here, θ is the angle between force and displacement. Work is a scalar quantity with SI unit Joule (J).

Work by Gravity

- Moving upwards: $W = -mgh$
- Moving downwards: $W = +mgh$

Work by a Variable Force

If force varies with position:

$$dW = \vec{F} \cdot d\vec{s}, \quad W = \int_i^f \vec{F} \cdot d\vec{s}$$

Work-Energy Theorem

Net work done equals change in kinetic energy:

$$W_{net} = \Delta K = K_f - K_i$$

Kinetic Energy

Energy due to motion:

$$K = \frac{1}{2}mv^2$$

Potential Energy

- Gravitational: $U = mgh$
- Elastic: $U = \frac{1}{2}kx^2$

Types of Forces

Conservative: Path-independent work, e.g., gravity, spring force.
Non-Conservative: Path-dependent work, e.g., friction.

Conservation of Mechanical Energy

If only conservative forces act:

$$E = K + U = \text{constant} \quad \Rightarrow \quad K_i + U_i = K_f + U_f$$

Power

Rate of doing work:

$$P = \frac{dW}{dt} = \vec{F} \cdot \vec{v} = Fv\cos\theta$$

SI unit: Watt (W). 1 hp = 746 W.

Impulse

$$\vec{I} = \int_{t_i}^{t_f} \vec{F}\, dt$$

Impulse-Momentum Theorem

$$\vec{I} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i$$

Conservation of Linear Momentum

If $\sum \vec{F}_{ext} = 0$:

$$\vec{P}_{initial} = \vec{P}_{final}, \quad \sum \vec{p}_i = \sum \vec{p}_f$$

Collision

- **Elastic:** Momentum and kinetic energy conserved.
- **Inelastic:** Momentum conserved; kinetic energy not conserved.

Coefficient of Restitution (e)

$$e = \frac{|v_2 - v_1|}{|u_1 - u_2|}$$

- Elastic: $e = 1$
- Perfectly inelastic: $e = 0$
- Inelastic: $0 < e < 1$