NCERT Solutions for Class 9th Science

Chapter 11 – WORK AND ENERGY

Q.1 A force of 7 N acts on an object. The displacement is, say 8 m, in the direction of the force (Fig. 11.3). Let us take it that the force acts on the object through the displacement. What is the work done in this case?

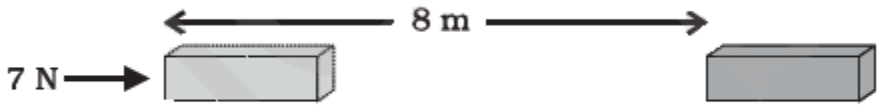


Fig. 11.3

Ans Work done = force x displacement (in the direction of force)
= 7 x 8 = **56 Nm = 56 J**

Q.2 When do we say that work is done?

Ans Two conditions need to be satisfied for work to be done:
(i) A force should act on an object, and
(ii) The object must be displaced in the direction of force.

Q.3 Write an expression for the work done when a force is acting on an object in the direction of its displacement.

Ans Let the force applied = F
Displacement in the direction of force = S
Hence, work done, ***W* = F x S**

Q.4 Define 1 J of work.

Ans 1 J of work is the amount of work done on an object when a force of 1 N displaces it by 1 m along the line of action of the force.
***W* (1 J)** = F (1 N) x S (1 m)

Q.5 A pair of bullocks exerts a force of 140 N on a plough. The field being ploughed is 15 m long. How much work is done in ploughing the length of the field?

Ans Force = 140 N

Displacement = length of field = 15 m

Work done in ploughing the field = 140 x 15 = **2100 J**

Q.6 What is the kinetic energy of an object?

Ans Kinetic energy is the energy possessed by an object due to its motion. The kinetic energy of an object increases with its speed. If the mass of an object is 'm' and is moving with velocity 'v', its kinetic energy will be equal to (1/2) mv^2. Its unit is joules (J).

Q.7 Write an expression for the kinetic energy of an object.

Ans If the mass of an object is 'm' and is moving with velocity 'v', it possesses kinetic energy,

K.E. = (1/2) mv^2; Its unit is joules (J).

Q.8 The kinetic energy of an object of mass, m moving with a velocity of 5 m/s is 25 J. What will be its kinetic energy when its velocity is doubled? What will be its kinetic energy when its velocity is increased three times?

Ans Kinetic energy, K.E. = (1/2) mv^2

Clearly, K.E. is directly proportional to square of velocity, i.e. K.E. α v^2

Hence, K.E. will become 4 times, when velocity is doubled i.e. K.E. = 25 x 4 = **100 J**

K.E. will become 9 times, when velocity is increased three times i.e. K.E. = 25 x 9 = **225 J**

Q.9 What is power?

Ans Power is defined as the rate of doing work or the rate of transfer of energy. If an agent does a work *W* in time t, then power is given by:

Power = work/time

P = *W*/t; Its unit is watt (symbol 'W')

Q.10 Define 1 watt of power.

Ans 1 watt is the power of an agent, which does work at the rate of 1 joule per second i.e. power is 1W when the rate of consumption of energy is 1 J/s.

P (1 watt) = *W* (1 joule) / t (1 second)

Q.11 A lamp consumes 1000 J of electrical energy in 10 s. What is its power?

Ans Work done (*W*) = Energy consumed by lamp = 1000 J

Time taken (t) = 10 s

» Power (P) = Work done / Time taken = 1000/10 = 100 W

Q.12 Define average power.

Ans The power of an agent may vary with time i.e. the agent may be doing work at different rates at different intervals of time. Thus the concept of average power arises. Average power is obtained by dividing the total energy consumed with the total time taken.

Average power = Total energy consumed / total time taken

EXERCISES

Q.1 Look at the activities listed below. Reason out whether or not work is done in the light of your understanding of the term 'work'.

- Suma is swimming in a pond.
- A donkey is carrying a load on its back.
- A wind-mill is lifting water from a well.
- A green plant is carrying out photosynthesis.
- An engine is pulling a train.
- Food grains are getting dried in the sun.
- A sailboat is moving due to wind energy.

Ans Two conditions need to be satisfied for work to be done:

(i) A force should act on an object, and

(ii) The object must be displaced in the direction of force.

• **Suma is swimming in a pond** – **Work is done** as for swimming Suma must have applied force backwards. The reaction applied by water is in the forward direction and so as the displacement caused by this force. Hence work is done in this case.

• **A donkey is carrying a load on its back** – **No work is done** as the force applied by donkey (upward direction) is in the perpendicular direction to the displacement (forward direction).

• **A wind-mill is lifting water from a well** – **Work is done** as force applied by wind mill (upward direction opposite to gravitational pull) caused displacement in the same direction (upward direction).

• **A green plant is carrying out photosynthesis** – **No work is done** as there is no displacement of leaves.

• **An engine is pulling a train** – **Work is done** as pull force applied by engine (forward direction) caused displacement of train in the same direction (forward direction).

• **Food grains are getting dried in the sun** – **No work is done** as there is no displacement of food grains during drying process.

• **A sailboat is moving due to wind energy** – **Work is done** as the force applied by wind (forward direction) caused displacement of sailboat in the same direction (forward direction).

Q.2 An object thrown at a certain angle to the ground moves in a curved path and falls back to the ground. The initial and the final points of the path of the object lie on the same horizontal line. What is the work done by the force of gravity on the object?

Ans Let the mass of object = m

Force of gravity = mg (downward direction)

Displacement (vertical direction) = 0 (as initial and final point lies on the same horizontal line)

Hence, work done = Force x Displacement = mg x 0 = **0 J**

Q.3 A battery lights a bulb. Describe the energy changes involved in the process.

Ans A battery has chemical energy. When it is used in a circuit, this energy will convert into electrical energy. When the bulb glows, this energy will convert into light energy. Heat will be produced after glowing of bulb i.e. finally the energy will be converted into heat energy. Thus, energy changes involved: **Chemical energy → Electrical energy → Light energy → Heat energy**

Q.4 Certain force acting on a 20 kg mass changes its velocity from 5 m/s to 2 m/s. Calculate the work done by the force.

Ans Initial kinetic energy, $E_1 = (1/2) \times 20 \times 5^2 = 250$ J

Final kinetic energy, $E_2 = (1/2) \times 20 \times 2^2 = 40$ J

Work done = Change in kinetic energy = $E_2 - E_1 = 40 - 250 =$ **-210 J**

Negative sign indicates that the displacement is in the direction opposite to the direction of force.

Q.5 A mass of 10 kg is at a point A on a table. It is moved to a point B. If the line joining A and B is horizontal, what is the work done on the object by the gravitational force? Explain your answer.

Ans **Work done** on the object by the gravitational force = 0.

Mass of object, m = 10 kg

Gravitational force on object = mg = 10g (downward direction)

Displacement (vertical direction) = 0 (as the line joining A and B is horizontal)

Hence, work done = Force x Displacement = 10g x 0 = **0 J**

Q.6 The potential energy of a freely falling object decreases progressively. Does this violate the law of conservation of energy? Why?

Ans **No,** it does not violate the law of conservation of energy.

When a body falls freely, its potential energy changes to kinetic energy progressively. The decrease in potential energy is equal to the increase in kinetic energy i.e. the total energy (sum of potential energy and kinetic energy) remains same (conserved) throughout the motion of object. Hence, law of conservation of energy is not violated.

Q.7 What are the various energy transformations that occur when you are riding a bicycle?

Ans Muscular energy is getting transformed into kinetic energy and heat energy.

Q.8 Does the transfer of energy take place when you push a huge rock with all your might and fail to move it? Where is the energy you spend going?

Ans **Yes**, muscular energy will get transformed into heat energy.

Energy will be spent in heating our body and atmosphere.

Q.9 A certain household has consumed 250 units of energy during a month. How much energy is this in joules?

Ans 1 unit = 1 kWh and 1 kWh = 3.6×10^6 J

Hence, Energy consumed for 250 units = $250 \times 3.6 \times 10^6$ = **9×10^8 J**

Q.10 An object of mass 40 kg is raised to a height of 5 m above the ground. What is its potential energy? If the object is allowed to fall, find its kinetic energy when it is half-way down.

Ans mass, m = 40 kg; height, h = 5 m; g = 10 m/s^2

» Potential Energy, P.E. = mgh = 40 x 10 x 5 = **2000 J**

At half-way down,

P.E. will be 2000 / 2 = 1000 J

Due to the law of conservation of energy,

At half-way down, Kinetic energy, K.E. = P.E. = **1000 J**

Q.11 What is the work done by the force of gravity on a satellite moving round the earth? Justify your answer.

Ans **No** work is done by the force of gravity on a satellite moving round the earth. This is because the direction of the gravitational force (downward direction) is perpendicular to the displacement or motion of the satellite.

Q.12 Can there be displacement of an object in the absence of any force acting on it? Think. Discuss this question with your friends and teacher.

Ans **Yes,** it is possible in case of a uniform motion.

If an object is moving with a constant velocity, no net force acts on it but it has displacement in the direction of motion.

Q.13 A person holds a bundle of hay over his head for 30 minutes and gets tired. Has he done some work or not? Justify your answer.

Ans **No** work is done by the person.

This is because in this case, the displacement is zero. (Work done = Force x Displacement)

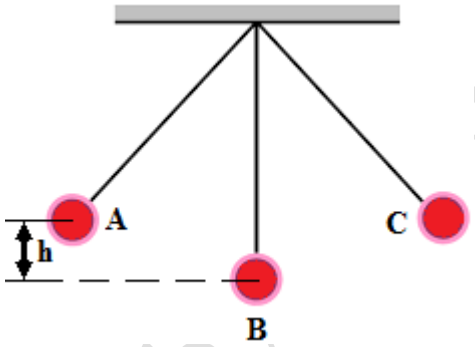
Q.14 An electric heater is rated 1500 W. How much energy does it use in 10 hours?

Ans Energy = Power x time taken

» E = 1500 x 10 = 15000 Wh = **15 kWh or 15 units** = 15 x 3.6 x 10^6 J = **54 x 10^6 J**

Q.15 Illustrate the law of conservation of energy by discussing the energy changes which occur when we draw a pendulum bob to one side and allow it to oscillate. Why does the bob eventually come to rest? What happens to its energy eventually? Is it a violation of the law of conservation of energy?

Ans **Law of conservation of energy:** Energy can neither be created nor destroyed, but one form of energy can be transformed to another.



The above figure gives oscillation of a pendulum. Position **A** and **C** are called extreme positions whereas position **B** is called mean position. When the bob is taken to any extreme positions (A or C), it rises through height 'h' above mean position (B) as shown in figure above. At this point, it has only potential energy and no kinetic energy (as the bob is at rest). When the bob is released, it reaches point B. During the path from A to B, potential energy decreases progressively and kinetic energy increases accordingly. At mean position i.e. at point B, it has only kinetic energy and no potential energy (as height, h becomes zero at this point). When the bob goes further and traverses path B to C, its kinetic energy decreases progressively and potential energy increases accordingly. At point C, it has only potential energy and no kinetic energy (as the bob comes to rest). During the whole process of oscillation, the total energy (kinetic energy + potential energy) remains constant at any point.

The bob does not oscillate forever and comes to rest after sometime due to the air resistance. The bob loses its energy to overcome this resistance or friction.

This does not violate the law of conservation of energy because energy lost by pendulum to overcome friction is gained by its surroundings. Hence, the total energy of the pendulum and surrounding system remains conserved.

Q.16 An object of mass, m is moving with a constant velocity, v. How much work should be done on the object in order to bring the object to rest?

Ans Initial kinetic energy, $E_1 = (1/2)\ mv^2$

The object comes to rest i.e. final kinetic energy = 0

Hence, work done = Change in kinetic energy = $E_2 - E_1 = -(1/2)\ mv^2$

Negative sign indicates that the work is done in the direction opposite to the motion of object.

Q.17 Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 km/h?

Ans mass, m = 1500 kg; velocity, v = 60 km/h = (60 x 1000) / 3600 = 50/3 m/s

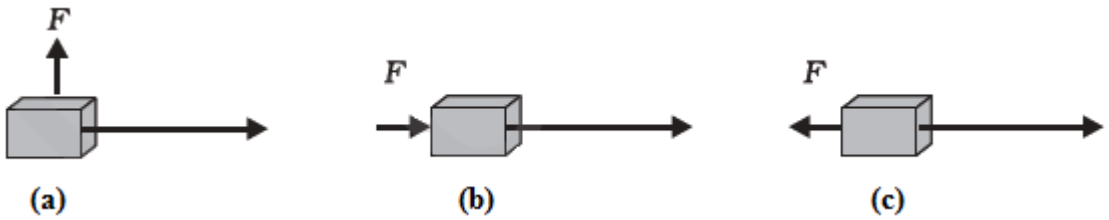
Initial kinetic energy of car, $E_1 = (1/2)\ mv^2 = (1/2) \times 1500 \times (50/3)^2 = 208333.33$ J

The car comes to rest i.e. final kinetic energy of car = 0

Hence, work done = Change in kinetic energy = $E_2 - E_1$ = **- 208333.33 J**

Negative sign indicates that the work is done in the direction opposite to the motion of car.

Q.18 In each of the following a force, F is acting on an object of mass, m. The direction of displacement is from west to east shown by the longer arrow. Observe the diagrams carefully and state whether the work done by the force is negative, positive or zero.



Ans Work done = Force x Displacement (in the direction of force)

(a) Work done by force is zero as displacement is perpendicular to the direction of force.

(b) Work done by force is positive as displacement is in the direction of force.

(c) Work done by force is negative as displacement is in opposite direction to that of force.

Q.19 Soni says that the acceleration in an object could be zero even when several forces are acting on it. Do you agree with her? Why?

Ans **Yes,** we agree with Soni that the acceleration in an object could be zero even when several forces are acting on it. This is possible when all the forces acting on an object cancel out each other. In case of uniform motion, an object moves with a constant velocity and net force acting on it is zero. Hence, the acceleration in the object is zero.

Q.20 Find the energy in kW h consumed in 10 hours by four devices of power 500 W each.

Ans Energy consumed by each device = Power x time taken = 500 x 10 = 5000 Wh = 5 kWh

» Energy consumed by 4 devices = 4 x 5 = **20 kWh or 20 units**

Q.21 A freely falling object eventually stops on reaching the ground. What happenes to its kinetic energy?

Ans The kinetic energy of a freely falling body increases progressively throughout the path and is maximum just before it hits the ground. On hitting the ground, this kinetic energy gets transformed into heat energy and sound energy.