CLASS IX: SCIENCE
Chapter 10: Work and Energy

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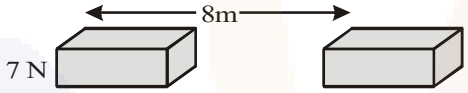
Q1. A force of 7 N acts on an object. The displacement is say 8 m in the direction of the force (see fig.). Let us take it that the force acts on the object through the displacement. What is the work done in this case ?



Ans. Given, force = 7 N ; displacement = 8 m

Work done = Force × Displacement

= 7 × 8 = **56 J**

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Q1. When do we say that work is done ?

Ans. Work is said to be done when: (i) a force should act on an object and (ii) the object must be displaced.

Q2. Write an expression for the work done when a force is acting on an object in the direction of its displacement.

Ans. Work done = Force × Displacement

or W = F × s

Q3. Define 1 J of work.

Ans. When a force of 1 N causes a displacement of 1 m in its own direction, then work done is said to be one joule.

Q4. 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. Work done = F × s = 140 × 15 = **2100 J**

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Q1. What is the kinetic energy of an object ?

Ans. The energy possessed by a body by virtue of its motion is called kinetic energy.

Q2. Write an expression for the kinetic energy of an object.

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

Where, m = mass of the object

v = speed of the object

Q3. The kinetic energy of an object of mass m, moving with a velocity of 5 ms^{-1} 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. Given, velocity of object, v = 5 ms^{-1} ;

kinetic energy of an object, E_K = 25 J

$E_K = \frac{1}{2}mv^2$ or $25 = \frac{1}{2} \times m \times (5)^2$

or $m = \frac{50}{25} = 2$ kg

When the velocity doubles,

$E_K = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times (10)^2 =$ **100 J**

When the velocity triples,

$E_K = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times (15)^2 =$ **225 J**

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Q1. What is power ?

Ans. Power is defined as the rate of doing work.

$$\text{Power} = \frac{\text{work done}}{\text{time taken}}$$

Q2. Define 1 watt of power.

Ans. When a work of 1 joule is done in 1 s, the power is said to be one watt.

Q3. A lamp consumes 1000 J of electrical energy in 10 s. What is its power ?

Ans. Power = $\frac{\text{Energy}}{\text{Time}} = \frac{1000}{10} =$ **100 W**

Q4. Define average power.

Ans. The ratio of the total work done or total energy consumed to the total time taken is called average power.

$$P_{average} = \frac{\text{total work done}}{\text{total time taken}}$$

The concept of average power is useful when the power of a device varies with time.

EXERCISES

Q1. Look at the activities listed below. Reason out whether or not work is done in the light of your understanding of the term 'work'.

(a) Suma is swimming in a pond.

(b) A donkey is carrying a load on its back.

(c) A wind-mill is lifting water from a well.

(d) A green plant is carrying out photosynthesis.

(e) An engine is pulling a train.

(f) Food grains are getting dried in the sun.

(g) A sailboat is moving due to wind energy.

Ans. (a) Work is done because the displacement of swimmer takes place and a force is applied.

(b) Donkey is not doing any work in carrying the load as weight (acting vertically downward) and displacement (acting horizontal) are perpendicular to each other. But, it does work against friction between its hoofs and the ground.

(c) Work is done because the displacement of water takes place and a force is applied by the wind mill. Wind mill does a work against gravity.

(d) No work is done, because no displacement takes place.

(e) Work is done because the displacement of train takes place and a force is applied by the engine.

(f) No work is done, because displacement does not take place.

(g) Work is done because the displacement of sailboat takes place and a force is applied by the wind.

Q2. 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. The object returns to its level of projection, therefore displacement is in horizontal direction, while force of gravity acts in vertically downward direction. Thus, force and displacement are in perpendicular directions. Hence, work done by the force of gravity is zero.

Q3. A battery lights a bulb. Describe the energy changes involved in the process.

Ans. Within the electric cell of the battery, the chemical energy changes into electric energy. The electric energy on flowing through the filament of the bulb, first changes into heat energy and then into the light energy.

Q4. Certain force acting on a 20 kg mass changes its velocity from 5 ms^{-1} to 2 ms^{-1}. Calculate the work done by the force.

Ans. Given, mass, m = 20 kg ;

initial velocity, u = 5 ms^{-1} ;

final velocity, v = 2 ms^{-1}

Work done by the force = change in kinetic energy

or $W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{1}{2}m\left(v^2 - u^2\right)$

or $W = \frac{1}{2}(20)[(2)^2 - (5)^2]$ = **–210 J**.

Q5. 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. The work done is zero. This is because the gravitational force and displacement are perpendicular to each other.

Q6. The potential energy of a freely falling object decreases progressively. Does this violate the law of conservation of energy ? Why ?

Ans. It does not violate the law of conservation of energy. The decrease in potential energy due to loss of height, increases the kinetic energy due to gain in speed such that total energy remains constant.

Q7. What are the various energy transformations that occur when you are riding a bicycle ?

Ans. The chemical energy of the food changes into muscular energy. On paddling, the muscular energy changes to rotational kinetic energy (i.e., mechanical energy) of the wheel.

Q8. 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. Energy transfer does not take place as no displacement takes place in the direction of applied force. The energy spent is used to deform the surface of rock which cannot be seen by naked eyes. That is, it is stored in the form of elastic potential energy of the rock.

Q9. A certain household has consumed 250 units of energy during a month. How much energy is this in joules ?

Ans. Energy consumed in a month

= 250 units = 250 kWh

= $250 \times 3.6 \times 10^6 = \mathbf{9 \times 10^8\ J}$

Q10. 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. Given, mass of object, m = 40 kg ;

height, h = 5 m ;

Acc. due to gravity, g = 10 ms^{-2}

Initial potential energy at a height of 5 m,

E_{P1} = mgh = 40 × 10 × 5 = 2000 J

Initial kinetic energy, E_{K1} = 0

Final potential energy at a height of 2.5 m

E_{P2} = mgh' = 40 × 10 × 2.5= 1000 J

Final kinetic energy, E_{K2} = ?

By conservation of energy,

Initial mech. energy = Final mech. energy

or $E_{P1} + E_{K1} = E_{P2} + E_{K2}$
or $2000 + 0 = 1000 + E_{K2}$

or E_{K2} = 2000 – 1000 J = **1000 J**

Q11. What is the work done by the force of gravity on a satellite moving around the earth ? Justify your answer.

Ans. The work done by the force of gravity on the satellite is zero because the force of gravity acts at right angles to the direction of motion of the satellite. Therefore, displacement and force are in perpendicular directions.

Q12. 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. In the absence of force, acceleration, a = 0 which means body is either at rest or it is in uniform motion. Thus, in case of uniform motion, there is a displacement but there is no force acting on the moving body. Example : When an object moves in deep space from one point to another point in a straight line, the displacement takes place, without the application of force.

Q13. 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. The person does no work because, no displacement takes place in this case.

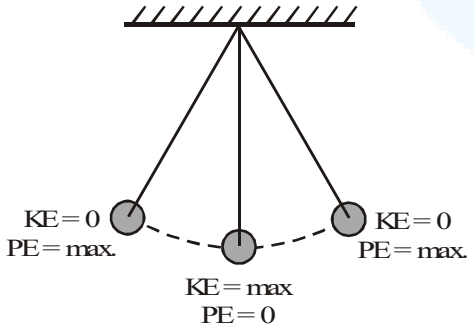
Q14. An electric heater is rated 1500 W. How much energy does it use in 10 hours ?

Ans. Energy used by heater = Power × time

$= 1500\ \text{W} \times 10\ \text{h} = \frac{1500}{1000}\ \text{kW} \times 10\ \text{h} =$ **15 kWh**

Q15. 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.



When the pendulum bob is pulled (say towards left), the energy supplied is stored in it in the form of potential energy (PE) on account of its higher position. When the pendulum is released so that it starts moving towards right, then its PE changes into kinetic energy (KE), such that in mean position, it has maximum KE, and zero PE. As the pendulum

moves towards extreme right, its KE changes into PE; such that at the extreme position, it has maximum PE and zero KE. When it moves from this extreme position to mean position, its PE again changes to KE. This means total mechanical energy remains constant. This illustrates the law of conservation of energy. Eventually, the bob comes to rest, because during each oscillation a part of the energy possessed by it is transferred to air and in overcoming friction at the point of suspension. Thus, the energy of the pendulum is dissipated in air. The law of conservation of energy is not violated because the energy merely changes its form and is not destroyed.

Q16. 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. Work done to bring the object to rest = change in kinetic energy of the object

$= 0 - \frac{1}{2}\ mv^2 = -\frac{1}{2}\ mv^2$

Q17. Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 kmh^{-1}.

Ans. Given, mass of car, m = 1500 kg ;

velocity of car, v = 60 kmh^{-1} $= 60 \times \frac{5}{18} = \frac{50}{3}$ m / s

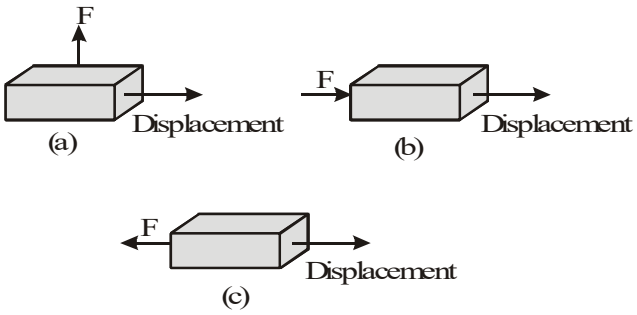
Work done = Change in kinetic energy of the car

or $W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{1}{2}m\left(v^2 - u^2\right)$

or $W = \frac{1}{2}(1500)[(0)^2 - (50/3)^2]$

or $W = -\frac{1}{2} \times 1500 \times \frac{2500}{9}$ $=$ **– 208333 J**

Q18. In each of the following, a force (see fig.) 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. In case of fig.(a) W = 0 because the force acts in the perpendicular direction of displacement.

In case of fig.(b) W is positive, because the force acts in the direction of displacement.

In case of fig.(c) W is negative, because the force acts in the direction opposite to the displacement.

Q19. 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 do agree. When a number of forces act on a body, such that they constitute balanced forces, then net force acting on the body is zero. In such a situation no acceleration occurs in the object.

Q20. Find the energy in kWh consumed in 10 hours by four devices of power 500 W each.

Ans. Total power of 4 devices = 4 × 500 W

$$= 2000 \text{ W} = \frac{2000 \text{ W}}{1000} = 2 \text{ kW}$$

Time = 10 h

Energy consumed = Power × time

= 2 kW × 10 h = **20 kWh**

Q21. A freely falling object eventually stops on reaching the ground. What happens to its kinetic energy ?

Ans. The kinetic energy on reaching the ground changes into heat energy, sound energy, etc. and therefore gets dissipated to the ground and air.