MahaScience9

CLASS 9 SCIENCE · MAHARASHTRA STATE BOARD

CHAPTER 2

Work and Energy

Chapter Notes

1. Conceptual Framework and Theoretical Foundation

While colloquial dialogue treats "work" as any exertion of mental or physical effort, classical physics establishes a rigorous mathematical definition: work is performed exclusively when an external force applied to an object causes a physical displacement of that object along the line of action of the force. Closely linked to work is **energy**, defined universally as the capacity of a physical system to perform work.

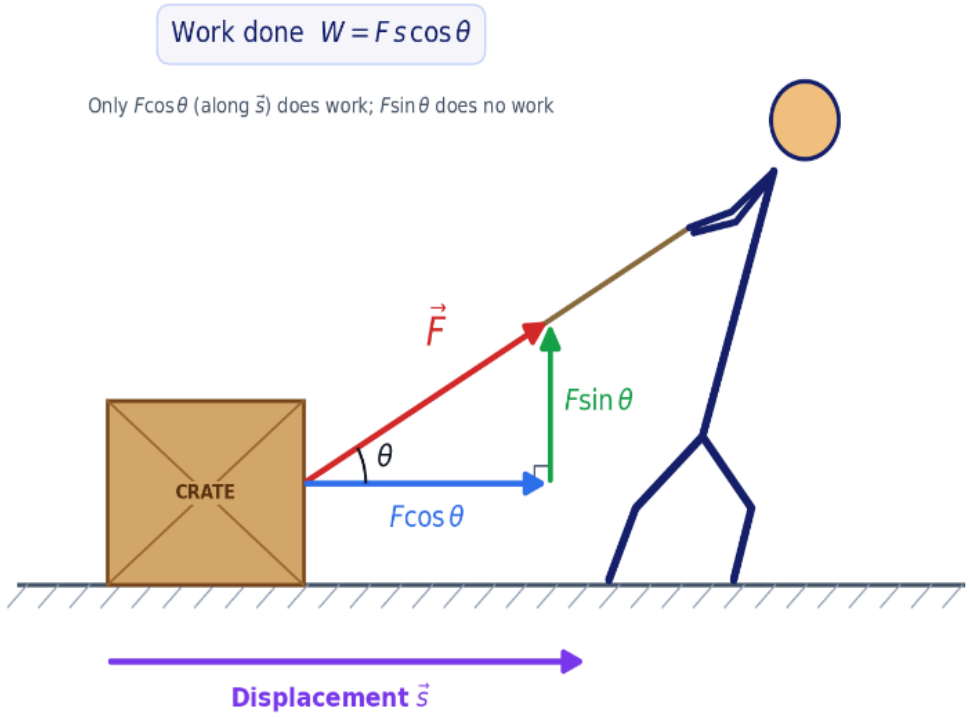
2. Scientific Definition of Work and Mathematical Formulation

When a constant force $\vec{F}$ is applied to an object, causing it to undergo a displacement $\vec{s}$ at an angle θ relative to the direction of the force, the work done (W) is given by the scalar dot product:

$$W = F \cdot s \cdot \cos\ (\theta)$$

- **Positive Work ($\theta = 0^\circ$):** Force and displacement act in the same direction (e.g., pulling a toy car forward).
- **Negative Work ($\theta = 180^\circ$):** Force and displacement act in opposite directions (e.g., frictional force opposing motion).
- **Zero Work ($\theta = 90^\circ$):** Force is perpendicular to displacement (e.g., a coolie carrying a heavy suitcase on their head while walking horizontally).

Figure 2.1 Work Done by a Force at an Angle



3. Forms of Mechanical Energy

Mechanical energy is partitioned into two primary classifications:

- **Kinetic Energy (KE):** The energy possessed by an object due to its active motion. Derived by calculating the work required to accelerate a mass m from rest to velocity v:

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

- **Potential Energy (PE):** The stored energy attributed to an object's relative position within a conservative force field (such as Earth's gravitational field or an elastic spring deformation). Gravitational potential energy is expressed as:

$$PE = mgh$$

where m is mass, g is acceleration due to gravity, and h is height above a datum plane.

4. Law of Conservation of Energy and Power

- **Conservation Law:** Energy can neither be created nor destroyed; it can only be transformed from one modal form into another. The total mechanical energy ($E = KE + PE$) of an isolated system remains constant in the absence of non-conservative dissipative forces like friction.

- **Power (P):** Defined as the time rate at which work is executed or energy is transferred:

$$P = \frac{W}{t} = \frac{\Delta E}{\Delta t}$$

Measured in Watts (W), where $1\ \mathrm{Watt} = 1\ \mathrm{Joule\ per\ second}$.

Figure 2.2 Conservation of Energy in a Freely Falling Ball

