

1 LAQ = 8 MARKS

5. WORK, ENERGY AND POWER

- Work - Units - Signs • Energy - K.E & P.E • Power - units
- Work-Energy theorem • Law of conservation of Energy
- Collisions • Coefficient of restitution

SMART SYNOPSIS

1. **Work (W)** is said to be done, when a force (F) acting on a body moves it, through some distance (d). Work done is a scalar. [VSAQ]

Formula: $W = \vec{F} \cdot \vec{d} = Fd \cos\theta = (F\cos\theta)d$

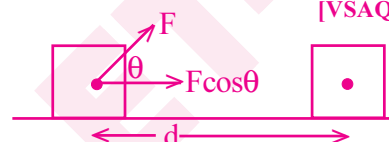
Here θ is angle between $\vec{F}$ and $\vec{d}$.

Also, Work is the energy transferred to an object due to a force causing it move a distance.

Note: Work in physics means 'mechanical work' which is different from our daily life work.

SI unit : joule (J); CGS unit: erg [VSAQ]

Conversions : 1 joule = 10^7 erg.



2. **Nature & Signs of workdone:** [VSAQ]

- (i) Workdone is **positive** if θ is **acute** (or) $\vec{F}$ and $\vec{d}$ are in the same direction.

Ex: Horizontal push or pull, lifting a bucket from a well. [VSAQ]

- (ii) Workdone is **negative** if θ is **obtuse** (or) $\vec{F}$ and $\vec{d}$ are in the opposite direction.

Ex: Gravity on a tossed ball, frictional force, breaking system. [VSAQ]

- (iii) Workdone is **zero** if θ is **90°** (or) $\vec{F}$ or $\vec{d}$ are zero.

Ex: Porter carrying a load on head ($\theta=90^\circ$), Pushing a wall ($d=0$). [VSAQ]

3. **ENERGY :** The **capacity to do work** is called Energy.

Energy is a scalar quantity. It is measured in the same units as work.

Units of Energy : SI unit: Joule. CGS unit : erg. [VSAQ]

Two types of Mechanical energy i) Potential energy (P.E or U) ii) Kinetic energy (K.E or K)

4. **Potential energy (U)** : It is the energy possessed by a body by virtue of its position. [VSAQ]

Ex : A 'stretched bow', water in a reservoir, a compressed spring

Formula : P.E = mgh or $U = mgh$

5. **Kinetic Energy** : It is the energy possessed by a body by virtue of its motion. [VSAQ]

Ex : A car in motion, a ball in motion, a bullet fired from a gun.

Formula : Kinetic energy $K.E = \frac{1}{2}mv^2$

6. **Relation between Kinetic energy (K) and Linear momentum (p)** : $K = \frac{p^2}{2m}$

7. **Power (P)**: The **rate of doing work** (transferring energy) is called power.

Formula : Power (P) = $\frac{\text{work}}{\text{time}}$ Power (P) = $\frac{W}{t}$ (or) $\frac{mgh}{t}$ (or) $\frac{\frac{1}{2}mv^2}{t}$

Units of Power: SI unit : watt (W) (or) joule/s

CGS unit : erg / s

Conversions: 1 watt = 10^7 erg/s ; 1 HP = 746 W, 1 KW = 1000 W, 1 MW = 10^6 W

8. **Law of conservation of energy**: [LAQ]

Total energy (PE + KE) remains constant in a closed system.

9. **Work-Energy theorem**: "Workdone by a constant resultant force acting on a body is equal to change in its kinetic energy". $W = \vec{F} \cdot \vec{d} = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$ [LAQ]

10. **Collisions**: If two bodies collide in a short time interval then velocities of colliding bodies change
(i) Total momentum will be conserved (ii) Total kinetic energy will be conserved

Examples : Hitting a cricket ball with a bat, collisions of Gas molecules.

Types of collisions :

[LAQ]

- 10.1 **Elastic collision** is the collision in which both Momentum and Kinetic energy are conserved.

Ex : Collision between 2 smooth Billiard balls, collisions between gas molecules

- 10.2 **Inelastic collision** is the collision in which only Momentum is conserved but not KE.

Ex: **Hitting** a ball with a bat, collision between a bullet and its target.

11. **Coefficient of restitution (e)** is the ratio of relative velocity of separation to [LAQ]

relative velocity of approach. **Formula**: $e = \frac{v_2 - v_1}{u_1 - u_2} = \frac{\text{Relative velocity of separation}}{\text{Relative velocity of approach}}$

- for an elastic collision $e = 1$
- for partial inelastic collision $e < 1$
- for perfectly inelastic collision $e = 0$

For better concept clarity refer **PHYSI BEATS P.No: 263**

1. WORK (W)

- Work is done when a force causes displacement in its direction.

$$W = FS \cos \theta = (F \cos \theta)S$$

- Work is a scalar quantity.

Units

- SI unit : joule (J)
- CGS unit : erg

NATURE OF WORK

- $0^\circ < \theta < 90^\circ \rightarrow$ Positive work
- $90^\circ < \theta < 180^\circ \rightarrow$ Negative work
- $\theta = 90^\circ \rightarrow$ Zero work

- Work is also zero if :

$$F = 0$$

$$S = 0$$

$$\text{Both } F = 0 \text{ and } S = 0$$

2. ENERGY

- Capacity to do work.
- Scalar quantity.
- Units are same as work.
 - SI : joule (J)
 - CGS : erg

POTENTIAL ENERGY (P.E.)

- Due to position or configuration.

$$PE = mgh$$

KINETIC ENERGY (K.E.)

- Due to motion.

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

or

$$KE = \frac{p^2}{2m}$$

$$\text{where } p = mv$$

3. WORK-ENERGY THEOREM

- Work done by the resultant force equals the change in kinetic energy.

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

4. LAW OF CONSERVATION OF ENERGY

- In a conservative system, total mechanical energy remains constant.

$$KE + PE = \text{constant}$$

5. WORK, ENERGY AND POWER**CONCEPTS & FORMULAS****ELASTIC COLLISION**

- Both momentum and kinetic energy are conserved.

Examples

- Collision between smooth billiard balls.
- Collision of gas molecules.

TYPES OF COLLISIONS

- (i) Elastic Collision
Momentum and kinetic energy are conserved.

- (ii) Inelastic Collision

Can be :

- Perfectly inelastic
- Partially inelastic

INELASTIC COLLISION

- Only momentum is conserved.
- Kinetic energy is not conserved.

Examples

- Bat hitting a ball.
- Bullet striking a target.

COEFFICIENT OF RESTITUTION (e)

- Ratio of relative velocity of separation to relative velocity of approach.

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

$$0 \leq e \leq 1$$

VALUES OF e

- Elastic collision: $e = 1$
- Partially inelastic $0 < e < 1$
- Perfectly inelastic $e = 0$

5. POWER (P)

- Rate of doing work or transferring energy.

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

Units

- SI unit : watt (W)

$$1 \text{ W} = 1 \text{ J/s}$$

- CGS unit : erg/s

6. COLLISIONS

- Occur in a very short time interval.
- Velocities of bodies change.
- Total momentum is conserved.
- Kinetic energy may be conserved or changed.

Examples

- Hitting a cricket ball.
- Collision of gas molecules.

KEY TAKEAWAY

- Power is the rate of doing work.
- Energy is the capacity to do work (K.E. or P.E.).
- Work depends on force, displacement and angle.
- Work-Energy Theorem links work and kinetic energy.
- In an isolated system, total mechanical energy is conserved.
- In collisions, momentum is always conserved.
- Coefficient of restitution determines the nature of collision.