Chapter 2: Work and Energy

Q. 1. Fill in the blanks:
(1) The work done is zero if there is no **displacement of the body**
(2) Flowing water has **kinetic** energy.
(3) By stretching the rubber strings of a catapult we store **potential** energy in it.
(4) The energy stored in a dry cell is in the form of **chemical energy**
(5) Power is **time rate of doing work**
(6) The work done is zero if the angle between the force acting on a body and the displacement of the body is **90^0**
(7) The CGS unit of work is the **erg**
(8) The SI unit of energy is the **joule**
(9) The kilowatt-hour is the unit of **energy**
(10) The rate of doing work is called **power**
(11) The potential energy of your body is least when you are **sleeping on the ground**
(12) The total energy of an object falling freely towards the ground **remains unchanged**
(13) If we increase the velocity of a car moving on a flat surface to four times its original speed, its potential energy **will not change**
(14) The work done on an object does not depend on **initial velocity of the object**
(15) Work done can be **positive, negative or zero**

Q. 2. True or false:
(1) Power is a scalar quantity. **True**
(2) The kilowatt-hour is a unit of energy. **True**
(3) The CGS unit of energy is the dyne. **False**
(4) The SI unit of work is the newton. **False**

Q.3. Difference between

Kinetic energy and potential energy

Kinetic energy	**Potential Energy**
Energy stored in an object due to its position, configuration, or state	Energy possessed by an object due to its motion
PE=mgh	KE=(½)mv^2
Can be stored and does not depend on the object's motion	Depends on the object's motion and disappears when it stops
Ex. A book placed on a shelf has potential energy due to its height	Ex. A moving car has kinetic energy due to its speed

Q. 4. Answer in one sentence:
(1) Define Work.
Answer: Work is said to be done when a force applied on an object causes displacement of the object
(2) Define Energy.
Answer: The capacity of a body to perform work is called its energy.
(3) Define Kinetic Energy.
Answer: The energy which an object has because of its motion is called its kinetic energy

(4) Define potential energy.
Answer: The energy stored in an object because of its specific state or position is called its potential energy.
(5) What is law of conservation of energy.
Answer: Energy can neither be created nor destroyed. It can be converted from one form into another. Thus, the total amount of energy in the universe remains constant
(6) What is free fall OR Define free fall.
Answer: An object falling solely under the influence of gravitational force is said to be in free fall or to be falling freely.
(7) Define power.
Answer: Power is the rate at which work is done.

Q. 5. Answer the following questions:
(1) At the moment of releasing the balls, which energy do the balls have?
Answer: At the moment of release, the balls possess potential energy. This energy is due to their height above the ground, and is related to their position in a gravitational field.
(2) As the balls roll down, which energy is converted into which other form of energy?
Answer: As the balls roll down, their potential energy is gradually converted into kinetic energy. This transformation occurs because the balls are moving, and kinetic energy increases as they gain speed while descending.
(3) Why do the balls cover the same distance on rolling down?
Answer: The balls cover the same distance while rolling down because they start from the same height and are subject to the same gravitational force. Assuming friction and air resistance are negligible, the conversion of potential energy to kinetic energy happens equally for all the balls, allowing them to travel the same distance.
(4) What is the form of the eventual total energy of the balls?
Answer: At the end of the roll, the balls' total energy is mostly in the form of kinetic energy, as their potential energy has been fully converted into motion. Some energy may also be lost as heat due to friction, but the primary form of energy is kinetic.
(5) Write the 5 examples of transformation of energy?
Answer:
1. Electric Bulb: Electrical energy converts into light and heat energy.
2. Solar Panels: Solar energy converts into electrical energy.
3. Car Engine: Chemical energy from fuel converts into kinetic and heat energy.
4. Hydroelectric Power Plant: Gravitational potential energy converts into electrical energy.
5. Photosynthesis: Light energy converts into chemical energy in plants.

(6) Explain positive work.
Answer: Definition: Work is considered positive when the force applied on an object and its displacement are in the same direction.
Example: Lifting a book vertically upwards by applying an upward force. The force (upward) and displacement (upward) are in the same direction.
Condition: $\theta=0°$, so $\cos(0°)=1$, and work is positive.
(7) Explain negative work.
Answer: Definition: Work is negative when the force applied on an object is in the opposite direction to its displacement.
Example: A car slowing down due to friction. The frictional force acts opposite to the car's direction of motion.
Condition: $\theta=180°$, so $\cos(180°)=-1$, and work is negative.
(8) Explain zero work.
Answer: Definition: Work is zero when the force applied does not cause any displacement, or the force is perpendicular to the direction of displacement.

Example: Carrying a bag while walking on a horizontal surface. The force (vertical, due to gravity) and displacement (horizontal) are perpendicular.
Condition: $\theta=90°$, so $\cos(90°)=0$, and work is zero.

(9) If an object has 0 momentum, does it have kinetic energy? Explain your answer.

Answer: If an object has 0 momentum, it means that either its mass is zero or its velocity is zero. Since kinetic energy is calculated using the formula (KE) = $\frac{1}{2}mv^2$, if the velocity (v) is zero, then the kinetic energy will also be zero, regardless of the mass. Therefore, an object with 0 momentum does not have kinetic energy.

(10) Why is the work done on an object moving with uniform circular motion zero?

Answer: In uniform circular motion, the object moves at a constant speed along a circular path. The direction of the object's velocity is continuously changing, but the speed remains constant. Since work is defined as $W=F \cdot d \cdot \cos(\theta)$, where θ is the angle between the force and the direction of displacement, the centripetal force acts perpendicular to the displacement at any point in the circular path ($\theta=90°$). Thus, $\cos(90°)=0$, resulting in zero work done.

Q. 6. Solve

(1) Ravi applied a force of 10 N and moved a book 30 cm in the direction of the force. How much was the work done by Ravi?

Given:

- Force applied (F) = 10 N
- Distance moved (d) = 30 cm = 0.30 m (converted to meters)
- Angle between force and direction of movement = 0° (since the force is applied in the same direction as the movement)

To Find:

Work done (W)

Formula:

Work done (W) = Force × Distance × cos(θ)

Since $\theta=0^\circ$, $\cos(0^\circ)=1$;

$W=F \cdot d$

Calculation:

$W=10N \cdot 0.30m=3J$

Answer:

Work done by Ravi = 3 J (Joules)

(2) Calculate the work done to take an object of mass 20 kg to a height of 10 m

Given:

- Mass of the object (m) = 20 kg
- Height (h) = 10 m
- Acceleration due to gravity (g) = 9.81 m/s^2

To Find:

Work done (W) to lift the object

Formula:

Work done (W) = m × g × h

Calculation:

$W=20\,kg \cdot 9.81\,m/s^2 \cdot 10\,m$
$=1962\,J$

Answer:

Work done = 1962 J (Joules)

(3) Pravin has applied a force of 100 N on an object, at an angle of 600 to the horizontal. The object gets displaced in the horizontal direction and 400 J work is done. What is the displacement of the object?

Given:

- Force applied (F) = 100 N
- Angle (θ) = 60°
- Work done (W) = 400 J
- Displacement (d) = ? (to be found)

To Find:

Displacement of the object (d)

Formula:

Work done (W) = F·d·cos(θ)

Calculation:

Rearrange the formula to solve for displacement (d):

d=$\frac{W}{F \cdot cos(\theta)}$

d=$\frac{400\,J}{100\,N \cdot cos(60°)}$

Since cos(60°)=0.5

d=$\frac{400}{100 \cdot 0.5}$

d=$\frac{400}{50}$ = 8m

Answer:

Displacement of the object = 8 m

(4) A stone having a mass of 250 gm is falling from a height. How much kinetic energy does it have at the moment when its velocity is 2 m/s?

Given:

- Mass of the stone (m) = 250 g = 0.25 kg (converted to kg)
- Velocity (v) = 2 m/s

To Find:

Kinetic energy (KE)

Formula:

Kinetic energy (KE) = $\frac{1}{2}mv^2$

Calculation:

KE=$\frac{1}{2} \cdot 0.25\,kg \cdot (2\,m/s)^2$

KE=$\frac{1}{2} \cdot 0.25 \cdot 4 = 0.5\,J$

Answer:

Kinetic energy = 0.5 J

(5) A 25 W electric bulb is used for 10 hours every day. How much electricity does it consume each day?

Given:

- Power of the bulb (P) = 25 W = 0.025 kW (converted to kW)
- Time used per day (t) = 10 hours

To Find:

Electricity consumed each day (in kWh)

Formula:

Electricity consumed (E) = Power (P) × Time (t)

Calculation:

$E=0.025\ kW\cdot 10\ hours=0.25\ kWh$

Answer:

Electricity consumed per day = 0.25 kWh

(6) An electric pump has 2 kW power. How much water will the pump lift every minute to a height of 10 m? (Ans : 1224.5 kg)

Given:

- Power of the pump (P) = 2 kW = 2000 W (converted to W)
- Height (h) = 10 m
- Time (t) = 1 minute = 60 seconds
- Acceleration due to gravity (g) = 9.81 m/s²

To Find:

Mass of water lifted (m)

Formula:

Power (P) = $\frac{W}{t}$ = $\frac{mgh}{t}$

Rearrange to find mass (m):

m= $\frac{P\cdot t}{g\cdot h}$

Calculation:

m= $\frac{2000\ W\cdot 60\ s}{9.81\ m/s^2\cdot 10\ m}$

m=$\frac{120000}{98.1}$ ≈1224.5 kg

Answer:

Mass of water lifted = 1224.5 kg

(7) If a 1200 W electric iron is used daily for 30 minutes, how much total electricity is consumed in the month of April? (Ans :18 Unit)

Given:

- Power of the iron (P) = 1200 W = 1.2 kW (converted to kW)
- Time used per day (t) = 30 minutes = 0.5 hours
- Number of days in April = 30 days

To Find:

Total electricity consumed in the month of April (in kWh)

Formula:

Electricity consumed (E) = Power (P) × Time (t) × Number of days

Calculation:

$E=1.2\ kW\cdot 0.5\ hours/day\cdot 30\ days$

$E=1.2\cdot 0.5\cdot 30=18\ kWh$

Answer:

Total electricity consumed in April = 18 kWh (or 18 Units)

(8) If the energy of a ball falling from a height of 10 metres is reduced by 40%, how high will it rebound? (Ans : 6 m)

Given:

- Initial height (h_1) = 10 m
- Energy loss = 40%
- Remaining energy = 60%

To Find:

Rebound height (h_2)

Concept:
The energy of the ball is proportional to the height, so the rebound height will be proportional to the remaining energy.
Formula:
$h_2=\frac{60}{100}\cdot h_1$
Calculation:
$h_2=\frac{60}{100}\cdot 10m = 6m$
Answer:
Rebound height = 6 m
(9) The velocity of a car increases from 54 km/hr to 72 km/hr. How much is the work done if the mass of the car is 1500 kg ? (Ans. : 131250 J)
Given:
- Initial velocity (u) = 54 km/h = 15 m/s (converted to m/s)
- Final velocity (v) = 72 km/h = 20 m/s (converted to m/s)
- Mass of the car (m) = 1500 kg

To Find:
Work done (W)
Formula:
Work done is equivalent to the change in kinetic energy:
$W = \frac{1}{2}\cdot m\cdot(v^2-u^2)$
Calculation:
$W = \frac{1}{2}\cdot m \cdot (v^2-u^2)$
$W = \frac{1}{2}\cdot 1500\text{ kg}\cdot(20^2-15^2)\text{ m}^2/\text{s}^2$
$W = 750 \cdot (400-225)$
$W = 750 \cdot 225$
$W = 131250J$
Answer:
Work done = 131250 J

(10) Ravi applied a force of 10 N and moved a book 30 cm in the direction of the force. How much was the work done by Ravi?
Given:
- Force applied (F) = 10 N
- Distance moved (d) = 30 cm = 0.30 m (converted to meters)
- Angle between force and direction of movement = 0° (since the force is applied in the same direction as the movement)

To Find:
Work done (W)
Formula:
Work done (W) = Force × Distance × cos(θ)
Calculation:
Since $\theta=0°$; $\cos(0°)=1$:
$W = F\cdot d$
$W = 10\text{ N}\cdot 0.30\text{ m}$
$W = 3\text{ J}$
Answer:
Work done by Ravi = 3 J