Chapter 10: Work and Energy — Detailed Premium Notes

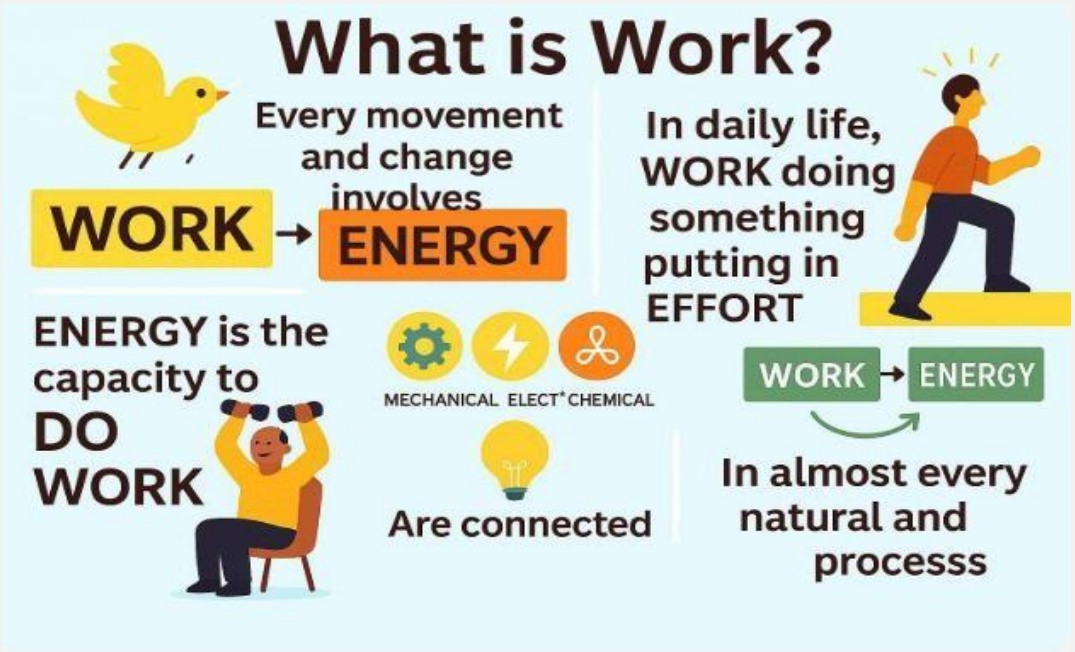
1.Introduction

All around us, every movement and change — from a flying bird to a glowing bulb — involves work and energy. These two ideas explain how things move and how energy flows in nature.

In daily life, *work* means doing something or putting in effort. But in science, work is done only when a force moves an object in its direction. This movement transfers energy from one body to another.

Energy is the capacity to do work. It enables us to move, lift, heat, and create motion. Every activity — whether mechanical, electrical, or chemical — depends on the transformation of energy.

Thus, work and energy are closely connected: whenever work is done, energy changes its form. Together, they form the basis of almost every natural and man-made process in the universe.



In short:

Work shows *how* energy is used, and energy shows *why* work can be done.

2.Work

In science, work is not about how much effort we put in — it depends on force and motion.
Work is said to be done when a force applied on an object causes it to move in the direction of that force.
If the object doesn't move or moves in a different direction, no work is done.

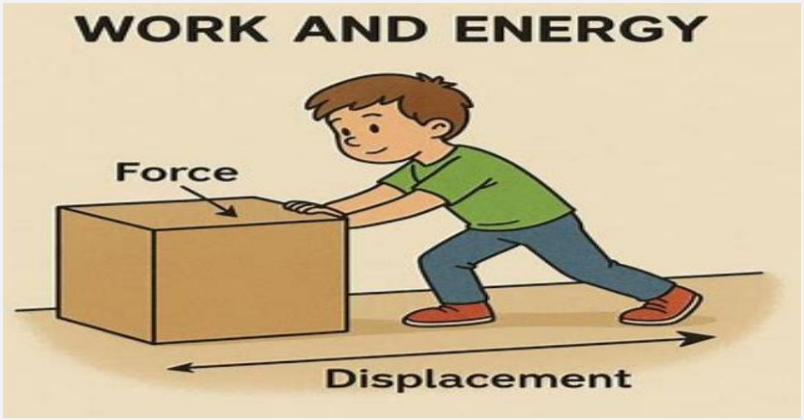
Example:

- ***Pushing a wall → No work***
- ***Lifting a book → Work done***

Formula
W = F × s × cosθ
SI Unit: Joule (J)
1 J = Work done when 1 newton force moves an object by 1 metre.

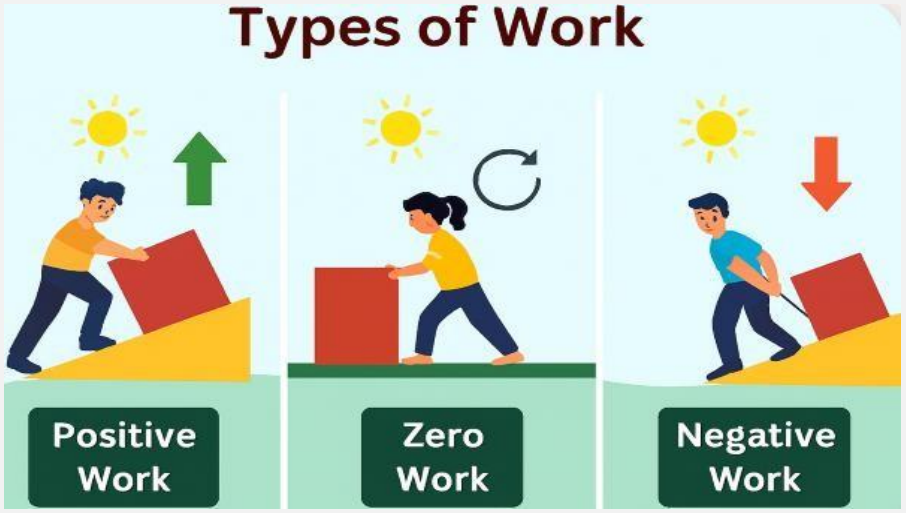
Conditions for Work

Force must be applied.
Object must move.
Motion must be in the direction of force.



Types of Work

- ***Positive: Force and motion in same direction.***
- ***Negative: Force and motion in opposite directions.***
- ***Zero: No displacement or force ⊥ motion.***



💡 ***Key Idea:***
Work is done only when force causes displacement, and whenever work is done, energy is transferred.

3.Energy

Everything we see happening around us — a flying bird, a glowing bulb, or a moving car — needs energy.
It is energy that makes all activities in the universe possible.

Definition

Energy is the capacity to do work.
Anything that can make an object move, change its shape, or produce light, heat, or sound possesses energy.

💡 ***Example: A moving car, a stretched rubber band, and a charged battery — all have energy because they can do work.***

Unit

SI Unit: Joule (J)
1 Joule of energy is the energy required to do 1 joule of work.

Relation Between Work and Energy

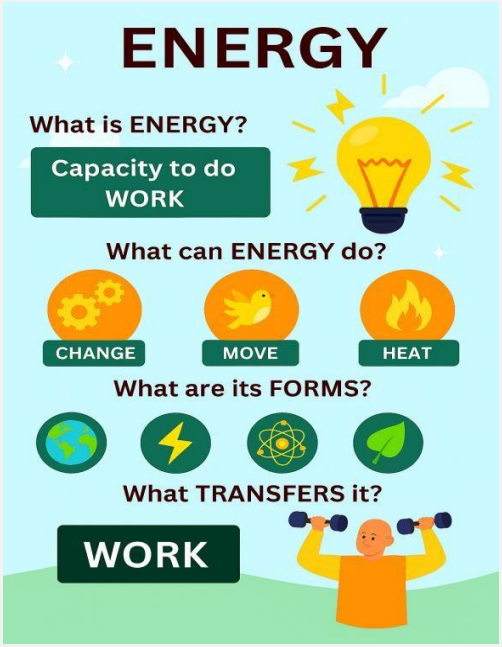
Work and energy are closely related:

- ***When work is done on an object → energy is transferred to it.***

- *When an object does work → it uses or loses energy. Work Done = Change in Energy*

Key Idea

Energy is what makes work possible — it is the fuel behind every motion and change in our surroundings.



4.Kinetic Energy (KE)

An object in motion has energy due to its movement. This energy is called Kinetic Energy.

Definition

Kinetic Energy is the energy possessed by a body because of its motion.

💡 ***Example: A moving car or a flying ball has kinetic energy.***

Formula

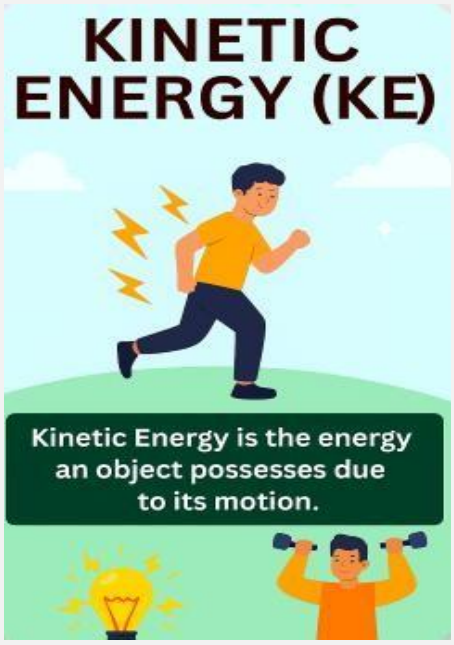
KE = ½ mv² where m = mass (kg), v = velocity (m/s)
SI Unit: Joule (J)

Key Idea

The faster or heavier an object is, the greater its kinetic energy. If velocity doubles, kinetic energy becomes four times.

In short:

Kinetic Energy = Energy of motion.



5.Potential Energy (PE)

Objects at rest but positioned to move have energy due to their position or configuration.
This energy is called Potential Energy.

Definition

Potential Energy is the energy possessed by a body due to its position or configuration.

💡 ***Example: A stretched rubber band, a lifted book, or water stored in a tank has potential energy.***

Formula (Gravitational PE)

PE = m g h
where, m =
mass (kg),
g = acceleration due to gravity (m/s²), h = height (m)

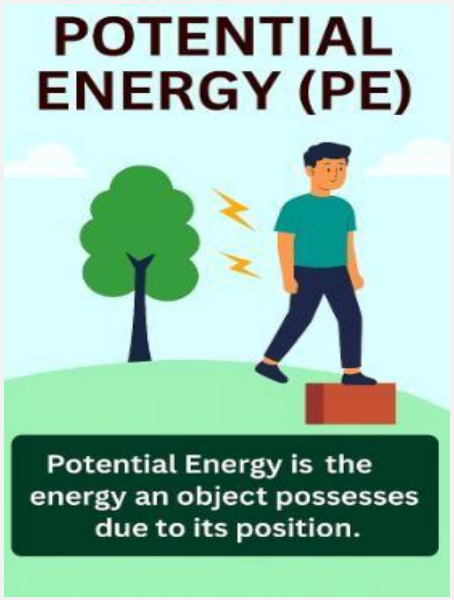
SI Unit: Joule (J)

Key Idea

- ***Potential Energy depends on mass, height, and gravity.***
- ***When the object is allowed to move, potential energy converts into kinetic energy.***

In short:

Potential Energy = Energy of position or stored energy.



6.Law of Conservation of Energy

Energy can neither be created nor destroyed; it can only change from one form to another.
The total energy of an isolated system always remains constant.

Explanation

- ***When a body falls, its potential energy decreases while kinetic energy increases.***
- ***The total energy (PE + KE) remains the same.*** ***Example:***

A pendulum swings:

- ***At the highest point → Maximum PE, Minimum KE***
- ***At the lowest point → Maximum KE, Minimum PE***
- ***Total energy remains constant throughout the motion***

Key Idea

In all processes, energy may change form (potential ↔ kinetic, chemical ↔ electrical, etc.), but the total energy is always conserved.

7.Power

Power is the rate at which work is done.
It tells us how quickly energy is transferred.

Definition

Power = Work done / Time taken
Example: Lifting a bag quickly requires more power than lifting it slowly.

Formula

P = W / t where,
P = Power, W =
Work done, t =
Time
SI Unit: Watt (W)
1 Watt: Power when 1 joule of work is done in 1 second

Key Idea

• More work in less time → Higher power •
Power measures how fast work is done

In short:

Power = Rate of doing work

8.Commercial Unit of Energy

- ***Electricity consumption is measured in kilowatt-hour (kWh).***
- ***1 kilowatt (kW) = 1000 watts (W).***
- ***1 kWh = 1000 W × 3600 s = 3,600,000 J = 3.6 MJ.***

9.Work Done in Various Situations

Situation	Is Work Done?	Explanation
Object moves in direction of force	Yes (Positive)	Force and displacement are in the same direction
Object moves opposite to force	Yes (Negative)	Force and displacement are in opposite directions
Object moves perpendicular to force	No (Zero Work)	Force is perpendicular, no displacement in the direction of force
Object not moving	No (Zero Work)	Displacement is zero

10.Examples of Work Done

- ***Lifting a bucket of water — positive work.***
- ***Pulling a cart — positive work.***
- ***Friction acting while sliding — negative work.***
- ***Holding a bag stationary — zero work.***

11.Energy Transformations

Energy changes from one form to another in almost all processes around us.
This is called energy transformation.

Explanation

- ***When energy changes form, the total energy remains conserved (Law of Conservation of Energy).***
- ***Example of transformations:***

a) **Electrical** → ***Light + Heat (Electric bulb)***
b) Chemical → Kinetic + Heat (Burning fuel in a car)

c) Potential → Kinetic (A falling stone)

Key Idea

Energy can never be created or destroyed, only transformed from one form to another.

12.Sample Problems

Q1: A force of 15 N is applied on a box to move it 8 meters in the direction of the force. Calculate the work done.

A1:

Work done, $W = F \times d \times \cos\theta$

$\theta = 0°$ (force and displacement same direction)

$W = 15 \times 8 \times 1 = 120$ joules

Q2: A 2 kg object is moving with a velocity of 3 m/s. Calculate its kinetic energy.

A2:

$KE = 0.5 \times m \times v^2 = 0.5 \times 2 \times 3^2 = 0.5 \times 2 \times 9 = 9$ joules

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Q3: Calculate the power of a machine that does 500 J work in 25 seconds.

A3:

Power, $P = W \div t = 500 \div 25 = 20$ watts