

Board – CBSE

Class –9th

Topic – Work and Energy

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 windmill 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. Work is done whenever the given two conditions are satisfied.

(i) A force acts on the body.

(ii) There is a displacement of the body by applying force in or opposite the force's direction.

(a) While swimming, Suma applies a force to push the water backwards. Therefore, Suma swims in the forward direction caused by the forward reaction of water. Here, the force causes a displacement. Hence, work is done by Seema while swimming.

(b) While carrying a load, the donkey has to apply a force upward. But, displacement of the load is in the forward direction. Since displacement is perpendicular to force, the work done is zero.

(c) A windmill works against the gravitational force to lift water. Hence, work is done by the windmill in lifting water from the well.

(d) In this case, there is no displacement of the leaves of the plant. Therefore, the work done is zero.

(e) An engine applies force to pull the train. This allows the train to move in the direction of the force. Therefore, there is a displacement in the train in the same direction. Hence, work is done by the engine on the train.

(f) Foodgrains do not move in the presence of solar energy. Hence, the work done is zero during the process of food grains getting dried in the Sun.

(g) Wind energy applies a force on the sailboat to push it in the forward direction. Therefore, there is a displacement in the boat in the direction of the force. Hence, work is done by wind on the boat.

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. Work done by the force of gravity on an object depends only on vertical displacement. Vertical displacement is given by the difference in the object's initial and final positions/heights, which is zero.

Work done by gravity is given by the expression,

$$W = mgh$$

Where,

$$h = \text{Vertical displacement} = 0$$

$$W = mg \times 0 = 0 \text{ J}$$

Therefore, the work done by gravity on the given object is zero joules.

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

Ans. When a bulb is connected to a battery, then the battery's chemical energy is transferred into electrical energy. When the bulb receives this electrical energy, then it converts it into light and heat energy. Hence, the transformation of energy in the given situation can be shown as.

Chemical Energy → *Electrical Energy* → *Light Energy* + *Heat Energy*

4. Certain force acting on a 20 kg mass changes its velocity from 5 m s^{-1} to 2 m s^{-1} . Calculate the work done by the force.

Ans. The expression gives kinetic energy,

$$(E_k)_v = \frac{1}{2}mv^2$$

Where,

E_k = Kinetic energy of the object moving with a velocity, v

m = mass of the object

(i) Kinetic energy when the object was moving with a velocity of 5 m s^{-1}

$$(E_k)_5 = \frac{1}{2} \times 20 \times (5)^2 = 250 \text{ J}$$

(ii) Kinetic energy when the object was moving with a velocity of 2 m s^{-1}

$$(E_k)_2 = \frac{1}{2} \times 20 \times (2)^2 = 40 \text{ J}$$

Work done by the force is equal to the change in kinetic energy.

$$\begin{aligned} \text{Therefore, work done by force} &= (E_k)_2 - (E_k)_5 \\ &= 40 - 250 = -210 \text{ J} \end{aligned}$$

The negative sign indicates that the force is acting in the direction opposite to the object's motion.

5. A mass of 10 kg is at point A on a table. It is moved to 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 by gravity depends only on the vertical displacement of the body. It does not depend upon the path of the body. Therefore, work done by gravity is given by the expression,

$$W = mgh$$

Where,

Vertical displacement, $h = 0$

$$\therefore W = mg \times 0 = 0$$

Hence, the work done by gravity on the body is zero.

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

Ans. No. The process does not violate the law of conservation of energy. This is because when the body falls from a height, its potential energy changes into kinetic energy progressively. A decrease in the potential energy is equal to an increase in the kinetic energy of the body. During the process, the total mechanical energy of the body remains conserved. Therefore, the law of conservation of energy is not violated.

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

Ans. While riding a bicycle, the muscular energy of the rider gets transferred into heat energy and kinetic energy of the bicycle. Heat energy heats the rider's body. Kinetic energy provides velocity to the bicycle. The transformation can be shown as.

Muscular Energy \rightarrow *Kinetic Energy* + *Heat Energy*

During the transformation, the total energy remains conserved.

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

Ans. When we push a huge rock, there is no transfer of muscular energy to the stationary rock. Also, there is no loss of energy because muscular energy is transferred into heat energy, which causes our body to become hot.

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

Ans. 1 unit of energy is equal to a 1-kilowatt hour (kWh).

$$1 \text{ unit} = 1 \text{ kWh}$$

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$$

$$\text{Therefore, 250 units of energy} = 250 \times 3.6 \times 10^6 = 9 \times 10^8 \text{ J}$$

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 halfway down.

Ans. The expression gives gravitational potential energy,

$$W = mgh$$

Where,

$$h = \text{Vertical displacement} = 5 \text{ m}$$

$$m = \text{Mass of the object} = 40 \text{ kg}$$

$$g = \text{Acceleration due to gravity} = 9.8 \text{ m s}^{-2}$$

$$\therefore W = 40 \times 5 \times 9.8 = 1960 \text{ J.}$$

At halfway down, the potential energy of the object will be $\frac{1960}{2} = 980 \text{ J}$.

At this point, the object has an equal amount of potential and kinetic energy. This is due to the law of conservation of energy. Hence, halfway down, the kinetic energy of the object will be 980 J.

11. What is the work done by the force of gravity on a satellite moving around the Earth? Justify your answer.

Ans. Work is done whenever the given two conditions are satisfied.

(i) A force acts on the body.

(ii) There is a displacement of the body by applying force in or opposite the force's direction.

If the direction of force is perpendicular to displacement, then the work done is zero.

When a satellite moves around the Earth, the direction of the force of gravity on the satellite is perpendicular to its displacement. Hence, the work done on the satellite by the Earth is zero.

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

Ans. Yes. For a uniformly moving object

Suppose an object is moving with constant velocity. The net force acting on it is zero. But, there is a displacement along the motion of the object. Hence, there can be a displacement without a force.

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. Work is done whenever the given two conditions are satisfied.

(i) A force acts on the body.

(ii) There is a displacement of the body by applying force in or opposite the force's direction.

When a person holds a bundle of hay over his head, there is no displacement in the bundle of hay.

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.

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

Ans. Energy consumed by an electric heater can be obtained with the help of the expression,

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

Where,

The power rating of the heater, $P = 1500 \text{ W} = 1.5 \text{ kW}$

Time for which the heater has operated, $T = 10 \text{ h}$

Work done = energy consumed by the heater

Therefore, energy consumed = $Power \times Time$

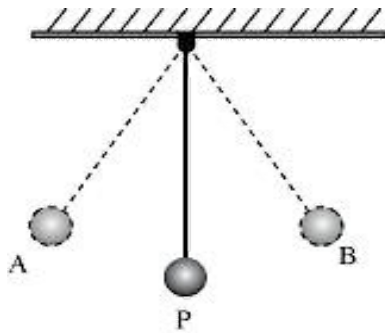
$$= 1.5 \times 10 = 15 \text{ kWh}$$

Hence, the energy consumed by the heater in 10 h is 15 kWh.

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. The law of conservation of energy states that energy can be neither created nor destroyed. It can only be converted from one form to another.

Consider the case of an oscillating pendulum.



When a pendulum moves from its mean position P to extreme positions A or B, it rises through a height h above the mean level P. At this point, the kinetic energy of the bob changes completely into potential energy. The kinetic energy becomes zero, and the bob possesses only potential energy. As it moves towards point P, its potential energy decreases progressively. Accordingly, the kinetic energy increases. As the bob reaches point P, its potential energy becomes zero, possessing only kinetic energy. This process is repeated as long as the pendulum oscillates.

The bob does not oscillate forever. It comes to rest because air resistance resists its motion. The pendulum loses its kinetic energy to overcome this friction and stops after some time.

The law of energy conservation is not violated because the energy lost by the pendulum to overcome friction is gained by its surroundings. Hence, the total energy of the pendulum and the surrounding system remain conserved.

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

Ans. The kinetic energy of an object of mass, m moving with a velocity, the expression gives v ,

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

To bring the object to rest, $\frac{1}{2}mv^2$ amount of work is required to be done on the object.

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

Ans. Kinetic energy, $E_k = \frac{1}{2}mv^2$

Where,

Mass of car, $m = 1500$ kg

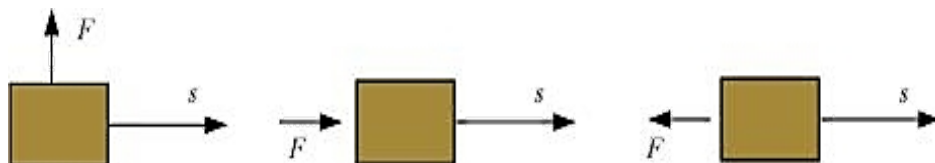
Velocity of car, $v = 60$ km/h $= 60 \times \frac{5}{18} \text{ ms}^{-1}$

$$\therefore E_k = \frac{1}{2} \times 1500 \times \left(60 \times \frac{5}{18}\right)^2 = 20.8 \times 10^4 \text{ J}$$

Hence, 20.8×10^4 J of work is required to stop the car.

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

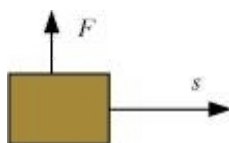
Ans.



Work is done whenever the given two conditions are satisfied.

- (i) A force acts on the body.
- (ii) There is a displacement of the body by applying force in or opposite the force's direction.

Case I



In this case, the direction of force acting on the block is perpendicular to the displacement. Therefore, work done by force on the block will be zero.

Case II



In this case, the direction of force acting on the block is in the direction of displacement. Therefore, work done by force on the block will be positive.

Case III



In this case, the direction of force acting on the block is opposite to the direction of displacement. Therefore, work done by force on the block will be negative.

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. Acceleration in an object could be zero even when several forces are acting on it. This happens when all the forces cancel out each other, i.e., the net force acting on the object is zero. For a uniformly moving object, the net force acting on the object is zero. Hence, the acceleration of the object is zero. Hence, Soni is right.

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

Ans. Energy consumed by an electric device can be obtained with the help of the expression for power,

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

Where,

The power rating of the device, $P = 500 \text{ W} = 0.50 \text{ kW}$

Time for which the device runs, $T = 10 \text{ h}$

Work done = energy consumed by the device

Therefore, energy consumed = Power \times Time

$$= 0.50 \times 10 = 5 \text{ kWh}$$

Hence, the energy consumed by four equal rating devices in 10 h will be $4 \times 5 \text{ kWh} = 20 \text{ kWh} = 20$ Units.

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

Ans. When an object falls freely towards the ground, its potential energy decreases, and kinetic energy increases. As the object touches the ground, all its potential energy gets converted into kinetic energy. As the object hits the hard ground, all its kinetic energy gets converted into heat and sound energy. It can also deform the ground depending upon the nature of the ground and the amount of kinetic energy possessed by the object.