CBSE CLASS 9 SCIENCE

Chapter 10: Work and Energy

Complete Concept & Question Bank

EXAM BOOSTER EDITION

SECTION 1: Chapter Overview

What is Work?

In physics, work is strictly defined as the product of an applied force vector and the resulting displacement of the object in the direction of that force vector. It acts as a quantitative indicator of energy transfer across mechanical systems.

What is Energy?

Energy represents the total internal capacity or potential ability of a physical system to perform work. When mechanical work is executed on an object, an equivalent quantum of energy is transferred directly into it.

Learning Outcomes

By the end of this chapter, you will be able to:

- Define scientific work parameters and identify the exact boundary conditions for work to occur.
- Calculate scalar work quantities alongside kinetic and potential energy metrics.
- State and mathematically validate the Universal Law of Conservation of Energy.
- Formulate definitions for mechanical Power and process metrics in real-world scenarios.
- Compute high-probability industrial and commercial numerical applications.

SECTION 2: Important Concepts

1. The Boundary Conditions of Work

For scientific work to be done, two non-negotiable criteria must be met: (i) an active external force vector must operate on the object, and (ii) the object must undergo a physical displacement. If displacement is zero, work is zero.

- **Positive Work ($\theta = 0°$):** Applied force matches the displacement trajectory (e.g., an engine pulling a train forward).
- **Negative Work ($\theta = 180°$):** Force opposes the active displacement vector (e.g., braking frictional vectors or gravity acting on an ascending object).
- **Zero Work ($\theta = 90°$):** Applied force acts completely perpendicularly to the displacement axis (e.g., centripetal gravity forces guiding a satellite in a circular orbit).

[Image of Positive Negative and Zero Work contexts]

Figure 10.1: Mechanical vector layouts depicting angle parameters for Positive, Negative, and Perpendicular (Zero) Work execution.

2. Forms of Mechanical Energy

Kinetic Energy (KE): The active energy field a physical body possesses due to its macroscopic state of motion. Derived as:

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

Potential Energy (PE): The stored configurations an object maintains by virtue of its position, height elevation, or geometry. The specific formula for Gravitational Potential Energy is structured as:

$$PE = mgh$$

3. The Law of Conservation of Energy

Energy can neither be created out of nothing nor destroyed during interactions; it can only undergo transformation from one form into another. The total mechanical energy ($ME = KE + PE$) of an isolated system remains fundamentally constant at all spatial coordinates.

[Image of energy conservation in a falling body and pendulum]

Figure 10.2: Energy transformation profiles for a freely falling object and oscillating pendulum showing continuous KE-PE conversion.

4. Power & Commercial Metrics

Power (P): The strict time-rate of work execution or system energy transformation. Evaluated as $P = W / t$ (SI Unit: Watt, where $1\ W = 1\ J/s$).

Kilowatt-Hour (kWh): The standard commercial unit tracking electric energy allocation. It measures the total energy consumed when a 1 kilowatt tool operates continuously for exactly one hour.

$$1\ kWh = 1000\ W \times 3600\ s = 3.6 \times 10^6\ Joules$$

SECTION 3: Important Formula Sheet

Formula	Physical Description	Standard SI Unit
$W = F \times s$	Linear Work Quantity	Joule (J) or N·m
$KE = \frac{1}{2}mv^2$	Kinetic Energy of Motion	Joule (J)
$PE = mgh$	Gravitational Potential Energy	Joule (J)
$P = W / t$	Mechanical Power Metric	Watt (W) or J/s
$E = P \times t$	Commercial Energy Formulation	Kilowatt-hour (kWh)

SECTION 4: Top 30 Frequently Repeated Questions

Very Short Answer Type (1 Mark)

Q1. Define 1 Joule of work.

Ans: Exactly 1 Joule of work is executed when an external unbalanced force vector of 1 Newton displaces a body by precisely 1 metre along its line of action.

Q2. What is the net work executed by gravity when an object moves completely horizontally across a floor?

Ans: Zero, because the downward gravity vector is oriented at exactly 90° relative to the horizontal displacement path.

Q3. If the linear velocity of a moving vehicle is doubled, how does its kinetic energy scale?

Ans: Because kinetic energy tracks the square of velocity ($KE \propto v^2$), doubling the velocity quadruples (increases by 4 times) the total kinetic energy.

Short Answer Type (2-3 Marks)

Q16. Why does a person carrying a heavy basket of hay standing static at a bus terminal for 30 minutes register zero work scientifically?

Ans: Although the individual exerts muscular forces to support the payload and encounters fatigue, the spatial displacement (s) of the load is zero. Since $W = F \times 0 = 0$, no scientific work is performed on the load.

SECTION 5: Top 20 Most Expected Questions

Q1. Derive the mathematical equation for Kinetic Energy from fundamental physics principles.

Ans: Let an object of mass m rest on a frictionless surface with initial velocity $u = 0$.

Apply a constant force vector F, accelerating it uniformly (a) across a linear displacement path s until it reaches final velocity v.

From the third equation of motion: $v^2 = u^2 + 2as \rightarrow v^2 = 0 + 2as \rightarrow s = v^2 / 2a$.

By definition, Work Done $W = F \times s$.

Substituting Newton's Second Law ($F = ma$) and the displacement term: $W = (ma) \times (v^2 / 2a)$.

Cancelling the acceleration scalar a yields: $W = \frac{1}{2}mv^2$.

This total work input is fully stored as kinetic energy inside the moving system, proving $KE = \frac{1}{2}mv^2$.

Q4. A home consumes exactly 250 commercial units of electrical energy over a monthly period. Express this resource use parameter in absolute Joules.

Ans: 1 commercial unit equals exactly 1 Kilowatt-hour (kWh).

We know that $1\ kWh = 3.6 \times 10^6\ J$.

Therefore, total consumption calculation: $250 \times 3.6 \times 10^6\ J = 9.0 \times 10^8\ Joules$.

SECTION 7: Most Important Numericals

Q3. A body of mass 5 kg falls down freely through a gravitational field from an initial elevation of 10 m down to a new position of 4 m. Compute the total loss in structural potential energy. (g = 10 m/s²)

Ans: Initial potential state: $PE_1 = mgh_1 = 5 \times 10 \times 10 = 500\ J$.

Final potential state: $PE_2 = mgh_2 = 5 \times 10 \times 4 = 200\ J$.

Net potential energy drop: $\Delta PE = PE_1 - PE_2 = 500 - 200 = 300\ Joules$.

Q6. A variable braking friction apparatus acts on a 20 kg rolling test mass, altering its tracking speed from 5 m/s down to 2 m/s. Calculate net work executed by the force.

Ans: Initial kinetic profile: $KE_{initial} = \frac{1}{2}mu^2 = \frac{1}{2} \times 20 \times 5^2 = 250\ J$.
Final kinetic profile: $KE_{final} = \frac{1}{2}mv^2 = \frac{1}{2} \times 20 \times 2^2 = 40\ J$.
By the Work-Energy Theorem, Work Done = Change in Kinetic Energy:
$W = KE_{final} - KE_{initial} = 40 - 250 = -210\ Joules$. The negative value denotes resistive work extraction.

SECTION 10: One-Day Before Exam Quick Sheet

Critical Concept Quick Checklist

- **Work Condition Test:** If a prompt mentions a porter walking with a trunk on his head, remember: work against gravity is zero because the force is up and motion is forward ($90°$).
- **Energy-Power Unit Split:** Do not mix up Kilowatt (kW = Power) with Kilowatt-hour (kWh = Energy). Examiners look for this specific distinction on final answer sheets.
- **Free Fall Energy Balance:** As height decreases, potential energy drops exactly by the amount that kinetic energy gains. Total structural energy remains identical at every single point along the fall.