WORK AND ENERGY

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.**

ANSWER:-

- Suma is swimming in a pond:
  Suma is doing work because she moves herself by pushing against the water with her arms and legs.
- A donkey is carrying a load on its back:
  The donkey is not doing work in terms of physics because the direction of the force (the weight of the load) and the donkey's movement (displacement) are at right angles to each other.
- A windmill is lifting water from a well:
  The windmill is doing work as it lifts water against gravity.
- A green plant is carrying out photosynthesis:
  There is no force or movement here, so no work is being done.
- An engine is pulling a train:
  The engine is doing work because it pulls the train against the friction between the wheels and the track.
- Food grains are getting dried in the sun:
  No force or movement is happening, so no work is done while the grains are drying.
- A sailboat is moving due to wind energy:
  The wind does work by pushing the sailboat in the direction of the wind force.

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?

ANSWER:-

When an object moves upwards, gravity does negative work because the force of gravity pulls downward, opposite to the direction of the object's motion. On the other hand, when the object moves downward, gravity does positive work because the force of gravity acts in the same direction as the object's movement. Over the entire motion (up and down), the total work done by gravity is zero because the negative work when going up is exactly canceled out by the positive work when coming down.

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

ANSWER:-

Battery converts chemical energy into electrical energy. This electrical energy is further converted into light and heat energy.

Q. 4. 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.

ANSWER:-

Mass of the body = 20 kg
Initial velocity = 5 m/s
Final velocity = 2 m/s
We know that,
Work done = change in kinetic energy

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

$$=\frac{1}{2}(20)\left(5^2-2^2\right)$$

$$=10(25-4)$$

$$=210J$$

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

ANSWER:-

The work done by gravitational force on a body is zero when the force is acting vertically downward, but the displacement is horizontal. Since the force and displacement are at right angles to each other, no work is done.

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

ANSWER:-

As a freely falling object moves, its potential energy decreases, and its kinetic energy increases because its speed increases. However, the total mechanical energy (which is the sum of potential and kinetic energy) stays the same, showing that the law of conservation of energy holds true.

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

ANSWER:-

The cyclist's muscular energy is converted into the rotational energy of the bike's wheels. This rotational energy is then turned into the kinetic energy that helps the bicycle move forward.

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?

ANSWER:-

When we push a rock but fail to move it, some of our energy is transferred to the rock, increasing its potential energy (because we're trying to lift or move it). However, since the rock doesn't move, the rest of the energy we apply is not used for work on the rock. Instead, it gets lost to the environment. This energy is dissipated through our muscles (in the form of heat) and through friction between the rock and our hands or the surface it's resting on.

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

ANSWER:-

We know that 1unit = 3,600,000 J

So,

$250 \text{ units} = 250 \times 3{,}600{,}000 \text{ J}$

$= 900{,}000{,}000 \text{ J}$

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

Hence, the energy consumed = 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.

ANSWER:-

We know that, potential energy = mgh

Where, m = 40 kg

$g = 9.8\ m/s^2$
$h = 5\ m$

So, the potential energy = 40 × 9.8 × 5 J = 1960 J
According to law of conservation of energy, the total mechanical energy (Kinetic and potential energy) of an object remains constant.
Therefore, when the object is half-way down, its potential energy become half the original energy and remaining half converted into kinetic energy.
Hence, the kinetic energy = 1/2 (1960) J = 980 J

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

ANSWER:-

When a satellite moves around the Earth, its displacement over a short interval is along the tangential direction (along the orbit). However, the gravitational force acting on the satellite is directed towards the center of the Earth (radially inward). Since the gravitational force and the satellite's displacement are perpendicular to each other, no work is done by the gravitational force. This is because, in physics, work is only done when the force and displacement have a component in the same direction.

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.

ANSWER:-

Yes, that's correct! In the absence of force, an object can still move if it was already in motion. According to Newton's first law, if there's no force acting on the object (F = 0), the object will either stay at rest or continue moving with constant velocity in a straight line (a = 0). If the object is moving in a straight line, there will be displacement. So, in the absence of force, displacement can still occur as long as the object was initially moving.

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.

ANSWER:-

The person holding a bundle of hay gets tired because their muscles are converting energy into heat (thermal energy). However, since the bundle of hay isn't moving, there is no displacement, meaning no work is done according to the physics definition (Work = Force × Displacement). Even though the person feels tired, no physical work is being done because there's no movement of the object.

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

ANSWER:-

We know that Energy Power time Here, Power = 1500 W
Time = 10 hours = 10×60×60 seconds = 36000 seconds

Therefore,

The energy used by heater = Power × time

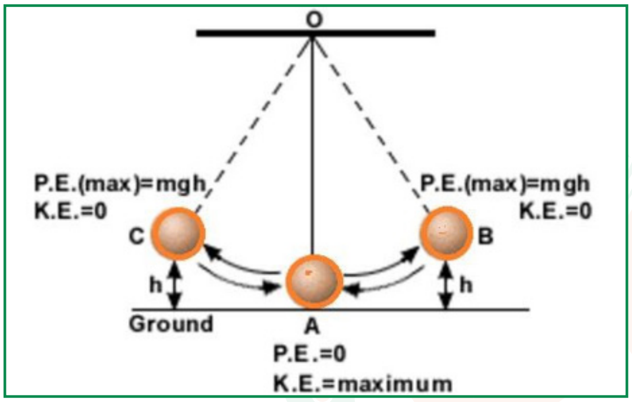
$= 1500 \times 36000$ J

$= 54000000$ J

$= 5.4 \times 10^7$ 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?

ANSWER:-



At points B and C, the pendulum bob reaches its maximum height. At these points, the potential energy is at its maximum, and the kinetic energy is zero because the bob momentarily stops before changing direction. This means all the energy is stored as potential energy at these points.

At point A, the pendulum bob is at its lowest point, where all the potential energy is converted into kinetic energy. Here, the kinetic energy is at its maximum, and the potential energy is zero because the bob is at its lowest position.

Throughout the motion, the total mechanical energy (which is the sum of kinetic and potential energy) remains constant, assuming no external forces like air resistance or friction. The energy simply changes between kinetic and potential forms as the pendulum swings back and forth.

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?

ANSWER:-

The object is in motion, so its energy = kinetic energy $= \frac{1}{2}mv^2$

The kinetic energy of the object, when it comes to rest = 0.

Work done on object = Change in kinetic energy = final K.E. – Initial K.E.

Work done on object $= 0 - \frac{1}{2}mv^2$

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

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

ANSWER:-

Mass of the car m = 1500 kg

Velocity of the car = 60 km/h

$$= \frac{60 \times 1000}{60 \times 60} = \frac{50}{3} \text{ m/s}$$

"The car is in motion, so its energy = kinetic energy $= \frac{1}{2}mv^2$

$$= \frac{1}{2}(1500)\left(\frac{50}{3}\right)^2$$

$$= 208333.3 \text{ J}$$

The kinetic energy of the car, when it comes to rest = 0J

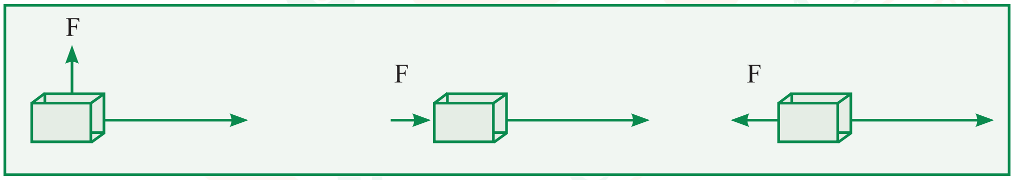
Work done on object = change in kinetic energy

= 208333.3 - 0 J

= 208333.3 J

Hence, the work required to stop the car is 208333.3 J.

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.



ANSWER:-

First case (Force and displacement are perpendicular): When the force and displacement are perpendicular to each other (for example, when a person is holding an object stationary), no work is done. This is because work is calculated as the product of force and displacement in the direction of the force, and when the force is perpendicular to displacement, there is no contribution to the work. So, work done = zero.

Second case (Force and displacement are in the same direction): When the force and displacement are in the same direction (for example, when you push a box across the floor), the work done is positive. This is because the force is helping to move the object in the direction of the displacement, so the energy is transferred to the object. Thus, work done is positive.

Third case (Force and displacement are in the opposite direction): When the force and displacement are in opposite directions (for example, when you apply force to stop a moving car), the work done is negative. This is because the force is acting opposite to the direction of the object's motion, which reduces the object's energy. Negative work means that energy is being taken away from the object.

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?

ANSWER:-

If the resultant force acting on a body in different directions is zero, then the acceleration will be zero.

We know that, $F = ma$,

In the net force is zero, $F = 0$, then $ma = 0$

$\Rightarrow a = 0$ [as $m \neq 0$]

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

ANSWER:-

The power of four devices = 4 × 500 W = 2000 W Time = 10 hours

Therefore, the energy consumed = power × time

= 2000 × 10 Wh

= 20000 Wh

= 20 kWh

= 20 units [1 unit = 1 kWh]

Q. 20. A freely falling object eventually stops on reaching the ground. What happenes to its kinetic energy?

ANSWER:-

When a freely falling body stops upon reaching the ground, its kinetic energy is converted into several forms of energy:

- **Heat Energy:** The collision generates heat, warming both the body and the ground.
- **Sound Energy:** Some of the kinetic energy is transformed into sound, which is why you hear a noise when the body hits the ground.
- **Potential Energy (due to deformation):** If the body or the ground deforms on impact (like a squished rubber ball or a slight indentation in the ground), some of the kinetic energy is temporarily stored as potential energy in the deformed object. This energy may then dissipate as heat or sound once the deformation is released.