CHAPTER 10

Work and Energy

NCERT FOCUS ANSWERS

Topic 1

1. Force, $F = 7$ N

Displacement, $s = 8$ m

Then, work done $= 7 \text{ N} \times 8 \text{ m} = 56 \text{ N m} = 56$ J

2. Work is done by a force on an object if the force acts on the object and the object is displaced from its original position.

3. If F is the constant force acting in the direction of displacement s, then work done by the force,

$W = F \times s = Fs$.

4. The amount of work done when a force of 1 N moves a body through a distance of 1 m in the direction of the force is called 1 joule.

5. Here, $F = 140$ N, $s = 15$ m.

Work done in ploughing the field,

$W = F \times s = (140 \text{ N}) \times (15 \text{ m}) = 2100$ J

6. (i) Suma is doing work. She is applying force to move forward.

(ii) Donkey is not doing any work. Here, the displacement and the force are at 90°.

(iii) Work is done by the windmill. The water is lifted against force of gravity.

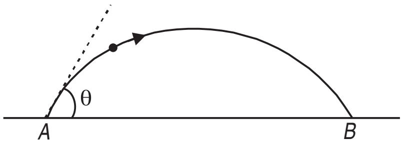
(iv) No work is done by a green plant during photosynthesis.

(v) The engine applies a pulling force on the train, and the train moves in the direction of this force. Therefore, engine is doing work.

(vi) During drying of food grains in the sun, no work is done.

(vii) Work is done by the wind. The sailboat moves in the direction of the force exerted by wind.

7. Since initial and the final positions of the path of the object thrown at a certain angle to the ground lie on the same horizontal plane, the displacement of the object is in the horizontal direction. The force of gravity on the object acts vertically downwards, so no work is said to be done.



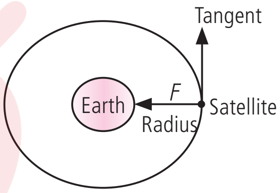
8. Here, the mass of 10 kg is moved horizontally from point A to B. The force of gravity acts vertically downwards. Thus, the mass moves in a direction at right angle to the force of gravity.

So, work done on the object by the force of gravity

$= Fs \cos\theta = Fs \cos 90° = 0$ $(\because \cos 90° = 0)$

Therefore, no work is done by the force of gravity on the object.

9. When a satellite moves around the earth, its displacement in a short interval is along the tangent to the circular path of the satellite. The gravitational force (F) acting on the satellite due to the earth is along the radius as shown in figure.



Since a tangent is always perpendicular to the radius, the displacement and the force are perpendicular to each other. There is no displacement of the satellite in the direction of the force, *i.e.*, $s = 0$. Thus, work done by the force of gravity on the satellite is zero as $W = F \times s = 0$.

10. Yes. In the absence of any force on the object, *i.e.*, $F = 0$, $ma = 0$ $(\because F = ma)$.

Accordingly a = 0 since $m \neq 0$, $a = 0$.

In such a case, the object is either at rest or in a state of uniform motion in a straight line. In the later case, there is a displacement of the object without any force acting on it.

11. When a person holds a bundle of hay over his head, there is no displacement in the hay bundle. Although the force of gravity is acting on the bundle, the person is not applying any force on it. Hence, in the absence of force, work done by the person on the bundle is zero.

12. (i) Here, the force acts at right angle to the displacement. So, work done by the force = 0.

(ii) Here, the direction of displacement is the same as that of the force. So, work done by the force is positive.

(iii) Here, the body moves in a direction opposite to the direction of the force. So, work done by the force is negative.

13. The acceleration of an object can be zero even if several forces are acting on it provided the resultant force (F) is zero. As $F = 0$, $ma = 0$ and accordingly $a = 0$ (as $m \neq 0$).

Topic 2

1. Kinetic energy of an object is the energy possessed by it due to its motion. In fact, kinetic energy of an object moving with a certain velocity is equal to the work done to make it acquire that velocity.

2. Kinetic energy of an object,

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

where m = mass of the object and

v = uniform velocity of the object

3. K.E. of an object $= \frac{1}{2} mv^2 = 25$ J

K.E. of the object with velocity double of initial

$$= \frac{1}{2} \times m\,(2v)^2 = 4 \times \left(\frac{1}{2} mv^2\right) = 4 \times 25 \text{ J} = 100 \text{ J}$$

K.E. of the object with velocity triple of initial

$$= \frac{1}{2} \times m\,(3v)^2 = 9 \times \left(\frac{1}{2} mv^2\right) = 9 \times 25 \text{ J} = 225 \text{ J}$$

4. Initial kinetic energy of the object,

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

When the object comes to rest,

final kinetic energy of the object, $K.E_f = 0$

Change in kinetic energy $= \frac{1}{2} mv^2 - 0 = \frac{1}{2} mv^2$

Work done on the object = change in its kinetic energy

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

5. Here, mass of the car, m = 1500 kg

Initial velocity of the car, u = 60 km h^{-1}

$$= \frac{60 \times 1000 \text{ m}}{60 \times 60 \text{ s}} = \frac{50}{3} \text{ m s}^{-1}$$

Initial kinetic energy of the car,

$$K.E_i = \frac{1}{2} mu^2 = \frac{1}{2} (1500 \text{ kg}) \left(\frac{50}{3} \text{ m s}^{-1}\right)^2 = 208333.3 \text{ J}$$

Final kinetic energy of the car,

$$K.E_f = \frac{1}{2} mv^2 = 0$$

Change in kinetic energy of the car

$= K.E_f - K.E_i = -208333.3$ J

The minus sign indicates that the work is being done against the moving car.

6. As the potential energy of the freely falling object decreases, its kinetic energy increases on account of an increase in its velocity. The sum of the potential energy and the kinetic energy of the object during its free fall remains the same, *i.e.*, the total mechanical energy (potential energy + kinetic energy) remains constant. Thus, the law of conservation of energy is not violated.

7. When a freely falling body eventually stops on reaching the ground, its kinetic energy appears in the form of :

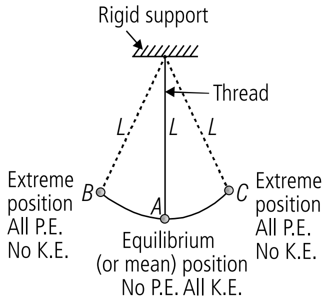
(i) heat energy, as the body and the ground become warmer due to collision.

(ii) sound energy, as sound is produced due to collision of the body with the ground.

(iii) potential energy of configuration of the body and the ground. The body may be deformed and the ground may be depressed at the place of collision.

This process in which the kinetic energy of a freely falling body is lost in an unproductive chain of energy changes is called dissipation of energy.

8. A small metallic ball (called bob) suspended by a light string (thread) from a frictionless, rigid support is called a simple pendulum. A simple pendulum is shown in figure.



The bob of a simple pendulum swings from one extreme position to the other through its mean position.

The bob is at its highest position at the extreme positions and at lowest at its mean position.

The energy changes which occur during the motion of the bob are shown in figure. So, when a pendulum swings to and fro, its energy changes constantly in the following sequence.

Extreme right position-All P.E. No K.E.

↓

Mean position-No P.E. All K.E.

↓

Extreme left position-All P.E. No K.E.

↓

Mean position-No P.E. All K.E.

↓

Extreme right position-All P.E. No K.E.

9. The muscular energy of the cyclist is converted into kinetic energy (rotational) of the pedals of the bicycle which is transferred to its wheels. The kinetic energy of the rotation of the wheels is converted into the kinetic energy of the bicycle and the cyclist.

10. No transfer of energy takes place when we push a huge rock unsuccessfully.

The energy is spent for the physical activity of muscles.

The person holding a bundle of hay on his head gets tired as he experiences muscular fatigue. This fatigue is due to the conversion of chemical energy into thermal energy by the muscular effort. The person has done no work as his effort causes no displacement of the bundle over his head, *i.e.*, $s = 0$.

Topic 3

1. The rate of doing work is called power. Thus,

$$\text{Power } (P) = \frac{\text{Total work done } (W)}{\text{Time taken } (t)} \quad \text{or} \quad P = \frac{W}{t}$$

2. Power of an object is said to be 1 W if it does 1 joule of work in 1 s, *i.e.*,

$$1 \text{ watt (W)} = \frac{1 \text{ joule (J)}}{1 \text{ second (s)}} = 1 \text{ J s}^{-1}$$

In other words, we can say that power is 1 W when the rate of consumption of energy is 1 J s^{-1}.

3. Energy consumed = 1000 J, Time = 10 s

$$\text{Power} = \frac{\text{Energy consumed}}{\text{Time}} = \frac{1000 \text{ J}}{10 \text{ s}} = 100 \text{ J s}^{-1}$$

$$= 100 \text{ W} \qquad (\because \; 1 \text{ J s}^{-1} = 1 \text{ W})$$

4. $$\text{Average power} = \frac{\text{Total energy consumed}}{\text{Total time taken}}$$

The concept of average power is useful when the power of an agent varies with time and it does work at different rates during different intervals of time.

5. Energy consumed = 250 units = 250 kWh

$= 250 \times 1000 \text{ W h} = 250 \times (1000 \text{ W}) (3600 \text{ s})$

$= 900 \times 10^6 = 9 \times 10^8 \text{ J}$

6. Here, power of the electric heater, $P = 1500$ W

Time for which it is used, $t = 10$ h

Energy used by the electric heater, *i.e.*,

$E = P \times t = 1500 \text{ W} \times 10 \text{ h} = 15000 \text{ Wh} = 15 \text{ kWh}$

$$\text{Energy consumed} = 15 \text{ kWh} \times \frac{3.6 \times 10^6 \text{ J}}{1 \text{ kWh}} = 5.4 \times 10^7 \text{ J}$$

$$(\because \; 1 \text{ kWh} = 3.6 \times 10^6 \text{ J})$$

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