Chapter: 06

Work and Energy

Exercise MCQs

1. **The work done will be zero when the angle between the force and the distance is:**

   (A) 45° (B) 60° (C) 90° (D) 180°

2. **If the direction of motion of the force is perpendicular to the direction of motion of body, then work done will be:**

   (A) maximum (B) minimum (C) Zero (D) None

3. **If the velocity of a body becomes double, then its kinetic energy will:**

   (A) remain the same (B) become double
   (C) become four times (D) become half

4. **The work done in lifting a brick of mass 2 kg through a height of 5 m above ground will be?**

   (A) 2.5J (B) 10 J (C) 50J (D) 100J

5. **The kinetic energy of a body of mass 2 kg is 25 J. It is speed is?**

   (A) $5ms^{-1}$ (B) $1.5ms^{-1}$ (C) $12.5ms^{-1}$ (D) $50ms^{-1}$

6. **Which one of the following converts light energy into electrical energy?**

   (A) electric bulb (B) electric generator (C) photocell (D) electric cell

7. **When a body is lifted through a height h, the work done on it appears in the form of its:**

   (A) kinetic energy (B) potential energy
   (C) elastic potential energy (D) geothermal energy

8. **The energy stored in coal is:**

   (A) heat energy (B) kinetic energy (C) chemical energy (D) nuclear energy

9. The energy stored in a dam is:

Ⓐ electric energy Ⓑ potential energy Ⓒ kinetic energy Ⓓ thermal energy

10. In Einstein's mass-energy equation, c is the:

Ⓐ speed of sound
Ⓑ speed of light
Ⓒ speed of electron
Ⓓ speed of earth

11. The rate of doing work is called:

Ⓐ energy Ⓑ torque Ⓒ power Ⓓ momentum

Answer Key:

1	Ⓒ	7	Ⓑ
2	Ⓒ	8	Ⓒ
3	Ⓒ	9	Ⓑ
4	Ⓓ	10	Ⓑ
5	Ⓐ	11	Ⓒ
6	Ⓒ		

Short Questions

1. Define work. What is its SI unit?

Ans: Work:

Work is said to be done when force acting on a body displaces it in the direction of the force.

Formula:

$$\text{Work} = \text{Force} \times \text{distance}$$

$$W = F \times S$$

SI unit of work:

SI unit of work is joule (J) or Nm

Joule:

The amount of work done will be one joule if a force of one Newton displaces a body through a distance of one meter in the direction of the force.

2. Why do we need energy?

Ans: We need energy to do different types of work in our daily life. When we say that body has energy, we mean that it has the ability to do work.

OR

- Energy is used by us to perform many activities of life.
- Energy is necessary for running and walking for humans.

3. When does a force do work? Explain.

Ans: Work is done when the force acting on a body displaces it in the direction of applied force.

4. Define energy, and give two types of mechanical energy.

Ans: Energy:

A body possesses energy if it is capable to do work.

Types of mechanical energy:

Mechanical energy has two following types:

(i) Kinetic energy (ii) Potential energy

Kinetic energy:

The energy possessed by a body due to its motion is called its kinetic energy.

Formula:

$$K.E = \frac{1}{2}mv^2$$

Potential energy:

The ability of a body to do work due to its position is known as its potential energy.

Formula:

$$P.E = mgh$$

5. Define potential energy and derive its relation.

Ans: Potential energy:

Energy possessed by a body due to its position is called potential energy.

$$P.E = mgh$$

Derivation:

$$P.E = work$$

$$P.E = F.d$$

$$P.E = (mg)(h)$$

$$P.E = mgh$$

6. Define K.E and derive its relation.

Ans: "The energy possessed by a body due to its motion is called kinetic energy".

Example:

- Moving air is called wind. We can use wind energy for doing various things. It drives windmills and pushes sailing boats.
- Moving water in a river can carry wooden logs through large distances and can also be used to drive turbines for generating electricity.

Mathematical Derivation:

Let a body of mass m is moving with velocity v. An opposing force F acting through a distance S brings it to rest. The body possesses kinetic energy and is capable to do work against opposing force F until add of its kinetic energy used up.

K.E of the body = Work done by it due to motion

$$K.E = FS$$

$$v_i = v$$

$$v_f = 0$$

As $F = ma$

$$a = -\frac{F}{m}$$

Since motion is opposed, hence, is a negative.

Using 3rd equation of motion:

$$2aS = v_f^2 - v_i^2$$

$$2\left(-\frac{F}{m}\right)S = (0)^2 - (v)^2$$

$$2(-FS) = -mv^2$$

$$-FS = -\frac{1}{2}mv^2$$

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

As we know that K.E is equal to the work done,

So $K.E = \frac{1}{2}mv^2$

The above equation gives the K .E possessed by a body of mass m moving with velocity v.

7. Why fossils fuels are called non-renewable form of energy?

Ans: The fossil fuels take millions of years for their formation. So, these are known as nonrenewable resources.

8. How is energy converted from one form to another? Explain.

Ans: With the help of different devices and through chemical reactions energy is converted from one form to another.

Example:

Solar cells are used to convert light energy into electrical energy.

9. Which form of energy is most preferred and why?

Ans: Solar energy is the most preferred energy because sunlight does not pollute the environment in any way.

Solar energy reaching Earth is a thousand times more than the energy consumption of mankind.

10. Name a device that converts mechanical energy into electrical energy.

Ans: A generator is a device that converts mechanical energy into electrical energy.

11. Name the five devices that convert electrical energy into mechanical energy.

Ans: Name of five devices:

(i) Washing machine
(ii) Electric motor
(iii) Electric grinder
(iv) Electric spinner
(v) Juicer

12. What is meant by the efficiency of a system?

Ans: Efficiency:

The efficiency of a system is the ratio of required form of energy obtained from a system as output to the total energy given to it as input.

Formula:

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}}$$

Input is the energy given to machine to work while output is work done by machine.

13. What is meant by the term power?

Ans: **Power:**

Power is defined as the rate of doing work.

Formula:

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

i.e. $$P = \frac{W}{t}$$

Unit:

The SI unit of power is watt (W).

14. How can you find the efficiency of a system?

Ans: The efficiency of a system can be determined by following the formula.

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}}$$

$$\%\text{Efficiency} = \frac{\text{Output}}{\text{Input}} \times 100$$

15. Define Watt.

Ans: **Watt:**

The power of a body is one watt if it does work at the rate of 1 joule per second ($1Js^{-1}$).

$$1 \text{ watt} = \frac{1J}{1 \text{ sec}}$$

Important Formulas

- $\%\text{Efficiency} = \frac{\text{Output}}{\text{Input}} \times 100$
- $\text{Efficiency} = \frac{\text{Output}}{\text{Input}}$
- $W = F \times S$
- $K.E = \frac{1}{2}mv^2$
- $P.E = mgh$
- $E = mc^2$
- $P = F.V$ or $P = \frac{W}{t}$

Important Values

- Speed of light = $e = 3 \times 10^8\ ms^{-1}$
- Density of water = $1000\ kgm^{-3}$
- Mass of 1 liter water = 1kg
- 1hp = 746 watt
- $1MJ = 10^6 J$

Units:

- Work = Joule
- Power = Watt
- Energy = Joule
- (1 joule = Newton meter)
  (Watt = Joule/sec)

Numerical

1. A man has pulled a cart through 35m applying a force of 300N. Find the work done by the man.

Ans: Given data:

S = 35m

F = 300N

To Find:

Work = W = ?

Solution:

$W = F \times S$

$W = 300 \times 35$

$W = 10500\ J$

Result:

Work done by the man = W = 10500 J

2. A block weighing 20N is lifted 6m vertically upward. Calculate the potential energy stored in it.

Ans: Given data:

Weight = S = 20N

$h = 6m$

To Find:

$P.E = ?$

Solution:

$$P.E = \text{Work done}$$
$$P.E = F.d = mgh = w.h$$
$$P.E = w.h$$
$$P.E = 20 \times 6$$
$$P.E = 120\ J$$

Result:

Potential energy $= P.E = 120\ J$

3. A car weighing 12kN has the speed of $20ms^{-1}$. Find its kinetic energy.

Ans: Given data:

$$\text{Weight} = w = 12kN = 12 \times 1000N = 12000N$$
$$v = 20ms^{-1}$$

To Find:

$K.E = ?$

Solution:

$$K.E = \frac{1}{2}mv^2 \quad \text{----------(i)}$$

Now, $w = mg$

$$m = \frac{w}{g} = \frac{12000}{10} = 1200kg$$
$$K.E = \frac{1}{2} \times 1200 \times (20)^2$$
$$K.E = \frac{1}{2} \times 1200 \times 400$$
$$K.E = 240000\ J \qquad \therefore\ 1000\ J = 1Kj$$
$$K.E = 240kJ$$

Result:

Kinetic energy $= K.E = 240kJ$

4. A 500g stone is thrown up with a velocity of $15ms^{-1}$. Find its.

(a) P.E at its maximum height.

(b) K.E when it hits the ground.

Ans: Given data:

$$m = 500g = \frac{500}{1000} = 0.5kg$$

$$v = 15ms^{-1}$$

To Find:

$$P.E = ?$$

$$K.E = ?$$

Solution:

$$K.E = \frac{1}{2}mv^2$$

$$K.E = \frac{1}{2} \times 0.5 \times (15)^2$$

$$K.E = \frac{1}{2} \times 1200 \times 225$$

$$\mathbf{K.E = 56.25\ J}$$

As we know that;

Potential energy at maximum height = Kinetic energy while throwing

$$K.E = P.E$$

So **P .E will also be = 56.25J**

Because energy is converted one form to another but it remains the same.

5. On reaching the top of a slope 6m high from its bottom, a cyclist has a speed of 1.5ms^{-1}. Find the K.E and P.E of the cyclist. The mass of the cyclist and his bicycle is 40kg.

Ans: Given data:

$$h = 6m$$

$$g = 1.5ms^{-1}$$

$$m = 40kg$$

To Find:

$$K.E = ?$$

$$P.E = ?$$

Solution:

$$K.E = \frac{1}{2}mv^2$$

$$K.E = \frac{1}{2} \times 40 \times (1.5)^2$$

$$K.E = \frac{1}{2} \times 40 \times 2.25$$

$$\mathbf{K.E = 45\ J}$$

$$P.E = mgh$$

$$P.E = 40 \times 10 \times 6$$

$$\mathbf{P.E = 2400J}$$

6. A motorboat moves at a steady speed of $4ms^{-1}$, water resistance acting on it is 4000N. Calculate the power of its engine.

Ans: Given data:

$$v = 4ms^{-1}$$

$$F = 4000N$$

To Find:

$$P = ?$$

Solution:

$$P = F.v$$

$$P = 4000 \times 4$$

$$P = 16000\ watt$$

$$P = 16 \times 1000$$

$$P = 16 \times 10^3$$

$$\mathbf{P = 16kW}$$

7. A man pulls a block with a force of 300N through 50m in 60s. Find the power used by him to pull the block.

Ans: Given data:

$$F = 300N$$

$$S = 50m$$

$$t = 60s$$

To Find:

$$P = ?$$

Solution:

$$P = \frac{W}{t} \qquad \therefore W = F \times S$$

$$P = \frac{F \times S}{t}$$

$$P = \frac{300 \times 50}{60}$$

$$\mathbf{P = 250watt}$$

8. A 50kg man moved 25 steps up in 20 seconds. Find his power, if each step is 16cm high.

Ans: Given data:

$$m = 50kg$$

$$t = 20s$$

$$\text{Height of each step} = 16cm = \frac{16}{100} = 0.16m$$

$$\text{Height of 25 step} = 0.16 \times 25 = 4m$$

To Find:

$$P = ?$$

Solution:

$$P = \frac{W}{t} \qquad \because W = mgh$$

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

$$P = \frac{50 \times 10 \times 4}{20}$$

$$\mathbf{P = 100watt}$$

9. Calculate the power of a pump which can lift 200kg of water through a height of 6m in 10 seconds.

Ans: Given data:

$$m = 200kg$$

$$h = 6m$$

$$t = 10s$$

To Find:

$$P = ?$$

Solution:

$$P = \frac{W}{t} \qquad \therefore W = mgh$$

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

$$P = \frac{200 \times 10 \times 6}{10}$$

$$\mathbf{P = 1200watt}$$

10. An electric motor of 1hp is used to run water pump. The water pump takes 10 minutes to fill an overhead tank. The tank has a capacity of 800 liters and height of 15m. Find the actual work done of motor to fill the tank. Also find efficiency of the system.
(Density of water = 1000kgm^{-1})
Mass of 1 litre of water = 1kg).

Ans: Given data:

$v = 800$ liters

$t = 10$ min $= 10 \times 60 = 600$ sec

$P = 1hP$ $\quad \therefore$ 1hp = 746 watt

$P = 746$ watt

$h = 15m$

To Find:

$W = ?$

Efficiency $= ?$

Solution:

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

$$W = P \times t$$

$$W = 746 \times 600$$

$$\mathbf{Input = W = 447600J}$$

We know that;

1 litre of water = 1kg of water

So,

$800\text{litres} = 800\text{kg}$

$m = 800\text{kg}$

Now,

$$W = mgh$$

$$W = 800 \times 10 \times 15$$

$$W = 120000J$$

Here

$$\text{Work input} = 447600\text{J}$$

$$\text{Work input} = 120000\text{J}$$

$$\%\text{Efficiency} = \frac{\text{Output}}{\text{Input}} \times 100$$

$$\%\text{Efficiency} = \frac{120000}{447600} \times 100$$

$$\%\textbf{Efficiency} = \textbf{26.8\%}$$