
Chapter 4: Work, Energy and Power

4.1 Introduction to Work, Energy and Power

- These concepts describe how physical effort (work) leads to changes in motion or energy and how quickly that energy is transferred (power).
- Widely applied in machines, vehicles, and daily life.

4.2 Work

- **Work** is said to be done when a force is applied and the object moves in the direction of the force.
- **Formula**: `Work = Force × Displacement × cos(θ)`
    - θ = angle between force and displacement
- **SI Unit**: Joule (J)
- **Conditions for Work**:
    - A force must be applied.
    - There must be displacement.
    - Displacement must have a component in the direction of the force.
- **Positive Work**: Force and displacement in same direction (e.g., lifting a box).
- **Negative Work**: Force and displacement in opposite directions (e.g., friction).

4.3 Energy

- **Energy** is the capacity to do work.
- **SI Unit**: Joule (J)
- **Types of Energy**:
    - **Kinetic Energy**: Energy of a moving object.
        - Formula: $KE = \frac{1}{2} mv^2$
    - **Potential Energy**: Energy due to position or configuration.
        - Formula: $PE = mgh$
    - **Mechanical Energy**: Sum of kinetic and potential energy.
        - $ME = KE + PE$

4.4 Forms of Energy

- **Mechanical Energy**
- **Heat Energy**
- **Light Energy**
- **Sound Energy**
- **Chemical Energy**
- **Electrical Energy**
- **Nuclear Energy**

4.5 Transformation of Energy

- Energy can change from one form to another.

    - **Examples**:
        - Electric fan: Electrical → Mechanical
        - Solar panel: Light → Electrical
        - Battery: Chemical → Electrical
- **Law of Conservation of Energy**:
    - Energy can neither be created nor destroyed, only transformed from one form to another.
    - Total energy remains constant in an isolated system.

4.6 Power

- **Power** is the rate of doing work or transferring energy.
- **Formula**: `Power = Work done / Time`
- **SI Unit**: Watt (W)
- **Other Units**:
    - Kilowatt (kW) = 1000 W
    - Horsepower (1 HP = 746 W)

4.7 Commercial Unit of Energy

- In homes and industries, energy is measured in kilowatt-hours (kWh).
- **1 kWh = 1000 watts × 3600 seconds = 3.6×10^6 J**
- **Used for**: Calculating electricity consumption.

4.8 Efficiency

- Efficiency is a measure of how effectively energy is converted from one form to another.
- **Formula**:
    - `Efficiency (%) = (Useful energy output / Total energy input) × 100`
- Always less than 100% due to energy loss (usually as heat, sound, etc.).

4.9 Simple Machines and Work

- Machines help us do work with less effort.
- Use mechanical advantage to multiply input force.
- Examples: Lever, pulley, inclined plane (covered in detail in later chapters).

4.10 Applications in Daily Life

- Using energy-efficient devices saves power.
- Understanding power ratings helps choose appliances (e.g., 60W bulb vs 9W LED).
- Helps in calculating electricity bills.