

Work and Energy (IX Science Solution) NCERT Exercise

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

Work is said to be done if (a) A force acts on the body. (b) The body displaced by the application of force in or opposite to the direction of force.

(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 in the upward direction. But, displacement of the load is in the forward direction. Since, displacement is perpendicular to force, the work done is zero.

(c) A wind mill works against the gravitational force to lift water. Hence, work is done by the wind mill 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 force. Therefore, there is a displacement in the train in the same direction. Hence, work is done by the engine on the train.

(f) Food grains 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 force. Hence, work is done by wind on the boat.

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

Work done by gravity is given by the expression,

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

3. When a bulb is connected to a battery, then the chemical energy of the battery 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 \rightarrow electrical energy \rightarrow Light energy \rightarrow Heat energy

$$4. \text{ Work done by force is equal to the change in kinetic energy} = \frac{1}{2}m(v^2 - u^2) \\ = \frac{1}{2} \times 20 (2^2 - 5^2) = -210 \text{ J}$$

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

5. 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, $h = 0$

$$\therefore W = mg \times 0 = 0 \text{ Hence, the work done by gravity on the body is zero.}$$

6. No. The process does not violate the law of conservation of energy. This is because when the body falls from a height, then 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, total mechanical energy of the body remains conserved. Therefore, the law of conservation of energy is not violated.

7. 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 a velocity to the bicycle. The transformation can be shown as:

Muscular energy \rightarrow Kinetic energy \rightarrow Heat energy

During the transformation, the total energy remains conserved.

8. When we push a huge rock, there is no transfer of muscular energy to the stationary rock. The Muscular energy we spend is going to heat our body.

9. 1 unit = 1 kWh ; 1 kWh = 3.6×10^6 J

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

10. Gravitational potential energy is given by the expression,
 $W = mgh = 40 \times 5 \times 10 = 2000$ J.

At half-way down, the potential energy of the object will be $= 2000/2 = 1000$ 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, half-way down, the kinetic energy of the object will be 1000 J.

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

12. 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.

Extra score Questions

Q. Can any object have mechanical energy even if its momentum is zero? Explain.

Ans: Yes, mechanical energy comprises of both potential energy and kinetic energy. Zero momentum means that velocity is zero. Hence, there is no kinetic energy but the object may possess potential energy.

Q. Can kinetic energy of a body be negative?

Ans: No, It is because mass and velocity cannot be negative

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

Ans: A freely falling object just before hitting the ground has maximum kinetic energy. After falling, it rolls on the rough ground and finally comes to rest. The kinetic energy of the object is used up in doing work against friction; which finally appears as heat energy.

Q. A light and a heavy object have the same momentum find out the ratio of their kinetic energies.

Which one has a larger kinetic energy?

Linear momentum of 1st object = $p_1 = m_1 v_1$

Linear momentum of 2nd object = $p_2 = m_2 v_2$

Given, $p_1 > p_2$ -----(i)

$\Rightarrow m_1 v_1 > m_2 v_2$

But, $m_1 < m_2$ (A light and a heavy object) $\Rightarrow v_1 > v_2$ -----(ii)

$KE = \frac{1}{2} m v^2 = \frac{1}{2} m v \times v = \frac{1}{2} p v$

From (i) and (ii) $p_1 v_1 > p_2 v_2 \Rightarrow \frac{1}{2} p_1 v_1 > \frac{1}{2} p_2 v_2 \Rightarrow KE_1 > KE_2$

Q. A rocket is moving up with a velocity v . If the velocity of this rocket is suddenly tripled, what will be the ratio of two kinetic energies?

Ans: Initial KE/Final KE = $(\frac{1}{2} m v^2) / (\frac{1}{2} m (3v)^2) = (\frac{1}{2} m v^2) / \{ \frac{1}{2} m (9v^2) \} = 1:9$

Q. Give one example each of potential energy (i) due to position (ii) due to shape.

Ans: (i) Potential energy due to position: Water stored in dam has potential energy.

(ii) Potential energy due to shape: In a toy car, the wound spring possesses potential energy, and as the spring is released, its potential energy changes into kinetic energy due to which the car moves.

Q. What kind of energy transformation takes place when a body is dropped from a certain height?

Ans: When a body falls, its potential energy gradually gets converted into kinetic energy. On reaching the ground, the whole of the potential energy of the body gets converted into kinetic energy.

Q. A man drops a stone of 200g from a height of 5m. What is its kinetic energy when it reaches the ground? What is its speed before it hits the ground?

Ans: Using the equation of motion,

$$u = 0\text{m/s}; v = ? \quad s = 5\text{m}$$

$$V^2 = u^2 + 2as$$

$$v^2 = 0 + 2 \times 9.8 \times 5 = 99\text{m}^2/\text{s}^2$$

This is the speed with which body hits the ground.

Kinetic energy of the body before hitting the ground is,

$$m = 200\text{g} = 0.2\text{kg}$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.2 \times 99 = 9.9\text{J}$$

Q. Two bodies have same momentum. Which will have greater kinetic energy- heavier body or lighter body?

Let mass of light body be ' m_1 ' & heavy body be ' m_2 '

$$\text{Given that } m_1v_1 = m_2v_2$$

$$\text{But, } KE = \frac{p^2}{2m}$$

Since as p is constant KE is inversely proportional to the mass of the object

Hence light body has greater kinetic energy

Q. An electric bulb of 60w is used for 6h per day. Calculate the units of energy consumed in one day by the bulb.

$$p = w/t \text{ or, } p = E/t$$

$$E = wt = 60\text{w} \times 6\text{h} = 60\text{w} \times 6 \times 3600 \text{ sec} = 1.3 \times 10^6 \text{ J}$$

Q. A boy of mass 50kg runs up to a stair case of 45 steps in 9s. If the height of a step is 15cm, find his power. ($g = 10\text{m/s}^2$)

Ans: h will be the net height attained by him once he puts all the steps i.e. $(45 \times 0.15) = 6.75\text{m}$

$$\text{Power} = w/t = PE/t = mgh/t = (50 \times 10 \times 6.75)/9 = 375 \text{ J/s}$$

Q. Two particles of masses 1g and 2g have equal momentum. Find the ratio between their kinetic energies?

$$\text{Momentum of first body, } p_1 = m_1v_1$$

$$\text{Momentum of second body, } p_2 = m_2v_2$$

$$\text{As given: } m_1/m_2 = \frac{1}{2} \text{ and } p_1 = p_2$$

$$v_1/v_2 = m_2/m_1 = 2$$

$$\text{Now kinetic energy, } k = \frac{1}{2}mv^2$$

$$\text{Ratio of kinetic energy, } k_1/k_2 = \frac{m_1v_1^2}{m_2v_2^2} = 2/1$$

Q. If the K.E. of a object increased by 300%, Find the % increased in momentum of the body

$$\text{Ans: } E = \frac{1}{2}mv^2 = \frac{p^2}{2m}$$

$$\Rightarrow \sqrt{2mE} = p$$

$$\text{New } E' = E + 300\% \text{ of } E = 4E$$

$$\text{New, } p' = \sqrt{2m4E} = 2\sqrt{2mE}$$

$$\text{Percentage increase in the momentum} = \frac{(p' - p)}{p} \times 100\%$$

$$= \frac{(2\sqrt{2mE} - \sqrt{2mE})}{\sqrt{2mE}} \times 100\% = 100\%$$

Q. A 400gm bag is lifted from ground and kept on the table at a height of 2m. The time taken to do so is 4s. (Assume $g = 10\text{m/s}^2$)

Ans: As we know that work done against the gravitational force = $mgh = 400/1000\text{gm} \times 10 \times 2 = 8\text{J}$ Now, Power = $w/t = 8/4 = 2 \text{ J/sec}$

Q. Two bodies I and II have the same kinetic energy. Their velocities v_1/v_2 are in the ratio of 1:2.

Since Two bodies I and II have the same kinetic energy: comparing the KE of both the bodies

$$K_1 = K_2$$

$$m_1v_1^2 = m_2v_2^2$$

$$\text{As given, } v_1/v_2 = 1/2 \Rightarrow v_2/v_1 = 2/1 \quad \therefore m_1/m_2 = (v_2/v_1)^2 = 4/1 \text{ or } 4:1$$