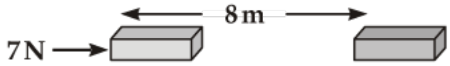
Date: 24/9/2021

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



Q2. When do we say that work is done?

Q3. Write an expression for the work done when a force is acting on an object in the direction of its displacement.

Q4. Define 1 J of work.

Q5. 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?

Q6. 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?

Q7. What is the kinetic energy of an object?

Q8. Write an expression for the kinetic energy of an object.

Q9. A freely falling object eventually stops on reaching the ground. What happens to its kinetic energy?

Q10. What is power?

Q11. Define 1 watt of power.

Q12. A lamp consumes 1000 J of electrical energy in 10 s. What is its power?

Q13. Define average power.

Q14. A battery lights the bulb. Describe the energy changes involved in the process.

Q15. The potential energy of a freely falling object decreases progressively. Does this violate the law of conservation of energy? Why?

Q16. What are the various energy transformations that occur when you ride a bicycle?

Q17. 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?

Q18. A certain household has consumed 250 units of energy during a month. How much energy is this in joules?

Q19. 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?

Q20. An electric heater is rated 1500 W. How much energy does it use in 10 hours?

Q21. Find the energy in kW h consumed in 10 hours by four devices of power 500 W each.

Q22. Look at the activities listed below. Reason out whether or not work is done in the light of your understanding of the term 'work'.

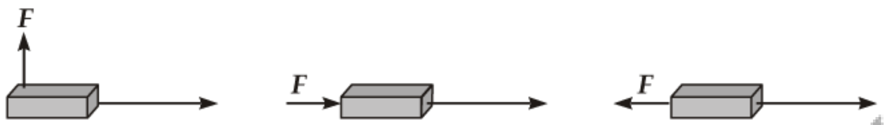
(a) Suma is swimming in a pond.
(b) A donkey is carrying a load on its back.
(c) A wind-mill is lifting water from a well.
(d) A green plant is carrying out photosynthesis.
(e) An engine is pulling a train.
(f) Foodgrains are getting dried in the sun.
(g) A sailboat is moving due to wind energy.

Q23. 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.

Q24. Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 km/h?

Q25. 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.

Q26. 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.



Q27. 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?

Q28. What is the work done by the force of gravity on a satellite moving around the earth? Justify your answer.

Q29. A mass of 10 kg is at a point A on the 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.

Q30. 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.

Q31. 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?

Q32. A person holds a bundle of hay over his head for 30 minutes and gets tried. Has he done some work or not? Justify your answer.

Date: 24/9/2021

S1. Here, force acting on the object $F = 7\,\text{N}$.

Displacement of object in the direction of force $s = 8\,\text{m}$.

$\therefore$ Work done on the object $W = Fs = 7 \times 8 = 56\,\text{J}$.

S2. In mechanics, work is said to be done when under the influence of an applied force an object moves through a certain distance. Thus, there are two essential conditions for work to be done. These are: (a) application of some force on the object, (b) displacement of the object in the direction of force.

S3. Work done is equal to the product of the force acting on an object in the direction of its displacement and its displacement.

$\therefore$ Work done (W) = Force in the direction of displacement (F) $\times$ Displacement (s).

S4. SI unit of work is 1 joule (1 J or 1 N m). Work is said to be 1 joule if under the influence of a force of 1 N the object moves through a distance of 1 m along the direction of applied force.

S5. Here force applied by the pair of bullocks $F = 140\,\text{N}$.

Displacement of the bullocks in the field $s = 15\,\text{m}$.

$\therefore$ Work done by bullocks $W = Fs = 140 \times 15 = 2100\,\text{J}$.

S6. We agree with Soni. If several forces act on an object such that their resultant (*i.e.*, the net) force is zero then the acceleration of the object will be zero.

S7. Kinectic energy of an object is the energy possessed by it due to its state of motion.

S8. If an object of mass m is moving with a speed v, then its kinetic energy is given by

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

S9. The kinetic energy of a freely falling object is consumed to do work against force of friction due to ground. This work done against friction leads to production of heat energy.

S10. The rate of doing work or the rate of transfer of energy is known as the power.

$$\therefore \quad \text{Power} = \frac{\text{Work}}{\text{Time}} = \frac{W}{t}.$$

S11. SI unit of power is a watt. Power is said to be 1 watt (1 W) if rate of doing work is 1 J s^{-1}.

S12. Here, Electrical energy consumed $E = 1000\,\text{J}$.

and Time $t = 10\,\text{s}$

$$\therefore \quad \text{Power} = \frac{E}{t} = \frac{1000\,\text{J}}{10\,\text{s}} = 100\,\text{W}.$$

S13. If power of person/machine varies with time, then his average power may be obtained by dividing the total energy consumed (or total work done) by the total time taken.

$$\therefore \quad \text{Average power} = \frac{\text{Total energy consumed (or total work done)}}{\text{Total time}}.$$

S14. Here firstly chemical reactions take place inside the battery. In the process, chemical energy is consumed and electric energy is produced.

Then secondly, the electrical energy is converted into heat and light energies. As a result, the temperature of bulb rises and the bulb emits light.

S15. When an object is freely falling its potential energy is progressively decreasing. But simultaneously, its velocity and consequently its kinetic energy is progressively increasing so that the total energy (sum of potential energy and kinetic energy) remains constant. So, the law of conservation of energy is strictly followed.

S16. At the time of riding a bicycle the rider applies force and rotates the paddle. In the process, he is doing mechanical work. As a result of this work, wheels of bicycle start moving. Thus, mechanical work is converted into kinetic energy. A part of this kinetic energy is used to overcome friction force acting on tyres by the road. This work done against friction is transformed into heat energy.

S17. Let a person pushes a huge rock but fails to move it. In this case the person is applying some force on the rock but there is no displacement in the direction of force. Hence, work done by the person is zero.

However, the person is supplying some muschlar energy tothe rock due to which he feels fatigue. The energy spent bythe person tends to deform the rock and is finally transformed into heat energy.

S18. One household unit energy = 1 kW h = 3.6×10^6 J.

As the given household has consumed 250 units of energy, hence the energy spent in joules

$$E = 250 \text{ kW h} = 250 \times 3.6 \times 10^6 \text{ J} = 900 \times 10^6 \text{ J} \quad \text{or} \quad 9 \times 10^8 \text{ J}.$$

S19. When an object of mass m is moving with a constant velocity v, it has an initial kinetic energy $E'_k = \frac{1}{2} mv^2$. Finally object comes to rest and its kinetic energy $E_k = 0$.

$\therefore$ Work done on the object to bring it to rest $W = E'_k - E_k = 0 - \frac{1}{2} mv^2 = -\frac{1}{2} mv^2$.

S20. Here, Power of electric heater $P = 1500$ W

Time for which heater is used $t = 10$ h

$\therefore$ Energy used $E = P \times t = 1500 \text{ W} \times 10 \text{ h}$

$$= \frac{1500 \times 10}{1000} \text{ kW h} = 15 \text{ kW h}.$$

S21. Here, Power of any one device $P = 500$ W

Total number of devices $n = 4$

Time for which the 4 devices are used $t = 10$ h

$\therefore$ Total energy consumed $E = Pnt = 500 \times 4 \times 10$ W h

$$= \frac{500 \times 4 \times 10}{1000} \text{ kW h} = 20 \text{ kW h}.$$

S22. (a) Suma is applying a force and displacement is also there, hence work is being done.

(b) When a donkey carries a load on its back, he is doing work against the force of friction due to road. However, he is not doing work against the weight of load.

(c) When a wind-mill lifts water from a well, it is doing work against the force of gravity.

(d) In photosynthesis process no work is being done as neither there is force being applied nor there is any displacement.

(e) An engine is definitely doing a work while pulling a train against the force of friction due to railway line on wheels of train.

(f) During drying of foodgrains no work is being done, as there is no displacement.

(g) During motion of sailboat due to wind energy work is being done against frictional (and viscous) force due to water.

S23. Here, mass of object $m = 20$ kg, initial velocity $u = 5\ \text{m s}^{-1}$ and final velocity $v = 2\ \text{m s}^{-1}$.

$\therefore$ Initial kinetic energy of object $E_1 = \frac{1}{2}mu^2 = \frac{1}{2}\times 20\times(5)^2 = 250$ J

and Final kinetic energy of object $E_2 = \frac{1}{2}mv^2 = \frac{1}{2}\times 20\times(2)^2 = 40$ J

$\therefore$ Loss in kinetic energy $= E_1 - E_2 = 250\text{ J} - 40\text{ J} = 210$ J

$\therefore$ Work done by the force W = Change in kinetic energy = – 210 J

Here, – ve sign of work shows that there is decrease in kinetic energy of the mass.

S24. Given, Mass of car $m = 1500$ kg

Initial velocity of car $u = 60\text{ km/h} = 60\times\frac{5}{18}\text{ m/s} = \frac{50}{3}\text{ m/s}$

Final velocity of car $v = 0$

$\therefore$ Work done on car = Change in kinetic energy of car

$$\therefore\quad W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{m}{2}(v^2 - u^2)$$

$$= \frac{1500}{2}\left[(0)^2 - \left(\frac{50}{3}\right)^2\right] = \frac{1500}{2}\times\left(0 - \frac{2500}{9}\right)$$

$$= -\frac{1500}{2}\times\frac{2500}{9} = -208333.3\text{ J}.$$

S25. Here, mass of object $m = 40$ kg, height above the ground $h = 5$ m.

$\therefore$ Potential energy of object $E_p = mgh = 40\times 9.8\times 5\text{ J} = 1960$ J

When the object falls and reaches half way down, then $h' = \frac{h}{2} = \frac{5}{2}$ m

$\therefore$ Potential energy of object now $E_p' = mgh' = 40\times 9.8\times\frac{5}{2} = 980$ J

$\therefore$ Loss in potential energy $= E_p - E_p' = 1960\text{ J} - 980\text{ J} = 980$ J

According to conservation law of energy

Loss in potential energy = Gain in kinetic energy

$\therefore$ Kinetic energy of object when it is half way down, $E_k = 980$ J.

S26. On observing the diagrams carefully we find as floows:

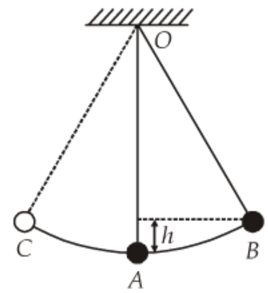
(a) In first (extreme left side) figure, the force is acting in a direction perpendicular to displacement, Hence, work done by the force is zero.

(b) In second figure, force and displacement both are in same direction. So, the work done by the source is positive.

(c) In third (extreme right side) figure, the force and displacement are in mutualy opposite directions, hence, the work done by the force is negative.

S27. Consider a pendulum bob suspended from a rigid support O. Let the bob be taken from its mean position A to one side up to point B. Initially at B the bob is at rest. It means its kinetic energy is zero. But as shown in figure, as compared to mean position A the bob at B is at a height h. It means that it possesses potential energy.

As the bob is allowed to oscillate then as it comes towards the mean position A, the potential energy of bob gradually decreases. In accordance with conservation law of energy, its kinetic energy progressively increases. At mean position A whole energy of pendulum bob is kinetic. As bob further moves from A to C, the kinetic energy progressively decreases and the potential energy, in turn, increases. At extreme position C whole energy of bob is again potential. Thus, during its motion the energy of pendulum bob may be converted from potential energy to kinetic energy or reverse but total sum of energy remains conserved.



The bob eventually comes to rest on account of force of friction and resistance due to air medium. Energy of bob is gradually dissipated to overcome air resistance and is converted into heat energy. Hence, even not the conservation law of energy is not violated.

S28. Work done by the force of gravity on a satellite moving round the earth is zero. In case of a satellite the force of gravity is fully utilised to provide centripetal force needed for its orbital motion around the earth. No part of the force acts along the direction of motion of satellite. Hence, work done is zero.

S29. In present question, the gravitational force acting on mass of 10 kg due to earth is in the vertical downward direction. But the motion of mass from point A to point B on the table is along horizontal direction. As direction of force makes an angle 90° (angle from horizontal to vertical direction) to the direction of displacement, hence there is no displacement along the direction of force and therefore, the work done on the given mass by the gravitational force is zero.

S30. If an object is in a state of motion, then as per Newton's first law of motion in the absence of any external force acting on it, the object will maintain its motion along a given straight line. So, the object will have a displacement.

However, if the object is initially at rest then there cannot be any displacement in the absence of any force acting on it.

S31. Work done by the force of gravity on the object is zero. Force of gravity acts in the vertical downward direction and the distance covered by the object is in the horizontal direction. As there is no displacement in the direction of force, hence the work done is zero.

S32. The person holding a bundle of hay over his head has not done any work.

In present case, the person is applying a force to hold the bundle but there is no displacement of the bundle of hay. In the absence of displacement, the work done by the person is zero.