

GRADE 11 STUDY GUIDE | 2025

Work, Energy and Power

Physical Sciences

1. Work Done by a Force

$$W = F \cdot \Delta(x) \cdot \cos(\theta)$$

Where: **W** = work (Joules), **F** = force (N), **Delta(x)** = displacement (m), **theta** = angle between **F** and displacement

- Work is a SCALAR quantity
- If $\theta = 0$ (force parallel to displacement): $W = F \times \Delta(x)$ [maximum work]
- If $\theta = 90^\circ$: $W = 0$ (force perpendicular -- no work done, e.g. normal force)
- If $\theta = 180^\circ$: $W = -F \times \Delta(x)$ [negative work, force opposes motion]

2. Kinetic and Potential Energy

$$\text{Kinetic Energy: } KE = \frac{1}{2}mv^2$$

$$\text{Gravitational PE: } PE = mgh$$

Units: Joules (J)

- KE depends on SPEED (scalar) -- same KE moving left or right at same speed
- PE depends on HEIGHT relative to a chosen reference level
- As an object falls: PE decreases, KE increases (assuming no friction)

3. Work-Energy Theorem

$$W_{\text{net}} = \Delta(KE) = KE_{\text{final}} - KE_{\text{initial}}$$

$$= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

The net work done on an object equals its change in kinetic energy. This is one of the most powerful tools in mechanics.

Example: A 2 kg box is pushed from rest across 5 m with $F_{\text{net}} = 10$ N. Find final speed.

$$W_{\text{net}} = 10 \times 5 = 50 \text{ J}$$

$$\Delta(KE) = 50 \text{ J}$$

$$\frac{1}{2}(2)v^2 - 0 = 50$$

$$v^2 = 50 \Rightarrow v = \sqrt{50} = 7.07 \text{ m/s}$$

4. Conservation of Mechanical Energy

$$ME = KE + PE = \text{constant} \quad (\text{when no friction/air resistance})$$

$$(1/2)mv_i^2 + mgh_i = (1/2)mv_f^2 + mgh_f$$

KEY: When friction IS present: ME is NOT conserved. The "lost" energy is converted to heat: $W_{\text{friction}} = \Delta(ME)$.
This is called NON-CONSERVATIVE work.

5. Power

$$P = W/t = F \cdot v$$

$$\text{Units: Watts (W)} = \text{J/s}$$

$$1 \text{ kW} = 1000 \text{ W} \mid 1 \text{ MW} = 10^6 \text{ W}$$

Power is the RATE at which work is done (or energy is transferred). A machine with greater power does the same work in LESS time.

Example: A motor lifts a 500 kg load 8 m in 10 s at constant speed. Find power.

$$W = mgh = 500 \times 9.8 \times 8 = 39\,200 \text{ J}$$

$$P = W/t = 39\,200 / 10 = 3\,920 \text{ W} = 3.92 \text{ kW}$$