Chapter – 11 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. Let us take it that the force acts on the object through the displacement. What is the work done in this case?

Answer: Force=7 N

Displacement=8 m

Work done = Force × Displacement

Work Done = 7 × 8 = 56 Joule

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Q1. When do we say that work is done?

Answer: Work is done in two conditions:

(i) A force acting on the body.

(ii) A displacement of the body when force is applied in or opposite to direction of force. When direction of force is perpendicular to displacement, then work done is zero.

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

Answer: Work is done when force applied and there is displacement of that object. i.e., W = F x s.

Q3. Define 1 J of work.

Answer: One Joule of work is done when a force of one Newton moves a body to a distance of one meter in the direction of the force.

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?

Answer: Force applied on the plough, F=140 N

Displacement of the plough, S=15 m

So, Work done is

$$W = F \times S = 140 \times 15 = 2100\, Joule$$

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Q.13 What is the kinetic energy of an object?

Answer: Kinetic Energy is the energy of a moving body. Kinetic energy of an object increases with its speed of the body.

Q.14 Write an expression for the kinetic energy of an object.

Answer:

Kinetic Energy: The energy of an object due to its motion is called as kinetic energy or energy of a moving body.

Suppose, an object of mass "m" is at rest on horizontal plane.

A Force, F acts on the object and the object moves from rest, from point A to B and its displacement is S.

The Work done on the object is:

Work done = Force x displacement

$$W = F \times S$$

As $$v^2 - u^2 = 2as$$

So $$W = \frac{m \times a\ (v2 - u2)}{2a}$$

$$W = \frac{mV2}{2}$$

Thus, Work -Done is equal to kinetic energy of the body.

$$K.E = \frac{1}{2} mv^2$$

Q.15 The kinetic energy of an object of mass, m moving with a velocity of $5\, m\, s^{-1}$ 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?

Answer: Velocity of object, $v = 5\, m\, s^{-1}$

Kinetic-energy of an object, K.E =25 J

$$K.E = \frac{1}{2} mv^2$$

$$25 = \frac{1}{2} \times m \times (5)2$$

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

$$K.E = \frac{1}{2} mv2$$

$$= \frac{1}{2} \times 2 \times (15)2 = 225\, Joule$$

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Q1. What is power?

Answer: Power is the amount of energy converted per unit time. S.I units, the unit of power is the Watt which is one joule per second. Power is a scalar quantity.

Q2. Define 1 watt of power.

Answer: A body have one watt of power if it work at the rate of one joule in one second. The SI unit of power is Watt. Other units are ergs / second, horse - power, metric horse-power or cheva-l vapour (CV)), and foot-pounds / minute. The unit Watt is named on the scientist James Watt**.**

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

Answer: So, the power of the lamp is 100 Watts.

Q4. Define average power.

Answer: The average power is ratio of total work done or total energy consumed and the total time taken. So the average power P for work done W over a time t, Average power ,P = W t.

Class 9 Science NCERT Textbook – Page 158 and 159 (Exercise)

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 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.**

Answer:

a) Suma is doing work, as Suma is swimming in a water pond by applying force.
b) A donkey is not doing work against gravity, as it is carrying weight at right angles to the force of gravity. A donkey is doing work against air resistance and friction.
c) A wind mill is doing work by lifting up water from the well against the force of gravity.
d) A green plant is not doing work in photosynthesis, because the force and the distance moved are zero.
e) An engine is doing work while pulling a train as engine applies force and the train moves.
f) When food-grains are dried in the sun no work is done, as neither force is applied nor any motion takes place.
g) When sailboat moves work is done, as wind is applying force to move the sailboat.

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?

Answer:

The initial and final points of the path of an object is on the horizontal line, the displacement of the object is in the horizontal direction. As there is no net displacement of the object in the vertical direction, so no work is done by the force of gravity.

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

Answer:

A battery convert chemical to electrical energy. Then electrical energy is converted into heat energy and finally to light energy in electrical bulb.

Due to heat energy the filament of bulb becomes white-hot and produce light energy. So, following energy changes occurs when a battery lights up a bulb:

$$Chemical\ energy \rightarrow Electrical\ energy \rightarrow Heat\ energy \rightarrow Light\ energy$$

Q4. 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.

Answer:

The work done by the force = the change in kinetic energy when the is are velocity changes from $5\ m\ /s$ - $2\ m\ /s$.

a)

Mass, $m = 20\ kg$
Velocity, $v = 5\ m/s$

$$\text{K.E} = \frac{1}{2}\ mv^2$$

$$= \frac{1}{2} \times 20 \times (5)^2$$

$$= \frac{1}{2} \times 20 \times 25$$

$$= 250\ Joule$$

b)

Mass, $m = 20\ kg$
Velocity, $v = 2\ m/s$

$$\text{K.E} = \frac{1}{2}\ mv^2$$

$$= \frac{1}{2} \times 20 \times (2)^2$$

$$= \frac{1}{2} \times 20 \times 4$$

$$= 40\ Joule$$

Work done = kinetic energy change

$$= 250 - 40\ J$$
$$= 210\ Joule$$

Q5. An object of mass 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.

Answer:

Work done on an object by the gravitational force is zero,as the motion of object is in the horizontal direction and the gravitational force is at right angles to the direction of motion of object.

$$W = F\cos 90^o \times s$$

$$W = F \times 0 \times s = 0$$

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

Answer:

When a freely falling object moves downwards, its height above the ground decreases so its potential energy decreases. As the freely falling object moves down, its velocity increases and so kinetic energy also increases.

During free fall, the sum of potential energy and kinetic energy of the falling objects remain is same and it do not violate the law of conservation of energy.

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

Answer:

The chemical energy of food in our body is converted into muscular energy of muscles. When we are riding a bicycle, the muscular energy of legs is converted into kinetic energy which rotates the pedals.

The rotational kinetic energy of pedals is transferred from bicycle chain to that of its wheels and it move forward. When the bicycle is moving, then the bicycle and the person riding the bicycle, both have kinetic energy.

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?

Answer:

Yes, energy transfer occurs when we push a huge rock and fail to move it. Our energy gets stored in the rock as potential energy due to the deformation of rock. The deformation in rock is negligible that we cannot observed. Some of the energy is used in stretching the arm muscles when pushing the rock as there is transfer of blood to the stretched muscles.

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

Answer:

$$\text{Energy consumed} = 250\ units$$
$$= 250\ kWh$$
$$1\ kilowatt - hour = 3.6\ \times\ 10^6\ joules$$
$$250\ kilowatt - hour = 3.6\ \times\ 10^6\ \times 250\ joules$$
$$= 9\ \times\ 10^8\ joules$$

The amount of energy in 250 units in a month $= 9\ \times\ 10^8\ joules$.

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 it is half way down (g = 10 m/s^2).

Answer:

$$\text{Mass, } m = 40\ kg$$
$$\text{Acceleration due to gravity, } g = 10\ m/s^2$$
$$\text{Height, } h = 5\ m$$
$$\text{Potential energy} = m\ \times g\ \times h$$
$$= 40\ \times 10\ \times 5\ J$$
$$= 2000\ Joules$$

Object is at height of 5 m and potential energy is 2000 Joules. When an object fall half way down, its height above the ground is half $= 5\ m$.

So, the potential energy of 40 kg object of 40 kg, at a height of 2.5 m:

Potential energy at 2.5 m height $= m\ \times g\ \times h$

$$= 40\ \times 10\ \times 2.5\ J$$
$$= 1000\ Joule$$

According to the law of conservation of energy:

Total potential = Potential energy at half way down + Kinetic energy at half way down

$$2000 = 1000 + Kinetic\ energy\ at\ half\ way\ down$$

Kinetic energy at half way down = 1000 Joule

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

Answer:

When satellite moves around the earth in a circular path, its displacement is to the tangent of the circular path for a short interval of time.

The gravitational force on the satellite is along the radius of the earth. Tangent is at right angles to the radius, so, the motion of satellite and force of gravity are at right angles to each other.

Work done is

$$W = F\cos 90^o \times s$$

$$\cos 90^o = 0$$

$$W = F \times 0 \times s$$

$$W = 0$$

So, the work done on a satellite moving round the earth by the gravitational force is zero.

Q12. Can there be displacement of an object in the absence of any force acting on it? Think. Discuss this question with your friend and teacher.

Answer:

Yes, there is displacement of an object in the absence of any force acting on it.

$$F = m \times a$$

When force, $F = 0$, then,

$$m \times a = 0$$

mass 'm' cannot be zero, when force F = 0, then,

$$acceleration, a = 0$$

So, the object is at rest or in uniform motion in a straight line and there is a displacement of the object in the absence of any force acting on it.

Q13. A person holds a bundle of hay over head for 30 minutes and gets tired. Has he done some work or not? Justify your answer.

Answer:

A person holding a bundle of hay over his head for 30 minutes has done no work because he has not moved the bundle to a distance ($s = 0$).

The person gets tired due to muscular tiredness as his muscles are stretched and blood is transferred to the strained muscles very rapidly.

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

Answer:

$$\text{Power, } P = 1500\ W$$

$$= \frac{1500}{1000}\ W$$

$$= 1.5\ kW$$

$$\text{Time, } t = 10\ hrs$$

$$Power = \frac{Energy\ used}{Time\ taken}$$

$$1.5\ kW = \frac{Energy\ used}{10\ hrs}$$

$$\text{Energy used} = 1.5\ kW \times 10\ h$$

$$= 15\ kWh \text{ or 15 units}$$

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?

Answer:

Initially, the pendulum is at rest, with its bob in the centre position A. When the pendulum bob is pulled to position B and then released, the bob starts swinging between position B and C.

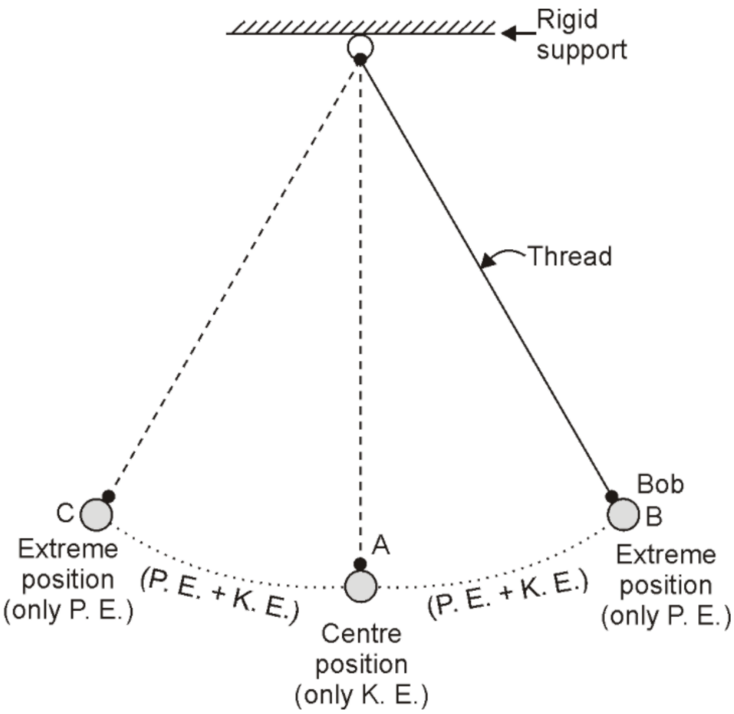
a) When the pendulum bob is at position B, it has potential energy and no kinetic energy.

b) As the bob starts moving from position B to A, potential energy goes on decreasing and kinetic energy goes on increasing.

c) When the bob reaches the centre position A, it has kinetic energy and no potential energy.

d) As the bob goes from position A to C, kinetic energy goes on decreasing but its potential energy goes on increasing.

e) On reaching the position C, the bob stops for a very small instant of time. So, at position C, the bob has potential energy.



Thus, at position B and C of a swinging pendulum, all the energy of pendulum bob is potential, and at position A, all energy of pendulum bob is kinetic.

At various intermediate positions, the energy of pendulum bob is partly potential and partly kinetic, but the total energy at any instant of time remains conserved into heat and sound energy.

The swinging pendulum bob comes to rest as it loses energy due to the friction of air.

Q16. An object of mass 'm' is moving with a constant velocity 'v'. How much work should be done on the object in order in order to bring the object to rest?

Answer:

An object of mass 'm' moves with a constant velocity v has a kinrtic energy equal to $\frac{1}{2}mv^2$. An equal amount of work is done on this moving object so its kinetic energyis zero and it comes to rest.

Q17. Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 km/h?

Answer:

When a car stops, its kinetic energy is zero. So, the work is done to stop the car which is equal to the kinetic energy of the moving car.

Mass of car, $m = 1500\ kg$

Velocity of car, $v = 60\ km/hr$

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

$$= \frac{50}{3}\ m/s$$

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

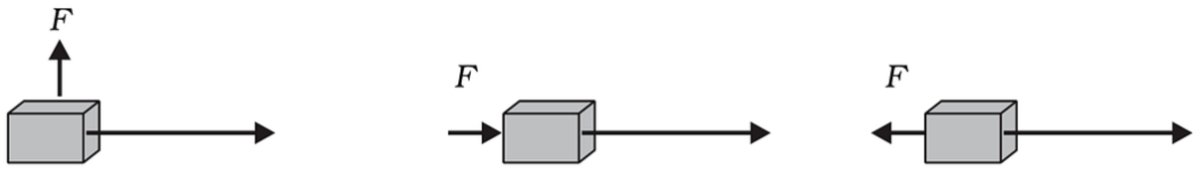
$$= \frac{1}{2} \times 1500\ \times \frac{(50)^2}{(3)}$$

$$= \frac{1500\ \times 2500}{2\ \times 9}$$

$$= 208333.3\ Joules$$

208333.3 Joules of work is done to stop this moving car.

Q18. 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:

a) In the first figure, the direction of force F and displacement are at right angles to each other. So, the work done is zero.
b) In the second figure, the displacement is in the direction of force F, so work done is positive.
c) In the third figure, the direction of force F is opposite to that of displacement, so work done is negative.

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?

Answer:

Yes, I agree with Soni, as the acceleration in an object is zero even when several forces are acting on it, if the resultant force (F) is zero.

$$F = m \times a$$

When force F = 0,

Then acceleration is zero, as mass cannot be zero.

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

Answer:

Power of one device = 500 W

Power of four devices = 500 × 4 W

$$= 2000\ W$$

$$= \frac{2000}{1000}\ kW$$

$$= 2\ kW$$

Time = 10 hrs

$$Power = \frac{Energy\ consumed}{Time\ taken}$$

$$2\ kW = \frac{Energy\ consumed}{10\ hrs}$$

Energy consumed = 2 kW × 10 hrs

$$= 20\ kWh$$

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

Answer:

A free-falling object have a kinetic energy, when it hits the ground and stops, then:

a) A part of kinetic energy is converted into sound energy.
b) A part of kinetic energy is converted into heat energy.
c) A part of kinetic energy is converted to potential energy.