

Work And Energy

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Q. 1. Define work and write its units.

Answer : In science, we define Work as product of the Force(F) & the Displacement(s) moved along the direction of force

$$W = \text{Force} \times \text{Displacement} \text{ -- (i)}$$

This formula for work used in only Translatory motion of the object.

Work has only Magnitude, no Direction. So, work is a Scalar quantity.

The SI unit of Force(F) is Newton(N) and Displacement(s) is meter(m).

Putting 1N and 1m in formula of work eq(i), work done comes out to be 1N-m.Hence unit of work is newton-meter(N-m) or joule(J).

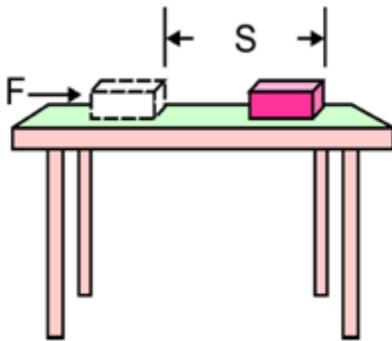


Fig - Work done in moving a block through a distance 's' and by applying force 'F'

Q. 2. Give few examples where displacement of an object is in the direction opposite to the force acting on the object.

Answer : Example (i)- When a ball thrown upward the Gravitational force acts downward and the direction of motion of ball is upward as shown in Fig-(i).

Example (ii) when a ball rolls over a surface it slows down due to frictional force which acts opposite to the direction of motion of ball as shown in Fig-(ii).

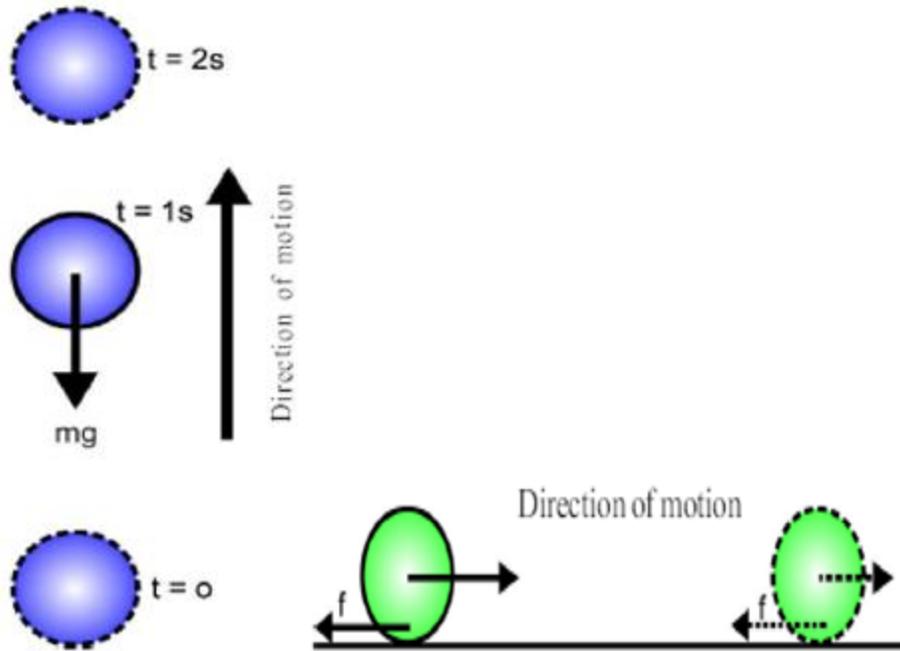


Fig -(i) Fig-(ii)

Q. 3. Identify the wrong statement among the following. Rewrite them by making necessary corrections.

- Work and energy have different units.
- When an aero plane takes off, the work done by its weight is positive.
- The potential energy of spring increases when it is extended and decreases when it is compressed.
- If the work done by external forces on a system is negative then the energy of the system decreases.
- When a body is falling freely from a height, its kinetic energy remains constant.
- The unit of power is watt.

Answer : a) Work and Energy have same unit joule(J),

Work is defined as $W = \text{Force} \times \text{Displacement}$, its unit came out be Newton-metre or precisely $\text{Kg} \frac{\text{m}^2}{\text{s}^2}$.---- (i)

Same thing with Energy, let us take Kinetic Energy, it is given by the formula $\frac{1}{2} m v^2$

Where m is mass of the object in kg

v is the velocity of the object in m/s,

Now putting the value of m and v in SI units we will get Kinetic Energy Units as $\text{Kg} \frac{\text{m}^2}{\text{s}^2}$

Which is same as of the units of work given in Eq-(i) ,hence proved they have same units.

b) Work done by its weight is negative as the weight is acting downward and plane is going upward.

c) When we try to extend or compress spring we increases its energy and this energy is stored as potential energy and when we release spring it loses its potential energy to do some work.

d) External negative force acting on a system decreases it energy because it acts opposite to the direction of motion of object .for example when friction acts on a object it gradually lowers its velocity.

e) Freely falling body loses its potential energy into kinetic energy. So, as potential energy decreases kinetic energy increases.

f) Unit of power is joule/second (Watt). Power is defined as rate of change of energy per unit time.

Q. 4. What is mechanical energy?

Answer : Sum of kinetic energy and potential energy of an object is its mechanical energy.

Q. 5. State the principle of conservation of energy.

Answer : The law states that energy can neither be created nor be destroyed, rather it can only be transferred from one form to another.

Q. 6. When you lift a box from the floor and put it on an Almira the potential energy of the box increases but there is no change in its kinetic energy. Is it violation of conservation of energy? Explain.

Answer : No, there is no violation of conservation of energy. When force is applied to lift the box ,it is moving along the direction of action of force so, the acting force increases its energy as potential energy. When box falls down it loses its potential energy into kinetic energy.

Q. 7. One person says that potential energy of a particular book kept in an almirah is 20 J and other says it is 30J. Is one of them necessarily wrong? Give reasons.

Answer : Nobody is wrong. Potential energy of an object depend upon the consideration of zero potential energy.

If we consider ground as zero potential energy lifting a 1kg object to a height of 3m taking $g=10\text{m/s}^2$ brings the object to 20J potential energy , whereas considering the surface at a vertical height of 1 m above ground as zero potential lifting a 1kg object to 2m makes the potential to 30J.

Q. 8. In which of the following cases is the work done positive or zero or negative?

- a) Work done by the porter on a suitcase in lifting it from the platform on to his head.
- b) Work done by the force of gravity on suitcase as the suitcase falls from porter's head.
- c) Work done by the porter standing on platform with suitcase on his head.
- d) Work done by force of gravity on a ball thrown up vertically up into the sky.
- e) Work done by force applied by hands of a man swimming in a pond.

Answer : a) Positive as the porter apply force on the suitcase in its direction of motion.

b) Positive as the gravity acts downward and suitcase is also falling downward

c) Zero Work is done as force exerted by its head on suitcase cause no motion.

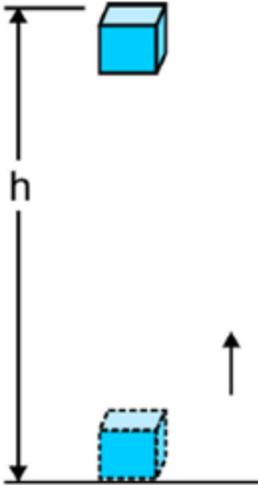
d) Negative as the gravity acts downward and ball is moving upward.

e) Negative as the swimmer propels his hands back so as to get a forward displacement.

Q. 9. What is potential energy? Derive an equation for gravitational potential energy of a body of mass 'm' at a height 'h'.

Answer : Potential energy of a body is its ability to do work, whereas gravitational potential energy of an body is its ability to do work in gravitational force.

Consider a object of mass 'm' raised to a height 'h' above the ground. The minimum force required to raise the object is mg. The object gains energy equal to work done on it.



$W = \text{Force} \times \text{Displacement}$

$W = mg \times h$

$W = mgh$

Q. 10. When an apple falls from a tree what happens to its gravitational potential energy just as it reaches the ground? After it strikes the ground?

Answer : When apple falls it gains some speed due to action of gravitational force on it. It gains kinetic energy and loses its gravitational potential energy.

When it strikes the ground the kinetic energy is lost in various forms such as in breaking the apple some energy is lost in heat energy and sound energy.

Q. 11. Let us assume that you have lifted a suitcase and kept it on a table. On which of the following does the work done by you depend or not depend? Why?

- a) The path taken by the suitcase.
- b) The time taken by you in doing so.
- c) The weight of the suitcase.
- d) Your weight.

Answer : Work Done = Force \times Displacement

a) It doesn't depend on the path taken because work done depends upon the displacement i.e. Final Position and Initial Position.

b) It doesn't depend upon time taken, work only depends upon force and displacement.

c) It does depend upon the weight of suitcase because the suitcase is raised against the gravitational force with a minimum force equal to the weight of body.

d) It doesn't depend on my weight as while lifting the suitcase gravitational force doesn't act against my weight and I don't move against gravitational force.

Q. 12. When you push your bicycle up an incline, the potential energy of the bicycle and yourself increase. Where does this energy come from?

Answer : Pushing up a bicycle and moving up the incline is done by my muscle ,So my muscle loses energy some of the lost energy goes into the potential energy of bicycle and myself.

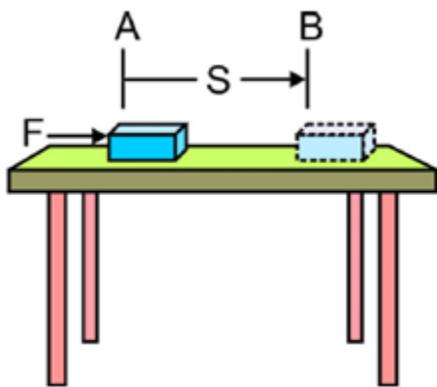
Q. 13. Why does a person standing for a long time get tired when he does not appear to be doing any work.

Answer : The person standing is not doing any work externally but a lot of work is being done inside the body.

The muscle of body is stretched during standing and heart has to pump more blood to the muscle this leads to loss of energy inside body and thus he gets tired.

Q. 14. What is kinetic energy? Derive an equation for the kinetic energy of a body of mass 'm' moving at a speed 'v'.

Answer :



A body in motion possesses kinetic energy

Let us assume that an object of mass(m) is at rest on a smooth horizontal plane as shown above . Let it be displaced through a distance 's' from the point A to B by force(F) acting upon it in the direction of the displacement. In the horizontal direction the net force F_{net} is equal to the applied force F .

The work done on the object by the net force $W = Fx$ ---(i)

Let the work done on the object cause a change in its velocity from 'u' to 'v' and the acceleration produced be 'a'

The relation between initial velocity u, final velocity v, acceleration 'a' and displacement 's' is given from the equation of motion as

$$v^2 - u^2 = 2as \text{ or } s = \frac{v^2 - u^2}{2a} \text{ ---(ii)}$$

By newton's second law of motion

$$F = m \times a \text{ --(iii)}$$

From equation (i), (ii) (iii) ,we have

$$W = ma \times \left(\frac{v^2 - u^2}{2a}\right)$$

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

Note:- A Special case is when the object is initially at rest i.e $u = 0$,In that particular case ,Formula of Kinetic Energy comes to be $K.E = \frac{1}{2}mv^2$.

Q. 15. A free-fall object eventually stops on reaching the ground. What happens to its kinetic energy?

Answer : As kinetic energy becomes zero on reaching the ground it gets converted into various forms of energy, Like heat energy due to impact with ground and due to air resistance with the object.

Q. 16. A man carrying a bag of total mass 25kg climbs up to a height of 10m in 50 seconds. Calculate the power delivered by him on the bag.

Answer : Given data,

mass (m)=25 kg

Displacement = 10 m

Time taken(t) = 50 s

As the man is working against gravity so force(F) applied is

$$mg = 25 \text{ kg} \times 10 \text{ m/s}^2 = 250 \text{ N}$$

Power = work done/time taken

$$= (\text{force} \times \text{displacement}) / (\text{time taken})$$

$$= \frac{250(\text{N}) \times 10(\text{m})}{50(\text{s})}$$

$$= 50 \text{ watt(w)}$$

Q. 17. A 10 kg ball is dropped from a height of 10m. Find

- (a) the initial potential energy of the ball ,**
- (b) the kinetic energy just before it reaches the ground**
- (c) the speed just before it reaches the ground.**

Answer : Given data

Mass of ball (m) = 10kg

Height(h) = 10m

(a) Potential energy = mgh

$$= 10 \text{ (kg)} \times 10 \text{ (m/s}^2) \times 10 \text{ (m)}$$

$$= 1000 \text{ (J)}$$

(b) When the ball reaches the ground the gravitational potential energy changes to kinetic energy

So, kinetic energy gained = 1000(J)

If we neglect the air resistance

(c) We know that Kinetic Energy = $\frac{1}{2}mv^2$ and from above data we have kinetic energy as 1000 J and mass of ball (m) as 10kg ,hence on equating for velocity we will get velocity as

$V = \sqrt{\frac{2 \times \text{Kinetic Energy}}{\text{Mass}}}$ substituting Kinetic Energy = 1000 J and mass as 10 kg ,we have

$$\text{Velocity} = \sqrt{\frac{2 \times 1000}{10}} = \sqrt{200} = 14.14 \text{ m/s}$$

Q. 18. Calculate the work done by a person in lifting a load of 20 kg from the ground and placing it 1m high on a table

Answer : Given Data:

Mass = 20kg

Height = 1m

Work is done against gravity so minimum force needed to lift the mass is (20×g), where g is acceleration due to gravity

Work done = force × displacement

$$= 20 \text{ (kg)} \times 10 \text{ (m/s}^2\text{)} \times 1 \text{ (m)}$$

$$= 200 \text{ (J)}$$

Q. 19. Find the mass of a body which has 5J of kinetic energy while moving at a speed of 2m/s.

Answer : Given Data:

Kinetic energy= 5 J

Velocity= 2 m/s

Using the formula of kinetic energy

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

$$\Rightarrow 5 = \frac{1}{2} \times m \times 2^2$$

$$\Rightarrow 5 = \frac{1}{2} \times 4m$$

$$\Rightarrow m = \frac{10}{4} \text{ kg}$$

Q. 20. A cycle together with its rider weighs 100kg. How much work is needed to set it moving at 3 m/s.

Answer : The energy required is kinetic energy of the cycle together with its rider

Given data :

mass (m) = 100kg

velocity (v) = 3 m/s

Kinetic Energy is given by the formula $\frac{1}{2}mv^2$ Putting the given values in the formula, we have

Q. 21. When the speed of a ball is doubled its kinetic energy

- (a) Remains same**
- (b) gets doubled**
- (c) Becomes half**
- (d) becomes 4 times**

Answer : B

Explanation: Because kinetic energy is directly proportional to square of speed

$$\text{Kinetic Energy} = \frac{1}{2}mv^2 \text{ --- (i)}$$

If speed becomes doubled then $V = 2v$ putting in the equation we have now new Kinetic Energy = $\frac{1}{2}m4v^2$ --(ii)

Dividing Eq (ii) and (i), we will get New Kinetic Energy as 4 times than the older one.

Q. 22. Two bodies of unequal masses are dropped from the top of building. Which of the following is equal for both bodies at any instance?

- (a) Speed
- (b) force of gravity
- (c) potential energy
- (d) kinetic energy

Answer : (a) Explanation: Speed of both the bodies will be equal at any instant of time.

According to equation of motion $v = u + at$.

Speed of free falling object doesn't depend on mass of the object.

While the force of gravity, potential energy, kinetic energy depends upon the mass of object.

Q. 23. A man with a box on his head is climbing up a ladder. The work done by the man on the box is

- (a) Positive
- (b) Negative
- (c) Zero
- (d) Undefined.

Answer : (a)

Explanation: Work done is positive because displacement is in the direction of the applied force.

Q. 24. A porter with a suitcase on his head is climbing up steps with uniform speed. The work done by the "weight of the suitcase" on the suitcase is

- (a) Positive
- (b) Negative
- (c) Zero
- (d) Undefined

Answer : (b)

Explanation : work done is negative because , gravitational force is the cause of weight and it acts downward on suitcase and displacement is upward.

Q. 25. How will the increasing energy needs and conservation of energy influence international peace, cooperation and security? Discuss.

Answer : The welfare of individuals, sustainable development of countries, and the life-supporting capacity of the global ecosystem depends on energy resources.

Energy supplies, particularly oil, are strategically important for industrial development and military weaponry. They help to increase national power. A nation endowed with sufficient energy resources can make its will prevail over the others.

Oil is a natural resource which is limited in quantity and is non-renewable in the economic sense. Alternatives to oil are being developed but they are not a viable replacement for oil. This creates economic interdependence between the nations.

The ability to obtain enough energy supplies at a reasonable cost is an important aspect of energy security.

In the future, energy resources may be in greater demand due to population and economic growth. This may lead to more conflicts.

The IEA which consists of 29 OECD member countries plays an important role in international energy cooperation. But its capacity to secure global cooperation is limited because the major developing countries are not its members. So there is a need for more collaboration and open markets in energy policy. Multilateral cooperation is extremely necessary for the stability of energy markets and a peaceful evolution of the international system.

Collaborated efforts to conserve energy in order to meet its increasing demand can go a long way in ensuring international peace and security.

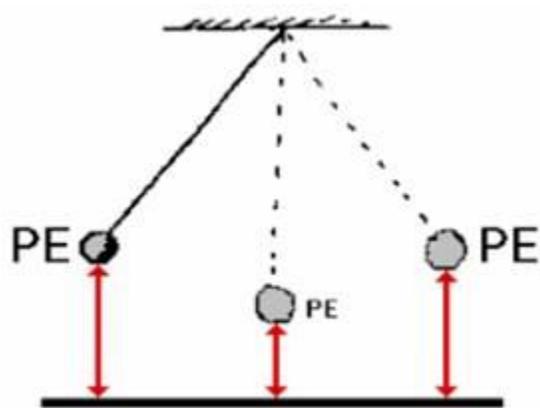
Q. 26. How do you appreciate role of energy conversion occurring naturally in maintaining ecological balance of nature.

Answer : We see various energy conversions in nature, for example

- i) Snow deposited at altitudes melts and the water so formed flows down to seas. In the process, its potential energy converted into kinetic energy. We convert the kinetic energy of water to electrical energy in hydroelectric power plants.
- ii) Dead plants buried deep below the earth's surface for millions of years get converted to fuels like petroleum and coal, which have chemical energy stored in them.
- iii) The food we eat comes from plant sources or animal sources which in turn take plant parts as their food.
- iv) When we eat food, several chemical processes take place and the chemical energy stored in food gets converted into various forms needed by the body. For example when we walk, run, exercise etc., the energy from food is used for kinetic energy.

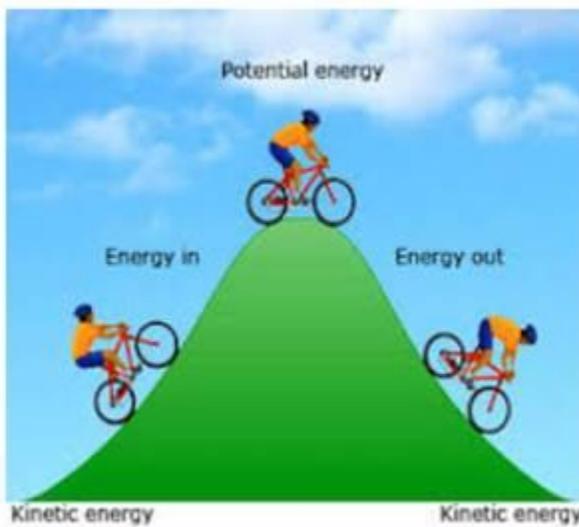
Q. 27. Collect pictures showing various situation where potential energy possessed by object depends on its shape and position. Prepare a scrap book.

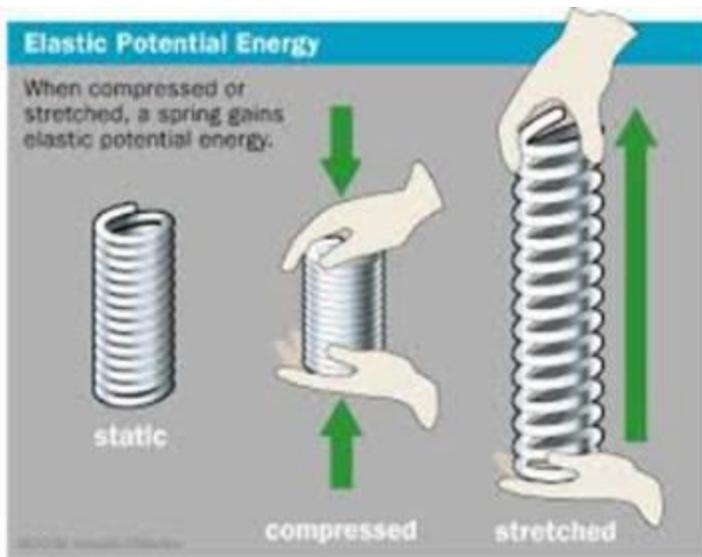
Answer :



Potential Energy

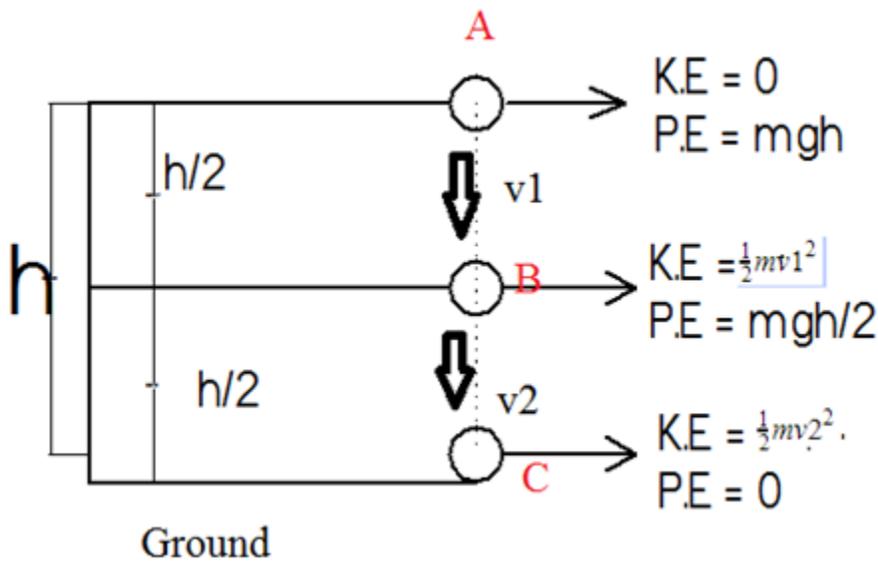
- Stored energy that results from the position or shape of an object





Q. 28. Draw a diagram to show conservation of mechanical energy in case of free falling body.

Answer :



Since Mechanical Energy is defined as Sum of Kinetic Energy and Potential Energy, It should be conserved at all points.

Let us consider a freely falling body, It is at a height 'H' from the ground.

Let the Total Mechanical Energy be M.E joules

Considering its motion at three points A,B & C .

At A velocity $v = 0$ hence its Kinetic Energy is zero, but its Potential energy = mgh

Hence, Mechanical Energy = Kinetic Energy + Potential Energy

$$M.E = mgh \text{ -- (i)}$$

At B velocity $v = v_1$, Kinetic Energy will be $\frac{1}{2}mv_1^2$ and Potential Energy will be $mgh/2$

Hence, Mechanical Energy = Kinetic Energy + Potential Energy

$$M.E = \frac{1}{2}mv_1^2 + mg\frac{h}{2} \text{ -- (ii)}$$

At C velocity $v = v_2$, Kinetic Energy will be $\frac{1}{2}mv_2^2$ and potential Energy will be Zero

Hence, Mechanical Energy = Kinetic Energy + Potential Energy

$$M.E = \frac{1}{2}mv_2^2 + 0 \text{ -- (iii)}$$

Since Mechanical Energy is Conserved , We can say that M.E at points A,B & C or Equations (i) ,(ii) & (iii) will be equal.