Work and Energy

Work

Q.1 When is Work said to be done?

Sol. Work is said to be done when a force that is applied on a body causes displacement of the body.
It is given by **W = F × d**, where 'F' is the force applied and 'd' is the displacement caused.

Q.2 Define SI unit of Work done.

Sol. The SI unit of Work done is Joule (J). 1 Joule work is said to be done when 1N force applied on a body causes its displacement by 1m.

$$\text{Work done} = \frac{\text{Force,F}}{\text{Displacement,d}} = \frac{1\text{N}}{1\text{m}} = 1\text{N/m or J}$$

Q.3 Define 1 joule.

Sol. 1 Joule is the amount of work done on a body by 1 N force that moves the body in the direction of force applied, to a distance of 1 meter.

$$\text{Work Done(1J)} = \text{Force(1N)} \times \text{Displacement(1m)}$$

Q.4 State reason, why work is a scalar quantity?

Sol. Work is the product of force (F) and the displacement (s). Since, Both, F and s are vector quantities and the dot product of vector quantities produces scalar quantity. Therefore, work is a scalar quantity.

Work done = F. s

Q.5 Calculate the work done by a man in rotating a wheel of an amusement slide in a fair 40 times in 1 minute?

Sol. The man is rotating the wheel of an amusement slide by just standing at a place. This concludes that the man is not undergoing any displacement. Since displacement is zero, therefore work done is zero.
(W = Force, F $\times$ Displacement, s)

Q.6 Define : - (a) Positive work done and

(b) Negative work done.

Sol. (a) **Positive work done**: If the force applied on a body causes the displacement in the direction of the force applied, then positive work is done i.e. the angle between the force applied and displacement is 0^o.

W = Fs

(b) **Negative work done:** If the force applied on a body causes the displacement in the direction opposite to the force applied, then negative work is done i.e. the angle between the force applied and displacement is 180^o.

W = -Fs

Q.7 Give an example for each:

(a) Zero work done

(b) Positive work done

(c) Negative work done

Sol. (a) **Force applied by a person on the wall of his room. W = 0**

When force is applied on a wall there is no displacement of the wall or the force does not cause movement of the wall. Therefore, no work is done on the wall.

As, $W = F \times s$, If displacement (s) is 0, then work done is also 0.

(b) **Ball when kicked by a boy. W = +Fs**

When the ball is moving in the direction of force applied, the work done is positive.

(c) **Force of friction acting on a moving bicycle. W = -Fs**

Work done by frictional force on a moving bicycle is negative work done by the frictional force.

Q.8 In which of the following cases work is said to be done?

(a) When we push a table.

(b) When a person holds a book in his hand and keeps it stationary.

(c) When a wire is twisted.

Sol. (a) **Work is done:** When we push a table, if the force applied by us is great enough to move it from its original position, then work is said to be done.

(b) **Work is not done:** When a person holds a book in his hand and keeps it stationary there occurs no movement of the book even when force is regularly applied on the book. So, work is not done.

(c) **Work is done:** When a wire is twisted the shape of the wire changes which concludes that work is done as there occurred changes in the configuration of the wire.

Q.9 What will be the nature of work done when force acting on a body retards its motion? Justify your answer by quoting examples.

Sol. When force retards the motion of a body, the motion is stopped i.e. a force opposite to the direction of the motion is applied. Thus, a negative work is done by the force.

For example:

- In tug of war, the work done by the losing team is negative.
- When a ball is thrown up in the air, the gravitation force acting downward upon the ball does negative work.

Q.10 Find the work done by a body experiencing circular motion.

Sol. During circular motion, the force applied at each point to the center of the circle is called centripetal force. This force is perpendicular to the displacement of the body. Therefore, the work done is zero as the angle between the displacement and the force applied is 90°.

Q.11 What amount of work is done by a man of height 2 m standing on a bus-terminus holding a 25 kg trunk on his head?

Sol. The man is just standing at a bus terminal; he didn't move from his place, i.e. displacement is 0. Since, **W = Force $\times$ Displacement**, when displacement is zero, work done is also zero. Therefore, Work done by the man is 0.

Q.12 Calculate the amount of work done in the following cases, with proper reasoning.

(a) An electron revolving around the nucleus in a circular orbit of radius 'r'.

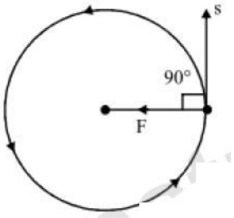
(b) A body of mass 'm' freely falling under the gravity from the top of a building of height 'h'.

Sol. (a) **Work done by the electron in revolving around the nucleus is zero.**

If an electron moves in a circular orbit, the centripetal force 'F' acts along the radius towards the Centre and the displacement 's' acts along the tangent to the orbit. Thus, the angle θ between 'F' and 's' is 90°.

Since, $W = F\, s \cos\theta°$ (When force is acting obliquely)

Therefore, $W = F\, s \cos 90° = 0$ (When $\theta = 90°$, then $\cos 90° = 0$)



As W= 0, no work is done by the electron while revolving around the nucleus.

(b) **Work done, when a body is dropped from a building of height, h under the gravity is positive.**

$W = F \times s \cos\theta°$

This is because the force of gravity and the movement of the body both are acting downwards, i.e. $\theta = 0^{\circ}$. So, the work done is positive.

Q.13 A worker lifts a load to a building of height 'h' by applying force in the same direction displacing the load under gravity.

(a) In which direction does the force of gravity acts?

(b) Which one of these forces is doing positive work? Give reason.

(c) **Which one of these forces is doi ive work? Give reason.**

Sol. (a) The force of gravity acts downwards.

(b) **Force applied by the worker:** The force applied by the worker in upward direction is doing positive work as the displacement is also in the upward direction. Since, the direction of force applied and the displacement is making the angle between the two 0^o.

(c) **Gravitational force:** The Force of gravity is acting downward whereas the direction of displacement is upward. Both making an angle of 180^o. Since this force is opposite to the direction of motion, negative work is done.

Q.14 A man is sitting on a bench and thinking about ideas meant for planning for his friend's birthday. What work is done by him in his planning's?

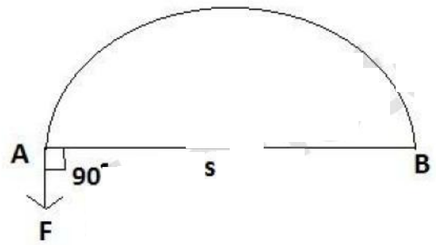
Sol. Since, mental labour is not considered as work in physics. Therefore, the man sitting on the bench is not doing any sort of work in thinking.

Q.15 When an object is thrown upward with certain angle moving in a curved path, it falls back on the ground. The initial and the final positions of the path of the object lie on the same horizontal line. How much work is done by the force of gravity on the object?

Sol. When the object is thrown above the ground making certain angle and returns back to the ground travelling a curved path the work done by the object is zero.

This is because the object thrown up experiences a force of gravity downwards i.e. F = mg (force acting due to earth's gravity).

Displacement of the object (s) is horizontal making an angle of 90^o with the force of gravity. Since when the force of gravity and the displacement is perpendicular to one another, then the **work done is zero by the force of gravity.**



Energy

Q.16 (a) Define energy.
(b) State the law of conservation of energy.

Sol. (a) Energy is the ability to do work.
(b) The 'law of conservation of energy' states that energy can neither be created nor destroyed, but can only be transformed from one form to other.

Q.17 (a) State the SI unit of energy.
(b) Which type of energy does a moving object possess?

Sol. (a) The SI unit of energy is joule.
(b) A moving object possesses kinetic energy.

Q.18 State the different forms of energy?

Sol. The different forms of energy are:

(i) Kinetic energy (ii) Potential energy (iii) Chemical energy
(iv) Heat energy (v) Light energy (vi) Sound energy
(vii) Electrical energy (viii) Nuclear energy

Q.19 Find out the relation between J and erg.

Sol. The SI and CGS unit of energy is J and erg respectively.
The relation between the two is:
1 Joule = 10^7 erg.

Q.20 What is the sum of kinetic energy and potential energy of a body collectively called?

Sol. Mechanical energy is the term used for the sum of kinetic energy and potential energy of a body.

Mechanical energy = K.E. + P.E. $= \frac{1}{2}mv^2 + mgh$.

A flying bird in sky possesses both kinetic and potential energy i.e. **Mechanical energy**.

Q.21 Derive an expression for pc[illegible] body with mass m placed at

height h.

Sol. The work done to lift an object against gravity to take it to a height h is stored in the form of P.E. of the object.

Work done = Force $\times$ Displacement

(Weight of a body, F = mg; Displacement, s = Height to which body is raised, h)

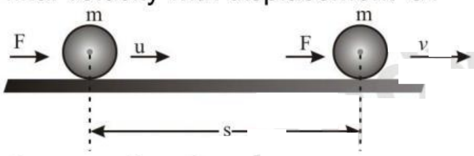
Therefore, $W = mg \times h = mgh$

Work done = Potential energy, P.E. = mgh

Q.22 Derive an expression for kinetic energy possessed by a body of mass 'm' moving with a speed 'v'.

Sol. Suppose an object of mass 'm' moving with an initial velocity 'u'. Force 'F' act on it and produces acceleration 'a'.

'v' being the final velocity with displacement 's'.



According to the equation of motion,

$v^2 - u^2 = 2as$, therefore $s = \frac{v^2 - u^2}{2a}$ .... eq(1)

Work done by the force, which causes the body displacement, s

$W = F \times s$ .... eq(2)

From Newton's Second Law of Motion,

$F = ma$ .... eq(3)

By substituting eqns. (1) and (3), in (2) we get

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

Or $W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$ ....eq (4)

By putting the value of u = 0 in eq (4) as the object is initially at rest

$W = \frac{1}{2}mv^2$ ....eq (5)

This work done (W) by the object, in acquiring a velocity *v* after starting from rest is stored in the object in the form of kinetic energy. The Work stored in a moving object is the kinetic energy of the object.

Therefore, the Kinetic energy of a moving object is half the product of the mass of the object and the square of the speed at which the object is moving.

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

Q.23 Define dissipation of energy.

Sol. Dissipation of energy is the conversion of energy from a useable form to a useless form as heat, sound, etc.

Q.24 Kinetic energy of a moving body could be negative. Is the above statement correct? Explain.

Sol. No, the kinetic energy of a moving body cannot be negative, since speed of a moving object can't be negative. There should be some positive value of the speed.

Q.25 During the oscillation of a pendulum at what stages the potential and kinetic energies are maximum?

Sol. The potential energy would be highest at the two extreme positions covered by the pendulum whereas the kinetic energy would be highest at the mean position.

Q.26 By Changing mass or velocity of a body, which will cause greater change in Kinetic energy of a body?

Sol. As, $K.E. = \frac{1}{2}mv^2, K.E. \alpha v^2$ and $K.E. \alpha m$. This means a greater change in kinetic energy will be caused when there would be changes in velocity.

Q.27 A body is having momentum, p = 0. Will it have mechanical energy? Explain.

Sol. Mechanical energy is the sum of potential and kinetic energy.
M.E. = K.E. + P.E.
Momentum, **p = mv**, where m = mass of the object and v = speed.
Therefore if p = 0 then v = 0 that means kinetic energy would be zero.

But, potential energy is independent of momentum so if p = 0, P.E. ≠ 0. Therefore, there would be some mechanical energy due to potential energy.
M.E. = P.E. when momentum is zero.

Q.28 A body of mass, m is moving with a velocity, v. Express its K.E. in terms of m and v.

Sol. The KE of the body will be $\frac{1}{2}mv^2$, Where, m= mass of body and v= velocity of the body.

Q.29 Sun is the ultimate source of energy. Explain how it provides energy for flowing water?

Sol. Sun being the ultimate source of energy is responsible for the flow of water on the earth. The heat of sun is used up by the water bodies to evaporate and form clouds. This water then precipitates in the form of rain, hail stone, snow, and meets the water bodies. On the other hand the glaciers melt with the Sun's heat and the water meets to the rivers and oceans. So, we can say that sun provides energy for conduction of water in the environment.

Q.30 On a heap of sand, two identical objects made are allowed to fall from the same height. It was observed that the iron object penetrates more in the sand than the wooden object. Which one of the two has more potential energy?

Sol. As the iron object penetrates more in the sand, it has done more work. Since work done is equal to the energy possessed by the object, so iron has more potential energy. **Work done = Potential energy. Therefore, greater the work done greater would be the Potential energy.**

Q.31 On a road, a bus and a car are moving with same KE. Which one is moving faster?

Sol. Kinetic energy, $KE = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2KE}{m}}$

If, K.E. is constant in both the cases, then mass is inversely proportional to the velocity,

$v \propto \frac{1}{\sqrt{m}}$

Therefore, when mass of a substance will be more its velocity will be less. Since, car is having less mass than the bus, it is moving faster

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Q.32 Write the expression for a relation between kinetic energy of a body and its momentum.

Sol. Kinetic energy = 1 /2 mv^2

$\Rightarrow$ 2 K.E. = mv^2

Where, m= mass of the body

v = velocity with which body moves

By multiplying both the sides by m, we get

$\Rightarrow$ 2m K.E. = $(mv)^2$

$\Rightarrow$ 2m K.E. = p^2 (Since, Momentum p = mv)

Therefore, K.E. = $p^2/2m$

Q.33 (a) Which type of energy is possessed by a stretched rubber band?

(b) There are two bodies, A and B with same kinetic energy. A is lighter than B, which one of the two will have greater momentum?

Sol. (a) Potential Energy, P.E. is defined as the energy possessed by a body due to its position or change in shape.

It is given by, **P.E. = mgh,**

Where, m= mass of the body

g = acceleration due to gravity

h = height

Therefore, energy possessed by a stretched rubber band is potential energy known as **elastic potential energy**.

(b) As Kinetic energy, $KE = \frac{1}{2}mv^2 = \frac{(mv)^2}{2m} = \frac{p^2}{2m}$

Therefore, $p^2 = 2\,m\,KE$ or $p = \sqrt{2mKE}$

Since, KE is the same for both the bodies; therefore momentum will depend upon mass i.e. $p \propto \sqrt{m}$.

Therefore, the heavier body B will have more momentum than the lighter body A.

Q.34 (a) Differentiate between potential energy and kinetic energy.
(b) Graphically show the relationship between kinetic energy and velocity.

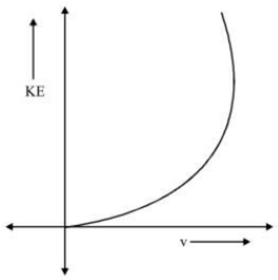
Sol. **(a)** **Potential energy** is defined as the energy possessed within a body by virtue of its position or shape. It is given by ,**P.E. = mgh**

Where, m= mass of the body
g = acceleration due to gravity
h = height at which the object is placed

Kinetic energy is defined as the energy possessed of a body by virtue of its motion. It is given by, **K.E. =** $\frac{1}{2}mv^2$

Where, m = mass of the body
v = velocity at which body is moving

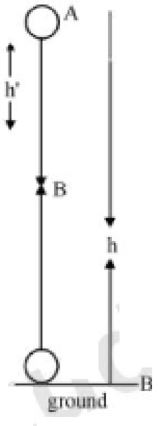
(b) **Kinetic energy (KE) =** $\frac{1}{2}mv^2$



Graph between K.E and velocity

Q.35 Prove with the help of mathematical expression that energy of a ball falling freely from a height is conserved at every point towards its downward motion.

Sol.



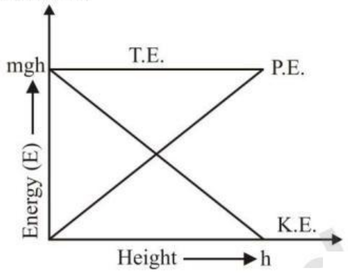
At height h,
u = 0 (since ball is stationery)
Therefore, total energy = kinetic energy + potential energy
$\Rightarrow$ 0 + mgh = mgh

After falling through a height h to h'
Velocity is given by $v^2 = u^2 + 2gs$ (a is taken as g, acceleration due to gravity)

$v^2 = 2gh'$ (as u = 0)
So, $v = \sqrt{2gh'}$
Therefore, total energy at this point = kinetic energy + potential energy
$= \frac{1}{2}mv^2 + mg(h-h')$ (as new height = h – h')
$= \frac{1}{2}m\,2gh' + mg(h-h')$
= mgh

At the ground,
Potential energy = zero
And velocity is given by $v^2 = u^2 + 2as$
$\Rightarrow v^2 = 2gh$ (u = 0)
Therefore, total energy = potential energy + kinetic energy
$= 0 + \frac{1}{2}m \times 2gh = mgh$
Since at every point energy is mgh, this proves that energy is conserved at each point.

Variation of P.E. and K.E.



T.E. ⟶ Total energy

Q.36 Following will possess potential energy or kinetic energy.
(a) A stretched slinky
(b) A stretched bow
(c) A speeding car
(d) Flowing water

Sol. (a) Potential energy
(b) Potential energy
(c) Kinetic energy
(d) Kinetic energy

Q.37 An archer stretches the string of h arget by an arrow. Explain the energy transformation taking place when the arrow is shot.

Sol. In the above system, archer does the work. Bow possesses potential energy due to the deformation of the string of the bow (Elastic potential energy), which is then transferred to the arrow in the form of Kinetic energy which is used up by the arrow to move towards the target.

Q.38 What changes occur to the potential energy of a compressed string tied at the ends when it is kept in an acid?

Sol. The potential energy stored in the spring is converted into heat energy due to the dissolution of spring molecules in the acid, their movement generates Kinetic energy which is then converted into heat. This heat increases the temperature of the acid.

Q.39 A pendulum bob is drawn to one side and allowed to oscillate.

(a) Explain the law of conservation of energy by discussing the energy changes which occurred during the act.

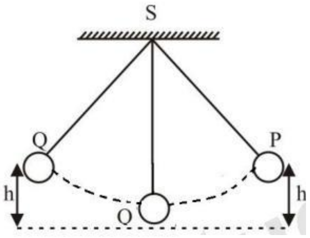
(b) Why do the bob eventually come to rest ?

(c) What happens to its energy ultimately? Is it a violation of the law of conservation of energy?

Sol. (a) **Energy changes in a moving pendulum, proving the law of conservation of energy.**

- Take a simple pendulum and suspend it to stiff support.

- Suppose OS be the mean position of the pendulum. Now, taking the pendulum to the position P manually and leaving it to move towards the position Q.



(i) At position P,

P.E. = mgh

This is because pendulum is made to rise at some height from the initial position.

K.E. = 0

This is as the pendulum is at rest.

(ii) Moving from P to O,

When released from position P, it begins to move towards position O.

Speed of the pendulum = increases

And height = decreases

This shows the potential energy is regularly converting into kinetic energy.

(iii) At position O,

P.E. = 0

K.E. = maximum

All the potential energy is converted to kinetic

(iv) **Moving from O to Q,**

Due to inertia of motion pendulum moves from O to Q.

K.E. is gradually converting into P.E therefore, K.E. decreases and P.E. increases.

(v) **At point Q**,

The whole kinetic energy of the moving pendulum is converted into potential energy as pendulum is again raised to maximum height.

P.E. = mgh

K.E. = 0

(vi) This conversion of energy between P.E. and K.E. occurs during the motion of the pendulum. But the total energy remains constant at every point in the movement of the pendulum.

(b) **According to the law of conservation of motion**, the energy could neither be created nor destroyed but can change from one form to another.

The energy in a system remains constant only till there aren't any external forces applied. Here in this case as air applies frictional force on the oscillating pendulum some amount of energy is utilized in overcoming this friction.

Therefore with the time lag, the energy of the pendulum keeps on decreasing and finally comes to zero.

(c) Since energy of the pendulum is being transferred in the atmosphere, therefore there is **no violation of law of conservation energy**, as energy is transformed to the atmosphere.

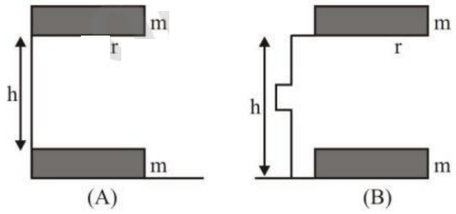
Q.40 Gravitational potential energy of an object is path dependent. Do you agree with this?

Sol. No, gravitational potential energy of an object is not path dependent as the potential energy depends on the vertical height of a substance from the ground. It just depends upon the final and initial positions attained by the object not the path.

Q.41 How is elastic potential energy in a body attained?

Sol. The elastic potential of a body is a result of alteration in the body's configuration. For example, a stretched band consists of elastic potential energy.

Q.42 (a) Differentiate between Potential energy and Kinetic energy.



(b) In the above figure, 'A' and 'B' are two routes through which a mass 'm' is raised to a vertical height 'h'. What would be the potential energy in both the cases?

Sol. (a) Potential energy of a body is the energy possessed by the body due to the

position or change in its shape.
Formula: P.E. = m g h
Example: a stone placed at some height above the ground.
Kinetic energy of a body is the energy possessed by the body due to movement of the body.

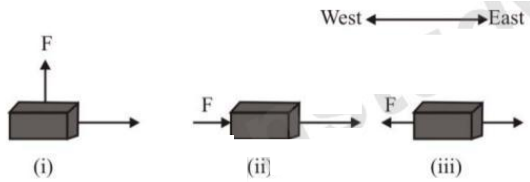
Formula: K.E. = $\frac{1}{2}mv^2$

Example: a motorcycle moving on the road.

(b) Potential energy of the body is path independent i.e. it does not depend on the path but on the height achieved against the gravity.
P.E. = mgh, where m= mass of the object,

g = acceleration due to gravity,
h = height of the object from the ground.

Q.43 There are three different situations given in the following figure, where a mass 'm' is being displaced under a force applied 'F', the direction of displacement is from west to east shown by the longer arrow. Determine the work done in each case.



Sol.
(i) Work done, W = F.s $\cos\theta$, where F = force applied, s = displacement and θ = angle between the F and s.
So, when $\theta = 90^\circ$, $\cos\theta$ is 0°. Then, work done is 0.
Work done- Since force applied and Displacement makes an angle of 90°, therefore the work done will be zero.

(ii) **Work done-** Since force applied and Displacement makes an angle of 0°, therefore the work done will be Positive.
(iii) **Work done-** Since force applied and Displacement makes an angle of 180°, therefore the work done will be Negative.

Q.44 What effect will be seen in the kinetic energy of a body when momentum is increased by two times?

Sol. The relation between the momentum p and kinetic energy K.E. is given by
K.E. = $p^2/2m$.
Therefore, K.E.α p^2
So, if p is increased by 2 times, then K.E. would be increased by 4 times. (K.E. = $(2\times)^2$= 4 times)

Q.45 What happens to the kinetic energy of a body, falling under the gravity?

Sol. The Kinetic energy of a freely falling object is transformed into heat and sound energy on reaching the ground. Since, energy cannot be created nor destroyed but can transform from one form to another.

Q.46 The acceleration in an object could be zero even when several forces are acting on it. Is the statement true or false? Give reason.

Sol. The above statement is correct as there are several forces acting on an object. If the net force acting on the object is zero then the acceleration is also zero.

Q.47 Write few examples where a body possesses both KE as well as PE.

Sol. **(i)** A **flying bird** possesses both P.E. as well as K.E. as the bird is on a height above the ground and in a state of movement.

(ii) A **moving ceiling fan** has both the P.E and K.E as it is placed on the wall at some height, and it is moving.

Energy transformation

Q.48 State the steps involved in energy conversion during electricity generation in a Hydel power station?

Sol.

Potential Energy of Water in reservoir
↓
KineticEnergy of water
↓
Kinetic energy of turbine
↓
Electrical energy

Q.49 State one example each of:
(a) Light energy converted into chemical energy
(b) Light energy into electric energy

Sol. (a) **In photosynthesis,** light energy is converted to chemical energy in the form of food (glucose).
(b) **In photocell,** light energy is captured and converted to electric energy.

Q.50 In working of an electric fan and a loudspeaker from where does the energy comes from?

Sol. **Electric fan,** electric energy is converted to kinetic energy and the fan moves which provide air circulation.

Loudspeaker, electric energy is converted to sound energy and we are able to listen to the sound produced.

Q.51 A boy is riding a bicycle, which energies are involved in this process?

Sol. The muscular energy spent by the boy in riding a bicycle is converted into kinetic energy as a result of which the bicycle moves forward.

Q.52 How energy is transformed in a thermal power station?

Sol. ***Energy transformation:***
Chemical energy → Heat energy → Kinetic energy → Electric energy
In a thermal power plant, coal is used as an energy resource. This coal when heated converts its stored chemical energy into heat energy. Now this heat is utilized by water to get converted into steam. This high pressure steam is then used to rotate the turbine.

This turbine then drives the generator which converts the kinetic energy of steam molecules into electric energy i.e. electricity.

Q.53 What energy transformation takes place in:
(a) Steam engine **(b) Solar cell**

Sol. (a) Heat energy of the steam is converted to kinetic or mechanical energy.
(b) Solar energy of the sun is converted to electric energy.

Q.54 Write a short note on Energy conversion occurring in:
(a) Pendulum
(b) Bulb.

Sol. (a) At the mean position, the pendulum has kinetic energy and no potential energy. When the pendulum is gradually made to rise, its kinetic energy is converted into potential energy. At the extreme positions, the pendulum has maximum potential energy and zero Kinetic energy. Again, when this pendulum reaches the mean position, the potential energy is converted to kinetic energy, and K.E. reaches to maximum.

(b) In a bulb, electric energy is transformed into Heat energy and Light energy.

Q.55 Why bulbs become hot while working?

Sol. When a bulb is lightened up some part of electric energy is converted to Heat and light energy. The light is used up in seeing the surroundings and heat makes the surface of bulb hot.

Q.56 What is the energy transformation that takes place when a saw is used to cut a log of wood?

Sol. A raised saw consist of Potential energy due to the virtue of its height attained. This potential energy is converted to kinetic energy on moving the saw towards the log. Further, this kinetic energy is then utilized to cut the log. Some amount of energy is simultaneously converted to heat. This is the reason why log becomes hot when saw is placed on it.

Q.57 Write a short note on Energy transformation in nature.

Sol. In nature, there are many processes involving energy transformations where energy is converted from one form to another.
In photosynthesis, light energy is converted to chemical energy in the form of food (glucose).
During rainfall, the potential energy stored in the cloud is converted to kinetic energy.

Power

Q.58 Define Power.

Sol. Power is defined as the rate at which work is done. It is denoted by Power,

$$P = \frac{W}{t}$$

Where, W = work done, and t = time taken.
The SI unit of power is Watt, W.

Q.59 What is one watt?

Sol. Power = Work done/ time taken
1 Watt = 1 Joule/1 second
1 Watt is a power of appliance which provides 1 J of Work done by a body in 1 second.

Q.60 What is average power?

Sol. $$\text{Average Power} = \frac{\text{Net Work done}}{\text{Total time taken}}$$

Q.61 State the relation between horse power and watt.

Sol. The SI unit of power is Watt.
Relation between 1 Horsepower and 1 Watt is:
1 horsepower (HP) = 746 Watt.

Q.62 (a) State three conditions need to be satisfied for work to be done.
(b) Express the mathematical expression for work done.

Sol. **a) Conditions to be satisfied for work done:**

- There should be some force applied on the object.
- Due to the force applied on the body there should be some displacement.
- The angle between the force applied and displacement should not be 90^o.

b) Mathematical expression of work done is given by

$$W = F.s = |Fs| \cos\theta$$

Where, W = work done,
F = force,

s = displacement,
θ = angle between F and s.

Q.63 (a) What is the commercial unit of energy? State its relation with joule.
(b) If mass of a body is doubled, what effect will it show on its kinetic energy?

Sol. (a) Kilowatt-hour (kWh) is the commercial unit of electrical energy.
The relation between 1 kWh and joule is,
1 kilowatt- hour = 1000 Watt for 1 hour
1 kilowatt- hour = 1000 joules/seconds for 1 hour

1 kilowatt- hour = 1000 joules/seconds × 60 × 60
1 kWh = 36, 00,000=3.6 × 10^6 J.

(b) As KE α m so, when mass (m) of a body is doubled then, its kinetic energy (KE) also gets doubled.

Q.64 What is 1 kWh?

Sol. If an appliance of 1 kW Power works for 1 hour then the energy consumed is said to be 1 kWh.

Q.65 Which energy is used by a bullet in piercing a target?

Sol. K.E. α v, if velocity is high K.E. is also high. Since bullet moves with very high velocity it possesses a large amount of kinetic energy. This energy is used in piercing the target by the bullet.

Q.66 When a substance is cooled what happens to the K.E. of its molecules?

Sol. When a substance is cooled, the velocity of its molecules decreases. As kinetic energy is directly proportional to velocity of the moving body therefore the kinetic energy also decreases. $K.E. = \frac{1}{2}mv^2$

Q.67 (a) What is Potential energy?
(b) Write an example of Elastic potential energy.

Sol. (a) The energy possessed by the object due to its change in position or shape is known as Potential energy.
There can be two types of potential energy:

- Gravitational P.E.
- Elastic P.E.

(b) In a bow and arrow when string of bow is stretched there is a temporary deformation in the string. This change in the shape of the string is conserved in the form of potential energy. This energy is then transferred to the arrow in the form of kinetic energy to travel. This potential energy due to deformation of the substance is known as **Elastic potential energy**.

Numerical

Q.1 Find the work done by a body with mass 10 kg when the body is displaced to a distance of 2m under acceleration of 5 m/s^2.

Sol. Given,

Mass of the body, m = 10 kg,

Acceleration, a = 5 m/s^2,

Displacement, s = 2 m

Therefore,

Work done, W = F × s

$= ma \times s \quad (\because F = ma)$

$= 10 \times 5 \times 2 = 100$ J.

The work done by the body will be 100 J.

Q.2 A Maruti car of mass 1500 kg is moving at the velocity of 60 km/h. Find out the work required to stop the car.

Sol. Given,

Mass of the car, m = 1500 kg

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

Final velocity of the car, v = 0 (As car would come to rest)

Work required to be done in stopping the car, W =?

Since, **Work done = Final Kinetic energy – Initial Kinetic energy**

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

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

$= \frac{1}{2}(1500)(0^2 - \frac{50}{3}^2)$

$= -\frac{1500 \times 50 \times 50}{2 \times 3 \times 3} = -\frac{3750000}{18} = -208333.333\,J$

$= -2.09 \times 10^5$ J

Therefore, the work done in stopping a car is -2.09×10^5 J.

Q.3 Calculate the work done by a girl of mass 55 kg when she runs up a flight of 40 stairs, with each stair measuring 0.15 m.

Sol. Given,

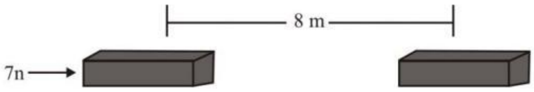
Mass of the girl, m = 55kg

Acceleration due to gravity, g = 10 ms^{-2}
Displacement, s= 40 × 0.15 m = 6m
Work done = F × s = mg × s (F= ma)
= 55 × 10 × 6
= 3300 J
The work done by the girl is 3300 J.

Q.4 An artificial satellite revolves around the Earth. What amount of work is done by it with respect to the gravity?

Sol. **When force is acting obliquely,**
Then, W = F.s cos θ
Where, W = work done
F = Force applied
s = Displacement
θ = Angle between the force and the displacement
When $\theta = 90^\circ$ then W=0 ($\cos 90^\circ = 0$)
Similarly, work done by the satellite is 0 as force of gravity of Earth acting on the satellite is at right angle (90°) to the direction of movement of satellite. Therefore, zero work is done by the satellite.

Q.5 In the given figure, a force of 7 N is applied on the block causing the displacement of 8 m, in the direction similar to the force applied. Find out the work done by the block in this case.



Sol. Given,
Force, F = 7 N
Displacement, s = 8m
Work done, W =?
Since, $W = F \times s$
W = 7 × 8 = 56 J.
The work done is 56 J.

Q.6 An object of mass 20 kg is moving with a velocity 5m/s. Due to certain forces applied from outside its velocity changes to 2 m /s. What work is done by the force?

Sol. Given,
Mass of the body, m = 20 kg
Initial velocity, u = 5 ms^{-1}
Final velocity, v = 2 ms^{-1}

Work done, W =?
Since,
Work done = Final Kinetic energy – Initial Kinetic energy (Work-energy theorem)

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

$$= \frac{1}{2}m(v^2 - u^2)$$
$$= \frac{1}{2}(20)(2^2 - 5^2)$$
$$= \frac{1}{2}(20)(4 - 25) = -210\,J$$

The work done by the force is -210 J,
Since, work done comes out to be negative, which infers that the direction of the force applied is opposite to the direction of motion which retards the motion.

Q.7 (a) Which two physical quantities are necessary for measurement of work done?

(b) Find the work done by a porter in lifting a luggage of 20 kg from ground on his head. (Given, height of porter, s =1.7 m, acceleration due to gravity, $g = 10\ m/s^2$). Also find out the work done by gravity on the luggage.

Sol. **(a)** Work done by a force is measured by calculating the product of **Force applied** and **displacement of the body** on which force is applied. $W = F \times s$

If the product comes out to be 0, zero work is done. If the product comes out to be positive or negative then the work done is positive or negative respectively.

(b) Given,
Mass of the luggage, m = 20 kg
Height of porter or displacement, s = 1.7 m,
Acceleration due to gravity, $g = 10\ m/s^2$
Work done, $W = F \times s$
$= m \times g \times s = 20 \times 10 \times 1.7 = 340$ J.
Work done by the porter in lifting the luggage is 340 J. (force and displacement in same direction)

The work done by the gravity on luggage is -340 J. (force of gravity acting downwards is opposite to the direction of displacement)

Q.8 Work done by a human heart per beat is 1.5 J. Find the power of human heart. (Given: Heart beats 72 times per minute)

Sol. Given,
Work done per beat = 1.5 J
No. of Beat = 72
Total work done by heart in one minute or 60 seconds = $1.5 \times 72 = 108$ J
Time taken = 1 minute = 60 s
Power = Work done / time taken
= 108 / 60 = 1.8 W ($\because$ J/s = W)
The Power of human heart is 1.8 W.

Q.9 A block of 5 kg placed on a table is moved horizontally at the same height. How much work is done by the gravitational force on the block?

Sol. Work done on the block by gravitational force would be zero.

Reason: Work done is given by, $W = F.s\cos\theta$, so when $\theta = 90^\circ$, $\cos\theta$ is 0. The Displacement of the block is horizontal and the gravitational force is acting downward. Both of them make an angle of 90°. Therefore, work done will be 0.

Q.10 What is the work done by the force of gravity on a ball of mass 1 kg when thrown upwards, with attaining the maximum height of 4 m. (given, acceleration due to gravity, $g = 10\ m/s^2$).

Sol. Given,

Mass of the ball, m = 1 kg

Force of gravity acting on the ball, $F = mg = 1kg \times 10\ m/s^2 = 10\ N$

Maximum Height attained by the ball or displacement, s = 4m

Work done = $- F \times s = -10\ N \times 4m = -40\ J$ (since force of gravity is against the displacement of the ball so the work done would be negative)

But, the work done against the gravity by the ball would be 40 J.

Q.11 How high an astronaut can jump on the surface of planet A if his weight on a planet is about half that on the earth. The height he could jump to on the surface of earth is 0.4.

Sol. Let, m= mass of the person

g_1 = Force of gravity on Earth

g_2 = Force of gravity on planet A

h_1 = Height attained on jump on earth.

h_2 = Height attained on jump on planet A

Weight of person on Earth = mg_1

Weight of person on planet A = mg_2

Weight on Earth = 2 Weight on planet A

Therefore, $mg_1 = 2\ mg_2$

According to the law of conservation of energy,

$$m\ g_1 h_1 = m\ g_2 h_2$$

So, $g_2 = \frac{g_1}{2}, \Rightarrow h_2 = 2h_1$

Therefore, person could jump up to a height, $h_2 = 2h_1$

$= 2 \times 0.4 = 0.8$ m

He can jump on the planet A up to a height 0.8 m.

Q.12 What would be the speed of a body of mass 1 kg when its kinetic energy would be 1J?

Sol. Given,

Mass of the body, m = 1 kg

Kinetic energy of the body, K.E. = 1 J

Speed with which body moves, v =?

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

Therefore, $1 = \frac{1}{2}(1)v^2$

$v^2 = 2$

$v = \sqrt{2} = 1.4$ m/s

Therefore, the speed with which the body will have Kinetic energy as 1 J is 1.4 m/s.

Q.13 A device moves different weights with a velocity of 30 m/s at a height of 50m. What is the total mechanical energy possessed by the weight with

mass 60 kg when lifted by the device (given: acceleration due to gravity, g = 10 m/s²)?

Sol. Given,

Mass of weight, m = 60 kg

Velocity, v = 30 m/s

Acceleration due to gravity, g = 10 m/s^2

Height at which the weight is = 50 m

Total mechanical energy, T.E. = Potential energy, P.E. + Kinetic energy, K.E.

$$T.E. = mgh + \frac{1}{2}mv^2$$

$$= 60 \times 10 \times 50 + 1/2 \times 60 \times (30)^2$$

$$= 30000 + 27000 = 57000 \text{ J}$$

The total mechanical energy of the weight = 57000 J

Q.14 Find the ratio of kinetic energies of two bodies of equal masses moving with uniform velocities v and 3v respectively.

Sol. Kinetic energy of first body, $KE_1 = \frac{1}{2}mv^2$

Kinetic energy of second body,

$$KE_2 = \frac{1}{2}m(3v)^2 = 9\left(\frac{1}{2}mv^2\right)$$

Therefore, the ratio between the two is, $\frac{KE_2}{KE_1} = \frac{9\left(\frac{1}{2}mv^2\right)}{\frac{1}{2}mv^2} = 9 = 9:1$

The ratio of kinetic energy of body two to one is 9:1.

Q.15 Kinetic energy of a truck moving at a speed of 15 m/s is 4.2 × 10⁵. Calculate the mass of the truck.

Sol. Given,

Kinetic energy, K.E. = 4.2×10^5 J

Speed, v = 15 m/s

$$K.E. = \frac{1}{2}mv^2, m = \frac{2K.E.}{v^2} = \frac{2(4.2\times10^5 J)}{(15m)^2} = 3733 \text{ kg}$$

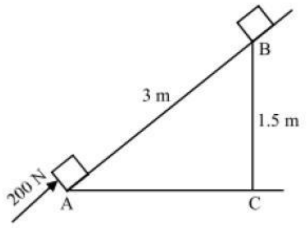
The mass of the truck = 3733 kg

Q.16 As shown in the figure a block of mass 30kg is pulled up by a rope with a constant speed by applying a force of 200 N parallel to the slope. A and B being the initial and the final position of the block, Calculate:

(a) The work done in moving the block from position A to B.

(b) The potential energy gained by the block in movement from A to B.

(c) The difference in work done by the force and the rise in potential energy of the block.



Sol.

(a) Given,

Mass of the block, m = 30 kg,

Force applied on the block, F = 200 N,

Distance covered = AB = 3 m,

Height at which the block is placed, h = 1.5 m

Work done by the force is moving the block from A to B,

W = F s = (200 N) (3 m) = 600 J

(b) Potential energy gained by the block, P.E. = mgh

= (30 kg) (10 m/s^2) (1.5 m) = 450 J

(c) The difference in energy is i.e.600 J – 450 J = 150 J

Q.17 (a) Determine the ratio of gravitational potential energy of an object, when height is doubled and mass tripled.

(b) Find out the ratio of work done by gravity in taking the object to zero height in both cases.

Sol. (a) Given,

Mass of an object, m

Height at which object is placed above the ground, h

Gravitational $P.E._1$ = m g h

Gravitational $P.E._2$ = (3m) g (2h) = 6 mgh (Potential energy after doubling the height and tripling the mass)

Therefore, the Ratio of the Potential energies $= \frac{P.E._2}{P.E._1} = \frac{6mgh}{mgh} = 6:1$

(b) Work done by gravity in bringing the mass m to ground, at zero height:

W_1 = Final Potential energy – Initial Potential energy

= 0 - mgh= - mgh

Work done by gravity in bringing the object of 3m mass m to ground, at zero height :

W_2 = Final Potential energy – Initial Potential energy

$= 0 - 6mgh = - 6mgh$

Therefore, the Ratio of the work done $= \frac{W_2}{W_1} = \frac{-6mgh}{-mgh} = 6:1$

Q.18 (a) A body placed at a greater height would have greater energy. Give reason.

(b) Find out the maximum potential energy when a stone of 2 kg mass is thrown up with a speed of 25 m/s.

Sol. (a) At a height potential energy is possessed by the body.

Potential energy = mgh,

Since, P.E. α h, therefore

As greater height is achieved the potential energy possessed by the body is also increased.

(b) Given,

Mass of body, m = 2 kg

Speed, v = 25 m/s

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

$$= \frac{1}{2}(2)(25)^2 = 625 \text{ J}$$

On reaching the height, the K.E. possessed by the stone is converted to P.E i.e. K.E. = P.E.

Therefore, the maximum potential energy would be 625 J.

Q.19 An electric heater is rated 1500 W. How much energy does it use in 10 h? Express your answer in (i) kWh (ii) joules

Sol. (i) **Energy in kWh**

Given,

Power, P = 1500 W = 1.5 kW

Time, t = 10 h

$$\text{Power} = \frac{\text{Energy consumed}}{\text{Time}}$$ Or Energy consumed, E = Power $\times$ Time

Energy consumed = 1.5 $\times$ 10 Wh= 15 kWh

(ii) **Energy in Joules**

Since, 1 kWh = 3.6×10^6 J

15 kWh = $15 \times 3.6 \times 10^6 = 5.4 \times 10^7$ J

Q.20 A 5 kg mass is thrown vertically upwards with a speed of 10 m/s. Calculate:

(a) Kinetic energy when it is thrown.

(b) Potential energy when it reaches at the highest point. Also find the maximum height attained by the body. (Given: acceleration due to gravity, g = 10 m/s^2)

Sol. (a) Given,

Mass of the body, m = 5 kg

Speed, v =10 m/s

The kinetic energy when body is thrown vertically upward is

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

$$= \frac{1}{2}(5)(10)^2$$

= 250 J

(b) At the highest point, v = 0. So K.E. = 0

The lost kinetic energy is transformed in potential energy.

Therefore, potential energy at the highest point = 250 J

The maximum Height attained by the body,

$$h = \frac{P.E.}{mg} = \frac{250}{5 \times 10} = 5 \text{ m}$$

Q.21 An object of mass 'm' moving with a velocity of 5 ms^{-1} has kinetic energy 25 J.

(a) Calculate the kinetic energy when its velocity is doubled?

(b) Calculate the kinetic energy when its velocity is increased three times?

Sol. **(a)** Given,

Kinetic energy, K.E. = 25 J

Velocity with which the object is moving = 5 ms^{-1}

Mass of the object, m =

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

$$= \frac{2 \times 25}{5^2} = 2kg$$

Therefore, m = 2kg

Initial kinetic energy, K.E. = 25

Kinetic energy when its velocity is doubled

When velocity is 5, the K.E. was 25

So, if velocity is doubled , 5 is multiplied by 2 = 10

Therefore, the kinetic energy will be

$$K.E. = \frac{1}{2}(2)(10)^2 = 100 J$$

(b) **Kinetic energy when its velocity is increased three times**

So, if velocity is tripled. 5 is multiplied by 3 = 15

Therefore, the kinetic energy will be

$$K.E. = \frac{1}{2}(2)(15)^2 = 225 J$$

Q.22 What would be the power of a pump which could lift 100 kg of water in 10 s to a water tank at a height of about 20 m. (Given: acceleration due to gravity, g = 10 ms^{-2})

Sol. $\text{Power} = \frac{\text{Work done}}{\text{Time}}$

Work done in lifting water to a height is stored in the form of Potential energy.

Therefore, $\text{Power} = \frac{mgh}{t}$ (since, W = mgh, where, m = mass of the water raised, g = acceleration due to gravity, h = height to which water is lifted)

$\text{Power} = \frac{100 \times 10 \times 20}{10}$ = 2000 watt or 2 kW

The power needed to raise 100 kg of water to 20 m high water tank = 2 kW

Q.23 From a tower 10 m height a ball is dropped. After striking the ground 40% of energy of the moving ball was lost. How much high can the ball bounce back with the left energy? ($g = 10\ ms^{-2}$).

Sol. The energy after ball stroked the ground is decreased by 40% from the initial. The amount of energy left will be 60 % with the ball. So, the ball will bounce back to 1/6 of the initial height. Therefore, it will bounce back to 6m of height.

Q.24 (a) Calculate the potential energy of a block of mass 40 kg when it is raised to a height of 5 m above the ground.

(b) If the same object is allowed to fall, what will be its kinetic energy when it is half-way down?

Sol. (a) Given,

Mass of the object, m = 40 kg

Height above the ground, h = 5m

Therefore, P.E. = mgh = $40 \times 10 \times 5$ = 2000 J

The potential energy of the block = 2000 J

(b) Now if the object is allowed to fall half - way down, the Kinetic energy will be:

P.E. possessed by the body will transform into Kinetic energy i.e.

$\text{K.E.} = \frac{\text{P.E.}}{2} = \frac{2000}{2} = 1000\text{ J.}$

The Kinetic energy of the block = 2000 J

This concludes that when the height is halved the potential energy is also halved. (P.E. α h)

Q.25 Calculate the height of an object of mass 12 kg placed at certain height above the ground. The potential energy of the object is 480 J.

Sol. Given, $g = 10\ ms^{-2}$.

Given,

Mass of the object, m= 12 kg,

Potential energy, P.E. = 480 J,

Acceleration due to gravity, $g = 10\ m/s^2$

Since, P.E. = mgh

Therefore, $h = \frac{\text{P.E.}}{mg}$

$$=\frac{480}{12\times10}=4m$$

The height of an object would be 4 m.

Q.26 A body of mass 2 kg is thrown up at a velocity of 10 m/s. Calculate
(a) The kinetic energy of the body at the time of throw.
(b) The potential energy of the body at the highest point.
(Given: acceleration due to gravity, g = 10 m/s^2)

Sol. (a) Given,
Mass of the body, m =2kg
Velocity of the body, v = 10 m/s
At the time of throw:

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

$$=\frac{1}{2}(2)(10)^2=100J$$

Potential energy, P.E. = 0
Here, kinetic energy is 100 J and potential energy is 0.

(b) At the highest point:
The velocity is zero at the highest point, v = 0, therefore. K.E. = 0
This is because the kinetic energy of the body is converted to Potential energy.
So, **at highest point potential energy is 100 J.**

Q.27 What amount of work is to be done in order to stop a moving object? (Take: Mass of the object = m)

Sol. Given,
Mass of an object = m
Initial velocity, u = v
Final velocity, v = 0 (To bring the object to rest)

Work done = Final kinetic energy –Initial kinetic energy

$$W=\frac{1}{2}m0^2-\frac{1}{2}mv^2$$

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

Q.28 The ratio of masses and speed of two objects is 1: 8 and4: 5 respectively, find the ratio of their KE.

Sol. Given,
Masses of two bodies, m_1 and m_2
Ratio, m_1 / m_2= 1:8
Speeds of the two bodies, v_1 and v_2
Ratio, v_1 / v_2 = 4:5
The ratio of their kinetic energy is

$$=\frac{K.E._1}{K.E._2}=\frac{m_1v_1^2}{m_2v_2^2}$$

$= \frac{1}{8} \times \left(\frac{4}{5}\right)^2 = \frac{2}{25}$

Therefore, the ratio the kinetic energy of the two masses is **2: 25**.

Q.29 A machine utilizes 1000 J of energy every second; it will consume 1 kWh of energy if it is used continuously for one hour. What will be the energy consumed in 10 hours by a device of 500 W of power?

Sol. Energy consumed = $\text{Power} \times \text{time}$

Given,

Power = 500 W = 500/1000 kW

Time = 10 h

Therefore, Energy consumed = $\frac{500}{1000} \times 10 = 5 \text{ kWh}$

Q.30 Ram and Shyam are working in an industry. Work done by Ram is 200J in 10s and that done by Shyam is 100J in 14s.

(a) Who is delivering more power, Ram or Shyam?

(b) Find the ratio of the power delivered by the two.

Sol. (a) Power delivered by Ram, $P_1 = \frac{200\text{J}}{10\text{s}} = 20\text{W}$

Power delivered by Shyam, $P_2 = \frac{100\text{J}}{4\text{s}} = 25\text{W}$

Therefore, Shyam delivers more power.

(b) $\frac{P_1}{P_2} = \frac{20}{25} = 4/5$

The ratio between the two is 4:5.

Q.31 (a) State the relation between Power delivered by a body and speed by which it moves.

(b) Calculate the weight in kg which a man working at power 100W can lift vertically with a constant speed of 1 m/s. [acceleration due to gravity, g = 10 ms^{-2}]

Sol. (a) The relation between the Power (P) and Speed (v) is given by:

Power, $P = \frac{W}{t}$

$P = \frac{Fs}{t} (\because W = Fs)$

$P = Fv \left(\because v = \frac{s}{t}\right)$

<u>(b)</u> Power, P = F. v

P= mg. v (since, F=mg)

Where,

Power, P = 100W

Speed, v= 1 m/s
Mass, m =?

Acceleration due to gravity, g = 10 m/s^2
100 = mg. v
100 = m × 10 × 1
m = 10 Kg.
Therefore, man working at the power of 100 W can lift 10 kg of weight.

Q.32 Underneath is the list of appliances used in a house in one day; find out the amount of electricity bill for a month of 30 days if the cost of one unit is Rs. 3.
(a) A TV of 100 W for 8 h
(b) A refrigerator of 300 W for 24 h
(c) 3 bulbs of 50 W for 4 h
(d) 2 tube lights of 40 W for 8 h

Sol. Energy consumed = Power × time
(a) Energy consumed by a TV for 8 h (1 kW = 1000 W)
$=100\times8=800$ W = 0.8 kW or Units.

(b) Energy consumed by a refrigerator in one day
$300\times24=7200$ W = 7.2k W or Units
(c) Energy consumed by 3 bulbs for 4 h
$3\times50\times4=600$ W = 0.6 kW or Units.
(d) Energy consumed by 2 tube lights for 8 h
$=2\times40\times8=640$ W = 0.64 kW or Units.

Total number of units consumed in a month by all appliances
= 30 × (0.8+7.2 + 0.6 + 0.64)
= 30 × 9.24
= 277.2 units.
Since, Cost of one unit = Rs. 3
Therefore, cost of 277.2 units = 3 × 277.2 = Rs. 831.6.

Q.33 Two sky sailors, A and B each of weight 400 N climbed up a rope at a height of 8 m. A takes 20 s and B takes 50 s to accomplish this task. Calculate the power expended by each girl.

Sol. Given,
Weight of girls (each), m = 400 N
Time taken by A to accomplish the task, t_1 = 20 s
Time taken by B to accomplish the task, t_2 = 50 s
Work done by A and B, W = P.E. due to the height = mgh = 400 × 8 = 3200 (Weight = mg)

As, Power = $\frac{\text{Work done}}{\text{Time}}$

Power expended by girl, A = $\frac{W}{t_1}$

$= \frac{3200}{20} = 160\text{ Watt}$

Power expended by girl, B = $\frac{W}{t_1}$

$= \frac{3200}{50} = 64$ Watt

Therefore, power expended by A and B, respectively is 160 W and 64 W.

Q.34 Which of the two exert more power in moving against the gravity?(Given, acceleration due to gravity, $g = 10\ ms^{-2}$)

(a) A butterfly of mass 1.0 g that flies upward at a rate of 0.5 ms^{-1}.

(b) A squirrel of mass 250 g climbs up on a tree at a rate of 0.5 ms^{-1}.

Sol. (a) Power = F $\times$v = mg$\times$ v

Power of butterfly = mg$\times$ v

Where, Force, F = mass, m$\times$ acceleration due to gravity,

g = 10^{-3}kg $\times$10 m/s^2= 10^{-2}

Speed, v = 0.5 ms^{-1}

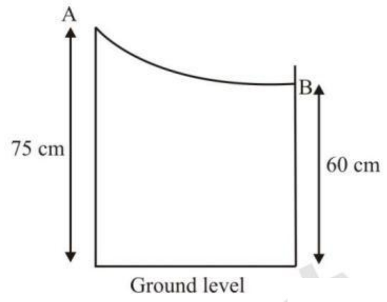
Power = 10^{-2} $\times$ 0.5 ms^{-1} = 0.005 watt.

(b) **Power of squirrel** = 250$\times$ $10^{-3}$$\times$ 10 $\times$ 0.5

= 1.25 watt

Therefore, power of the squirrel is more than that of butterfly.

Q.35 A skier of mass 50 kg jumps from point 'A' to 'B'. Calculate the change in potential energy during the act.



Sol. Given,

Mass of the skier, m = 50kg

Acceleration due to gravity, g = 10m/s^2

At position A, P.E.$_1$ = mgh$_1$ = mg (75)

At position B, P.E.$_2$ = mgh$_2$ = mg (60)

Change in the gravitational potential energy = P.E.$_1$ - P.E.$_2$

= mg (75-60)

= 15 mg

= 15$\times$ 50 $\times$10 = 7500 Joule or 7.5 kJ

Value based questions:

Q.1 In a school, students are asked to save electricity both at school and home. They are told to switch off the lights and fans before leaving the class rooms. Two best friends Vijay and Ajay are in class 10th. Vijay saves electricity by switching the appliances off when not in use while Ajay makes fun of his habits. He always leaves the T.V. and computer ON.
On the basis of above passage, answer the following questions:
(a) Why is it necessary to save energy?
(b) Which type of character is possessed by the friends?

Sol. (a) Energy stored in the fossil fuels (nonrenewable substances) is used to generate electricity or other usable forms of energy. If they are depleted then they cannot be regenerated again. So, it is necessary to save energy.
(b) Vijay uses the resources sensibly and is concerned about the environment. On the other hand, Ajay is not anxious about the over-exploitation of the resources.

Q.2 Due to heavy winds a tree fell down in the middle of the road and the vehicles got stuck in the way. Two residents came forward to place it aside but could not accomplish it as they were too heavy. A passerby helped them with heavy blocks. They cleared the road and the traffic began to flow as usual.
(i) Which value is shown by the passerby and the residents?
(ii) Which energy is stored when the heavy log of the tree is lifted to some height?

Sol. (i) Social valves and helping nature is shown by their act.
(ii) Potential energy is stored to lift the log to a height.

Q.3 Tanya was sitting in her room and preparing for her exams for whole night. By the morning she finished her syllabus, she was drowsy. She then got ready and went to school for her exam.
Answer the following questions, with reference to the above passage.

(a) What work did Tanya do?
(b) From where did Tanya have energy for studying?
(c) What values were possessed by Tanya?

Sol. (a) As Tanya didn't show any displacement she was just sitting in her room.
Therefore work done is
$W = F \times 0 = 0$ (as $s = 0$)

(b) Energy from food is utilized in muscular energ
(c) Tanya is hard working and dedicated towards

Q.4 Mr. Pasha is the head of a middle class family; he is worried about the increasing electricity bill. Every day for eight hours four tubes light of 60 W each, three fans of 60 W each and a geyser of 500 W are being used. He finds the usage of many appliances unnecessary. He asked his family members to use the high energy utilizing appliances only when needed.
With the help of above passage answer the following questions.
(a) Calculate the total units of electricity consumed in a month (30 days).

(b) What are the values possessed by Mr. Pasha?

Sol. (a) As energy = power × time
$= [(60 \times 4 + 60 \times 3 + 500) \times 8] = 7.360$ kWh
$= 7.360 \times 30 = 220.8$ units.
(b) Mr. Pasha shows awareness towards saving energy.

Q.5 Two friends, Abhishek and Avinash playing with a catapult (gulel) decided to pluck mangoes from mango trees in their garden with the help of catapult. They collected many mangoes. Abhishek was directing the catapult on a bird sitting on a tree. But Avinash prevented him from doing so.
(i) Which energy is possessed by the stretched string of the catapult?
(ii) What will happen if the stone is thrown without stretching the string of the catapult?
(iii) Which quality was showed by Avinash in preventing the bird from striking?

Sol. (i) The energy possessed by the stretched string is elastic potential energy due to change in the shape of the substance.
(ii) If this is done then the stone would fall down. This is because the string of catapult possesses energy only when it is stretched, so when a stone is thrown without stretching the string, no energy transformation occurs.
(iii) Because aiming the bird would hurt the bird, it may also die. Avinash's act of saving the bird is nature loving. He cares for animals and birds.

Practice Questions

1 Mark Questions

1. Define SI unit of work.

2. A student is writing a three hours science paper. How much work is done by the student? Give reasons to your answer.

3. List two essential conditions for work to be done.

4. Give one example when work done by a body negative.

5. A 2 m high person is holding a 25 kg trunk on his head and is standing at a roadways bus-terminus. How much work is done by the person?

6. Calculate the work done when a force of 15 N moves a body by 5 m in its direction.

7. Moon is experiencing a gravitational force due to earth and is revolving around the earth in a circular orbit. How much work is done by moon?

8. State law of conservation of energy.

9. Name the term used for the sum of kinetic energy and potential energy of a body.

10. If the heart works 60 joules in one minute, what is its power?

11. Define 1 KWh.

12. Define 1 W of power.

13. Name the type of energy possessed by a raised hammer.

14. In an oscillating pendulum, at what position the potential and kinetic energy are maximum?

15. A coolie is walking on a railway platform with a load of 30 kg on his head. How much work is done by coolie?

16. Identify the kind of energy possessed by a running athlete.

17. At what speed a body of mass 1 kg will have a kinetic energy of 1 J.?

18. If the speed of the body is halved, what is the change in its kinetic energy?

19. A horse of mass 210 kg and a dog of mass 25 kg are running at the same speed. Which of the two possesses more kinetic energy? How?

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

21. What will cause greater change in Kinetic energy of a body. Changing its mass or changing its velocity?

22. What is power? What is its SI unit ?

23. To what height should a body of mass 5 kg be raised so that its potential energy is 490 J? [g = 9.8 m/s^2]

24. On pushing a mighty stone, a child is unable to move it. If work done is zero, where is the energy, he, lost?

25. State the SI unit of

(a) work,
(b) power.

26. Relate watt to joule.

27. What is one unit of electrical energy consumed equal to?

28. Relate one horsepower to the SI unit of power?

29. A ball of mass 5 kg is dropped from a tower d, height 2 m. What is its K.E. half way down?

30. Define one joule.

31. Define one Watt.

32. In what situation(s) is work done equal to zero?

33. When a body falls freely, its potential energy

(A) ....and simultaneously,
(B) its kinetic energy...........

34. A machine of 500 W works for 2 hours. Find the number of units of electricity consumed.

35. How is energy conversion occurring in a Hydel power station?

36. If a force of 50 N moves a body with constant speed of 10 m/s, how much power is spent?

37. State the CGS unit of energy.

38. Relate the CGS unit of energy to its SI unit.

39. Derive a relation between kinetic energy of a body and its momentum.

Solutions

1. SI unit of work is Joule. 1 Joule of work is done when a force of 1 N displaces a body by 1 m.

2. Work done = Force × displacement as displacement is zero. No work is done by the student.

3. (i) Force should be applied on body.

(ii) Body should move in the direction of force.

4. When a body is raised vertical upward, displacement and gravitation force are is in opposite direction. The work done by gravity is negative.

5. Zero. As displacement is zero.

6. Work done = 15 × 5 = 75 J.

7. No work is done by moon as the gravity force and displacement are perpendicular to each other.

8. Law of conservation of energy states that energy can only be converted from one form to another, it can neither be created nor destroyed.

9. Mechanical Energy.

10. Power = $\frac{60J}{60s}$ = 1 W. [1 min = 60 s]

11. 1 KWh is the energy consumed when power of 1000 w is consumed for 1 hour.

12. When one joule of work is done in one second, the power is said to be 1 watt.

13. Potential Energy.

14. At the highest point of the bob, potential energy is maximum, while at the lowest point kinetic energy is maximum.

15. Since force due to load is downward, and the coolie is moving in horizontal direction, no work is done by coolie.

16. Kinetic energy.

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

$$V = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2\times1}{1}} = \sqrt{2}\, m/s$$

18. Since $K.E\, \alpha v^2$

If v is halved; KE = 1/4 of the original.

19. $K.E\, \alpha\, Mass.$

Since mass of horse is greater than that of dog, the horse will posses greater kinetic energy.

20. A freely falling body loses potential energy , but it gains equal amount of kinetic energy such that the sum total of energy remains constant. Hence , this does not violate the law of conservation of energy.

---

21. Changing velocity of a body will cause greater change in the kinetic energy of the body.

---

22. Power is the rate of doing work. Its unit is watt.

1 Watt = 1 Joule/s.

---

23. P.E = mg.h

$h=\frac{P.E}{mg}=\frac{490}{5\times9.8}=10\,m.$

---

24. The energy is lost in the form of heat energy.

---

25. (a) SI unit of work is Joule.

(b) SI unit of power is Watt

---

26. 1 watt = 1 Joule / 1 sec

---

27. 1 unit of electrical energy = 3.6×10^6 Joule

---

28. 1 horse power = 746 Watts

---

29. A ball is dropped from 2 m. The halfway point is when it has moved through 1m.

By III equation of motion
$v^2-\mu^2=2gh$
$v^2=2\times10\times1$
K.E = $\frac{1}{2}mv^2=\frac{1}{2}\times2\times10\times1=1J.$

---

30. 1 Joule of work is said to be done when a body is displaced by 1m due to a force of 1N

---

31. 1 watt is the power of an object which does work at the rate of 1 Joule per second

---

32. Work is equal to zero when-

(i) Force is zero
(ii) Displacement is zero
(iii) Displacement is perpendicular to the direction of force.

33. (A) decreases, (B) increases

34. Work done 500 × 2 = 1000 Wh

= 1 KWh.
unit of electricity consumed = 1.

35. Potential Energy of water in dam $\rightarrow$ Kinetic energy of water passing through gates $\rightarrow$ Kinetic energy of turbines $\rightarrow$ Electrical Energy.

36. Power = $\frac{Work done}{Time} = \frac{F \times d}{t}$ = F × V.

= 50 × 10 = 500 W

37. CGS unit of energy is ergs

38. 1 Joule = 10^7 ergs

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

= $\frac{1}{2}\frac{m^2v^2}{m} = \frac{p^2}{2m}$, where p is the momentum.

2 Marks Questions

1. List two conditions which need to be satisfied for the work to be done on an object?

2. Define energy and define its SI unit.

3. An archer stretches a bow to release an arrow to hit the target at a distance of 10 m. Explain who does the work,in which form is the energy possessed the bow and the arrow.

4. Write the form of energy possessed by the body in the following situations:

(a) a coconut falling from tree.
(b) an object raised to a certain height
(c) blowing wind
(d) A child driving a bicycle on road

5. Given below are a few situations, study them and state in which of the given cases work is said to be done. Give reason for your answer.

(a) A person pushing hard a huge rock but the rock does not move.
(b) A bullock pulling a cart up to 1 km on road.
(c) A girl pulling a trolley for about 2 m distance.
(d) A person standing with a heavy bag on his head.

6. A porter lifts a luggage of 15 kg from the ground and puts it on his head 1.5 m above the ground. Calculate the work done by him on the luggage.

7. A ball of mass 2 kg is dropped from a height. What is the work done by its weight in two seconds after the ball is dropped?

8. A bag of wheat weighs 60 kg. Find the height to which it is lifted so that its potential energy is 3000 J. (g = 10 ms^{-2})

9. A body of mass 2 kg is thrown up with a speed of 25 m/s. Find its maximum potential energy.

10. (a) Define 1 Watt.

(b) An electric bulb of 60W (sixty watt) is used for 6 (six) hours per day. Calculate the units of energy consumed in one day by the bulb.

---

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

---

12. A man of mass 60 kg runs up a flight of 30 steps in 40 s. If each step is 20 cm high, calculate his power.

---

13. (a) What is meant by potential energy of a body?

(b) A body of mass 'm' is raised to a vertical height. 'h' through two different paths A and B. What will be the potential energy of the body in the two cases? Give reason for your answer.

---

14. What is the amount of work done in the following cases? Justify your answer by giving the appropriate reason.

(a)By an electron revolving in a circular orbit of radius around a nucleus.
(b)By the force of gravity, when a stone of mass 'm' is dropped from the top of a multi- stored building of height 'h'.

---

15. An electric bulb of 100 W works for 4 hours a day. Calculate the units of energy consumed in 15 days.

---

16. 16 bulbs of 40 W are used for 6 hours a day along with one 100 W bulb for 2 hours. Calculate the `units' of energy consumed in one day by all bulbs.

---

17. (a) Define kinetic energy.

(b) Write an expression for kinetic energy of an object and also give its SI unit.

---

18. Find the power of human heart, which beats 72 times per minutes, if it does 1.5 J of work every beat.

---

19. The momentum of a body is increased four times. What is its final kinetic energy?

---

20. A ball of mass 0.5 kg is thrown up with a velocity of 15 m/s. Find its potential energy at the highest point. [Take g = 10 m/s^2]

---

21. State energy conversion occurring in

(a) pendulum (b) bulb.

---

22. A bulb/machine becomes hot after working for some time. Why?

23. A boy of mass 80 kg is running at 10 m/s. Find the work done by him.

24. Give one example of

(a) positive work
(b) zero work done.

25. A man rotates the wheel of an amusement slide in a fair. How much work is done by him if he rotates the wheel 40 times in 1 minute?

26. How is energy conserved in a simple pendulum?

27. What is the power of a pump if it pulls 200 kg water from a 20 m deep well in 30 s?[g = 10 m/s^2]

28. Define (a) kinetic energy (b) potential energy.

29. Derive an expression for kinetic energy of a body of mass m, moving with velocity v.

30. Sun is the ultimate source of energy. How does it provide energy of flowing water?

31. If energy of universe is constant, why are we facing energy crisis?

32. State the commercial unit of energy and its relation with joule.

33. In what form is energy possessed by:

(a) Water stored in a dam
(b) A stretched bow
(c) A raised bat
(d) A running horse?

34. Derive an expression for potential energy of a body.

35. Fill in the blanks:

(a) 1 MW = ? W
(b) 1 J = ? KJ

Solutions

1. (i) Force should be applied on body.

(ii) Body should move in the direction of force.

---

2. Energy is the capacity to do work. The unit of energy of an object is joule. 1 Joule = 1N × 1m

---

3. The archer does the work in pulling the bow string taut. The muscular energy of archer arm a$\rightarrow$ potential energy of taut string $\rightarrow$ kinetic energy of arrow.

---

4. (a) Kinetic energy + potential energy (when at a height)

(b) Potential energy.

(c) Kinetic energy.

(d) Kinetic energy.

---

5. (a) No work is done as there is no displacement.

(b) Work done as there is displacement.

(c) Work done as there is displacement when force is applied.

(d) No work done as displacement is zero.

---

6. Work done = Force × displacement

= mg × h

= 15 × 10 × 1.5

= 225 J.

---

7. Work done = increase in K.E

Now, v = u + at

= 0 + 10 × 2 = 20 m/s.

$$K.E = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times (20)^2 = 400J.$$

---

8. P.E = mgh.

$h = \frac{P.E}{mg} = \frac{3000}{60 \times 10} = 5m.$

---

9. Max. P.E = Max. K.E

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

$= \frac{1}{2} \times 2 \times (25)^2 = 625J.$

---

10. (a) When one joule of work is done in one second, the power is said to be 1 watt.

(b) Energy consumed = power × time

= 60 W × 6 h.

= 360 Wh =0.36 KWh = 0.36 Units.

---

11. Work done $= \frac{1}{2}mv^2$.

$= \frac{1}{2} \times 1500 \times (60 \times \frac{5}{18})^2$

$= 20.83 \times 10^4 J.$

(should be equal and opposite to the K.E)

---

12. Total height reached by man = 30 × $\frac{20}{100}m$ = 6 m

Power = work done/time = mgh/time = $\frac{1500 \times 10 \times 6}{40} = 90W$

---

13. (a) Potential energy is defined as the energy possessed by a body due to its position or configuration.

(b) The potential energy in both the cases will be mgh. This is so as the P.E depends on the vertical height, not the path aken.

---

14. (a) No work is done as the electrostatic force is perpendicular to the displacement.

(b) Work done = mgh (Force × displacement)

---

15. Energy consumed = Power × Time

= 100 × 4 × 15

= 6000 Wh

= 6 KWh = 6 units

---

16. Total energy consumed

= Energy consumed by (16 bulbs of 40w + 1 bulb of 100w)

= (16 × 40 × 6) + 100 × 2

= 4040 Wh

= 4.040 KWh = 4.04 units

---

17. The energy possessed by an object due to its motion is the kinetic energy of an object.

K.E = $\frac{1}{2}mv^2$ where m is mass and v is velocity of object.

---

18. Power of human heart

= Work done in each beat × no. of beats in 1 s.

= $1.5 \times \frac{72}{60} = 1.8W.$

---

19. K.E = $\frac{p^2}{2m}$. If momentum is increased 4 times , K.E will become

$\frac{(4P)^2}{2m} = 16\frac{P^2}{2m}$ i.e 16 times.

---

20. u = 15 m/s : v=0, g= 10 m/s^2

$\Rightarrow v^2 - u^2 = 2gh$

$\Rightarrow gh = \frac{1}{2}(v^2 - u^2) = \frac{1}{2}u^2$

P.E = mgh =$\frac{1}{2}mu^2 = \frac{1}{2} \times 0.5 \times 15 \times 15 = 56.25J$

---

21. (a) K.E → P.E → K.E → P.E

(b) Electrical energy → Heat energy → Light.

---

22. A bulb/machine gets hot after sometime as some of its energy is converted into heat energy. In bulb this is due to the resistance of wires, in machine this is due to friction between body parts.

23. Work done = Force × displacement

= mg × distance moved in 1 s.

= 80 × 10 × 10

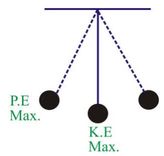
= 8000J in 1 sec.

24. (a) When an object falls under gravitational attraction, positive work is done by gravity.

(b) If an object does not move when force is applied, zero work is done.

25. Since the net displacement of wheel is zero, no work is done by the man.

26.



In a simple pendulum, work is done when the bob is raised. This is its P.E .When the bob is released, it moves down, its P.E decreases, but K.E increases. At the lowest point K.E is maximum, P.E is zero. The bob rises to the other side. K.E decreases P.E increases. The total energy remains constant or we can say its energy is conserved.

27. Power of pump = $\frac{Workdone}{Time} = \frac{mgh}{Time}$

= $\frac{200 \times 10 \times 20}{30}$

= 1333.3 W.

28. (a) The energy possessed by an object due to its motion is the kinetic energy of an object.

(b) Potential energy is defined as the energy possessed by a body due to its position or configuration.

29. Work done = F × d.

= m × a × d -------(1)

By Newton's III equation of motion.

$v^2 - u^2$ = 2ad , where d is the displacement

Therefore, $ad = \frac{v^2 - u^2}{2}$ -------------(2).

Substituting (2) in (1), we have

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

If the initial velocity is zero, then work done = $\frac{1}{2}mv^2$

This is the K.E of the body.

---

30. A part of sun's energy is in the form of heat energy. Due to the heat energy, water evaporates from seas and oceans and fall as rain fall in the mountains, This water comes down the plains and create flowing rivers. Thus sun's energy is converted into kinetic energy of the flowing water.

---

31. We are facing energy crisis because the energy consumed is from fossil fuels.The reserve of fossil fuel is limited and will get exhausted in some years.

---

32. Commercial unit of energy is KWh .

1 KWh = $3.6 \times 10^6 J.$

---

33. (a) Potential Energy.

(b) Potential Energy.

(c) Potential Energy.

(d) Kinetic Energy.

---

34. Potential energy is the energy stored in a body when work is done on it.

Work done = Force × displacement

= mg × h (distance moved)

= mgh

---

35. (a) 1 Mw = $10^6 W.$

(b) 1 J = $10^{-3} KJ.$

3 Marks Questions

1. Water is falling on the blades of a turbine at the rate of 800 kg per minute, height of fall is 50 m. Calculate the power given to turbine.(g = 10 m/ s^2)

2. A force of 10 N acts on a body of 2 kg for 3 seconds. Find the kinetic energy acquired by the body in 3 seconds.

3. State Law of conservation of energy and express it in the form of an equation for a body of mass m falling from a point A at height h', above the ground at
(a) A
(b) C at a height h from ground
(c) B.

4. Mention the commercial unit of energy. Express it in terms of joules. Calculate the energy in joule consumed by a device of 60 W in 1 hour."

5. (a) When is the work done by a body said to be negative?

(b) An object of mass 5 kg is dropped from a height of 10 M. Find its kinetic energy, when it is half way down.

6. A body of mass 5 kg is thrown vertically upwards with a speed of 10 m/s. What is its kinetic energy when it is thrown? Find its potential energy when it reaches at the highest point.Also find the maximum height attained by the body.(g = 10 m/ s^2).

7. Calculate the electricity bill amount for a month of April, if 4 bulbs of 40 W for 5 hrs, 4 tube lights of 60 W for 5 hrs, a T.V of 100 W for 6 hrs, a washing machine of 400 W for 3 hrs are used per day. The cost per unit is Rs. 1.80.

8. A force applied on a body of mass 4 kg for 5 seconds changes its velocity from 10 m/s to 20 m/s. Find the power required.

9. A car weighing 1200 kg is uniformly accelerated from rest and covers a distance of 40 m in 5 seconds. Calculate the work done by the engine of car during this time. What is the final kinetic energy

of car?

10. (a) An object of mass 'm' is moving with a constant velocity V. How much work should be done on the object to bring it to rest?

(b) Earth is revolving round the sun. What is the work done by the gravitational force exerted by the sun on earth? Justify your answer.

11. (a) Give one situation where force is applied but no work is done. Explain why.

(b) A pump is used to raise water to a height of 20 m. It transfers 2000 kg of water in 15 minutes. Calculate power of the pump. [g = 10 m
s^2]

12. (a) The potential energy of a freely falling object decreases progressively.

(i) What happens to its kinetic energy.

(ii) Total mechanical energy? State the law on which your answer is based.

(b) A household consumes 1 kWh of energy per day. How much energy is this in joules?

13. (a) State and define SI unit of power.

(b) A person carrying 10 bricks each of mass 2.5 kg on his head moves to a height 20 m in 50 s. Calculate power spent in carrying bricks by the person.
(g = 10 m/
s^2)

14. Give an example in each case where work done by a force is :
(a) zero
(b) positive
(c) negative

15. A student lifts an object in the upward direction. In doing so, he applies the force on the object in the upward direction and displaces it in that direction:
(However, the force of gravity is also acting on the object.)
(a) State the direction in which force of gravity is acting on it.
(b) Which one of these forces is doing positive work? Give reason.
(c) Which one of these forces is doing negative work? Give reason.

16. Define kinetic energy.
A stone of mass 2 kg is falling from rest from the top of a steep hill. What will be its kinetic energy after 5 s? (g = 10 m
s^{-2})

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

18. Two women Shanti and Kamla each of mass 50 kg and 60 kg respectively climb up through a height of 10 m. Shanti takes 20 s while Kamla takes 40 s to reach.Calculate the difference in the power expended by Shanti and Kamla.(Assuming g = 10 m
s^{-2})

19. (a) Define Potential energy.

(b) Give an example where potential energy is acquired by a body due to change in its shape.

(c) A skier of mass 50 kg stands at 'A' at the top of a ski jump. He takes off at 'A' for his jump to 'B'.

Calculate the change in his gravitational potential energy between 'A' and 'B'. Where height of A is 75 m and height of B is 60 m.

20. Two bulbs of 40W each are lighted for eight hours daily. Find the cost of electrical energy consumed by them in one week at Rs. 3 per unit.

21. Find the change in momentum of a body when its kinetic energy becomes four times the original value.

Solutions

1. Power = Work done/time

=
$\frac{mgh}{t} = \frac{800 \times 10 \times 50}{60} = 6670W.$

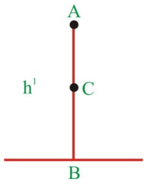
2. Velocity acquired v = u + at

=
$0[\mkern?]1mu+[\mkern?]1mu\frac{10}{2}\times 3$ as a
$a = \frac{F}{m} = \frac{10}{2}$

= 15 m/s.

K.E =
$\frac{1}{2}mv^2 = \frac{1}{2}\times 2\times (15)^2 = 225J.$

3. Law of conservation of energy states that energy can only be converted from one form to another, it can neither be created nor destroyed.



(a) T.E at A = mgh' (P.E = mgh' , K.E = 0).

(b) Velocity at C is found by

$v^2 - u^2 = 2g(h' - h)$

$v^2 = 2g(h' - h)$

$K.E = \frac{1}{2}mv^2 = mg(h' - h)$

at C, P.E = mgh'

T.E at C = P.E + K.E = mg(h – h') + mgh' = mgh

(c) At B; P.E = 0.

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

Total energy is the same at all points.

---

4. Commercial unit of energy = KWh

1kWh =
$3.6 \times 10^6 J$

Energy consumed = 60 Wh, time = 1 hr = 60 × 60 s.

= 60 × 60 × 60 J

=
$1.08 \times 10^5 J$

---

5. (a) Work done is said to be negative if force and displacement are in opposite directions.

(b) When body falls 5m, its velocity v can be found by

$v^2 - u^2 = 2gh$

$v^2 = 2 \times 10 \times 5$

K.E =
$\frac{1}{2}mv^2 = \frac{1}{2} \times 5 \times 2 \times 10 \times 5$ = 250 J.

6. K.E= $\frac{1}{2}mv^2 = \frac{1}{2} \times 5 \times 2 \times (10)^2 = 250J$ (m = 5 kg)

At the highest point P.E = 250 J. (as it is equal to K.E maximum)mgh = 250

$h = \frac{250}{5 \times 10}$ = 5 M.

7. In one day energy consumed by

(i) 4 balls = 4 × 40 × 5 = 800 Wh.

(ii) 4 tube light = 4 × 60 × 5 = 1200 Wh.

(iii) T.V = 100 × 6 = 600 Wh.

(iv) washing machine = 400 × 3 = 1200 Wh.

Total energy consumed in 1 day = 3800 Wh.

Total energy consumed in 30 days = 114000 Wh.

= 114000 KWh/1000 = 114 units.

Total cost = 114 × 1.80 = Rs. 205.20.

8. Power = Change in $\frac{K.E}{Time}$

= $\frac{1}{2} \times \frac{4 \times (20^2 - 10^2)}{5}$

= 120 W.

9. Distance covered S = $ut + \frac{1}{2}at^2$

40 = $\frac{1}{2} \times a \times 5^2$

a = $\frac{40 \times 2}{25}$

= $\frac{16}{5} m/s^2$

Work done = F × d

= m × a× d

= 1200 × 16/5 × 40 = 153600 J.

---

10. (a) Work done should be equal to the energy possessed by the body that is $\frac{1}{2}mv^2$.

(b) Zero work is done as net displacement in the direction of force is zero.

---

11. (a) You push a heavy box , but it does not move. Then work done is zero as d = 0.

(b) Power of pump = Work done / time = mgh / t.

= $\frac{2000\times10\times20}{15\times60}$

= 444.4 Watts.

---

12. (a) (i) K.E increases.

(ii) Total mechanical energy remains constant. Law of conservation of energy.

(b) 1 kWh = $3.6\times10^6 J.$

---

13. (a) 1 Watt is the power of an object which does work at the rate of 1 Joule per second.

(b) Power = $\frac{mgh}{t}=\frac{10\times2.5\times10\times20}{50}$ = 100 W.

---

14. (a) Since W = F × d , W is zero , if d= 0 i.e if a body does not move when force is applied.

(b) Work is positive if F and d are in the same direction e.g. a ball falls, work done by gravity is positive.

(c) If a body is raised , work done by gravity is negative.

---

15. (a) Downwards

(b) The student is doing positive work as the displacement is in the direction of force applied by him.

(c) Gravitational force does negative work as the displacement is upward and gravity is downwards.

---

16. (a) The energy possessed by an object due to its motion is the kinetic energy of an object.

(b) v = u + at

= 0 + 10 × 5

= 50 m/s.

K.E = $\frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times 50 \times 50.$

= 2500 J.

---

17. A freely falling body loses potential energy , but it gains equal amount of kinetic energy such that the sum total of energy remains constant. Hence , this does not violate the law of conservation of energy.

---

18. Power expended by Shanti = $\frac{mgh}{t} = \frac{50 \times 60 \times 10}{20}$. = 250 w.

Power expended by Kamla = $\frac{60 \times 10 \times 10}{40}$ = 150 W.

Difference in power expended = 100 W.

---

19. (a) Potential energy is defined as the energy possessed by a body due to its position or configuration.

(b) If a spring is compressed , it acquires potential energy.

(c) Change in gravitational potential energy.

= P.E at A - P.E at B

= $mgh_2 - mgh_1 = mg(h_2 - h_1)$

= 50 × 10 × (75-60) = 7500 J.

---

20. Energy consumed = 2 × (40 × 8) × 7

= 4480 Wh = 4.48 KWh = 448 Units

Cost = 4.48 × 3 = Rs. 13.44.

---

21. Momentum P = $\sqrt{2mK.E}$ (as K.E = $\frac{p^2}{2m}$)

If

$P_1 =$

$\sqrt{2mK.E}$

then

$P_2 =$

$\sqrt{2m.4KE} = 2\sqrt{2mK.E} = 2P_1$

Change in momentum

$P_2 - P_1 = 2P_1 - P_1 = P_1$

5 marks Questions

1. (a) Justify that "a body at a greater height has larger energy".

(b) A body of mass 2 kg is thrown up at a velocity of 10 m/s. Find the kinetic energy of the body at the time of throw. Also, find the potential energy of the body at the highest point.

The value of g = 10m/ s^2.

---

2. (a) State the principle of conservation of energy. What are the various energy transformations that occur when you are riding a bicycle?

(b) A body of mass 25 g has a momentum of 0.40 kg m/s. Find its kinetic energy.

---

3. (a) Two bodies of equal masses move with uniform velocities v and 3v respectively. Find the ratio of their kinetic energies.

(b) Define Power. An electric heater is rated 1500 W. How much energy does it use in 10 h? Express your answer in (i) kWh (ii) joules

---

4. What do you mean by work? Give an example of negative work done. What is the work to be done to increase the velocity of a car from 18 km/h to 90 km/h if the mass of the car is 2000 kg?

---

5. (a) Define kinetic energy of an object. Can kinetic energy of an object be negative? Give reason.

(b) A car weighing 1200 kg is uniformly accelerated from rest and covers a distance of 40 m in 5 seconds. Calculate the work, the car engine had to do during this time.

---

6. (a) A ball thrown vertically upwards returns to the thrower. How do the kinetic and potential energies of the ball change?

(b) Calculate the power of a pump which lifts 100 kg of water to a water tank placed at a height of 20 m in 10 s.(Given = 10 m s^{-2})

---

7. **(a)** A battery lights a bulb. Describe the energy changes involved in the process.

(b) Calculate the amount of work needed to stop a car of 500 kg, moving at a speed of 36 Km/h.

---

8. **(a)** Give reason for the following:

(i) The kinetic energy of a freely falling object increases, yet it holds law of conservation of energy.

(ii) A girl fills up 10 pages of a notebook in order to practice sums, yet she has not done 'work' in terms of Science/Scientific concept.

(iii) Work done by gravitational force on an object moved along a horizontal path, is zero.

(b) Find the energy in kWh consumed in 24 hours by two electric devices, one of 100 W and other of 500 W.

---

9. What is meant by energy? How is energy related to work done? A person pushes a wall and fails to move it. What is the work done? Why does he get tired?

Solutions

1. (a) Consider two bodies A and B having same mass m places that
$h_A > h_B.$

Then P.E at A =
mgh_A

P.E at B =
$mgh_B.$

Hence P.E at A > P.E at B.

(b) K.E =
$\frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times (10)^2 = 100J.$

Since initial velocity = 10, as
$v^2 - u^2 = 2gh.$

h =
$\frac{-10^2}{-2 \times 10} = 5m.$

P.E = mgh = 2 × 10 × 5 =100 J.

---

2. **(a)** Law of conservation of energy states that energy can only be converted from one form to another, it can neither be created nor destroyed.

Muscular energy

→ Kinetic energy
→ Heat energy.

(b) K.E =
$\frac{p^2}{2m} = \frac{(0.40)^2}{2 \times \frac{25}{1000}} = 3.2J$

---

3. **(a)** K.E
$\propto v^2$

$\frac{K.E(1)}{K.E(2)} = \frac{v^2}{(3v)^2} = \frac{1}{9}$

(b) Power is rate of doing work.

Energy = P × t = 1500 × 10 = 15 kwh.

=
$15 \times 3.6 \times 10^6 J = 5.4 \times 10^7 J.$

---

4. When a body is displaced in the direction of force applied, work is said to be done.

Friction always opposes motion. So work done by friction is negative.

Work done = Increase in K.E

=
$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

=
$\frac{1}{2} \times 2000 \times [(90 \times \frac{5}{18})^2 - (18 \times \frac{5}{18})^2]$

=
$6 \times 10^5 J.$

---

5. **(a)** The energy possessed by an object due to its motion is the kinetic energy of an object.

K.E can never be negative

K.E =
$\frac{1}{2}mv^2$. All the terms are positive. further , K.E is a scalar quantity.

(b) S =
$ut + \frac{1}{2}at^2$

40 = 0 + 1/2 × a × 25.

a =
$\frac{80}{25} m/s^2$

25

Work done = m × a × s

= 1200 × 80/25 × 40 = 1536000 J

= 153.600 kJ

---

6 . **(a)** When a ball is thrown up , it has K.E. As it moves up, its K.E. decreases and P.E energy increases. At the highest point its P.E is maximum , K.E is zero .As the ball moves down P.E decreases and K.E increases.

(b) Power =
$\frac{Workdone}{Time} = \frac{mgh}{t} = \frac{100 \times 10 \times 20}{10} = 2000W.$

---

7. **(a)** Chemical Energy
→ Electrical Energy
→ Heat Energy
→ Light Energy.

(b) Velocity of car = 36 km/h.=
$36 \times \frac{5}{18} m/s = 10 m/s$ .The work done to stop the car should be qual to the K.E possessed by the car.

$\frac{1}{2}mv^2 = \frac{1}{2} \times 500 \times (10)^2 = 25000J.$

---

8. **(a)** (i) The K.E of a freely falling body increases, but its P.E. decreases such that its total energy remains constant. Hence, law of conservation of energy holds.

(ii) In terms of Science, work is done if a force is applied and causes displacement. In this work, since displacement is zero, So work done is zero.

(iii) Since gravitational force is downward, and displacement is horizontal, there is no displacement in the direction of force. So work done is zero.

(b) Energy consumed = P × t

= (100 + 500) 24 = 600 × 24 Wh

= 14400 Wh = 14.4 KWh.

---

9. Energy is the capacity to do work.

Work can only be done, if a body has energy. e.g. if a body has K.E, it can move another body or if a body has P.E., it can move from one place to another.

Work done by person is zero as there is no displacement.

He gets tired as his energy is spent is muscular contraction which gets transformed to heat energy.

Previous Year's Questions

1 Mark Questions

Q.1 Name two devices which convert electrical energy into sound.

[CBSE, 2012]

Loudspeaker and microphone.

Q.2 Identify the kind of energy possessed by a running athlete.

[CBSE (CCE), 2011]

Kinetic energy.

Q.3 The potential energy of a free falling object decreases progressively. Does this violate the law of conservation of energy? Why?

[CBSE (CCE), 2011]

Decrease in P.E. = Increase in K.E. so there is no loss in the energy by the object. There is only the transformation of the energy.

Q.4 When a ball is thrown vertically upwards, its velocity goes on decreasing. What happens to its potential energy as its velocity becomes zero?

[Board, 2011]

According to the law of conservation, energy can neither be created nor be destroyed but can transform from one form to another.

Therefore, **K.E. Lost by the ball = P.E. gained by the ball**

So, as velocity of ball becomes zero then K.E. would be zero and the P.E. would be maximum.

Q.5 If the heart works 60 joules in one minute, what is its power ?

[CBSE, 2011]

$$Power = \frac{Workdone}{Time} = \frac{60J}{60s} = 1W.$$

(1 Watt, W = J/s)

Q.6 A coolie is walking on a railway platform with a load of 30 kg on his head. How much work is done by coolie?

[CBSE, 2011]

Coolie is carrying a load on his head so force exerted by it under gravity and displacement of the load makes 90^o angle.

W = F cos 90^o × s

W= 0 (cos 90^o = 0)

Therefore, Work done by the coolie is zero.

Q.7 A horse of mass 210 kg and a dog of mass 25 kg are running at the same speed. Which of the two possesses more kinetic energy? How?

[CBSE (CCE), 2011]

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

Kinetic energy is directly proportional to mass. So as mass increases, kinetic energy also increases. Here, mass of horse is greater than that of dog, so kinetic energy of the horse is greater than dog when speed is constant.

Q.8 What will cause greater change in kinetic energy of a body? Changing its mass or changing its velocity.

[CBSE, 2010]

As $KE = \frac{1}{2}mv^2$ therefore, K.E. α m and K.E. α v^2. Therefore the change in velocity of a body will cause greater change in kinetic energy.

2 Marks Questions

Q.9 Identify and state the type of transformation of energy in the following cases:

(a) When coal is burnt.

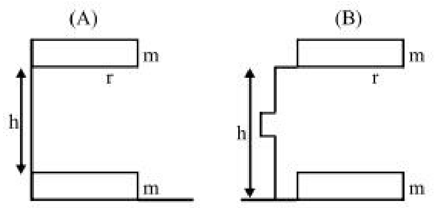
(b) In a thermal power plant

[Board, 2014]

(a) Chemical energy stored in coal is converted to heat energy.

(b) Chemical energy of fuel is first converted into heat energy than to kinetic energy and finally to electrical energy.

Q.10 (a) What is meant by potential energy of a body?



(b) A body of mass m is raised to a vertical height h through two different paths A and B. What will be the potential energy of the body in the two cases? Give reason for your answer.

[CBSE, 2014]

(a) Potential energy is the energy possessed by a body due to its position and shape.

(b) The potential energy in both the cases is equal.

P.E. = mgh

It is independent of the path followed for attaining the height.

Q.11 Calculate the total energy consumed in the month of November in a household in which four devices of power 500 W each are used daily for 10 h.

[CBSE, 2013]

Given,

Power, P = 500 W;

Time, t = (4 × 10 × 30) h = 1200 h

Total energy consumed in the month of November = P × t

= 500 × 1200

= 600000 Wh = 600 kWh (Since, 1 kWh =1000W)

= 600 unit.

Q.12 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?

[Board, 2012]

Work done = Force × displacement

= 140 × 15

= 2100 J = 2.1kJ

Q.13 A body of mass 2 kg is thrown up with a speed of 25 m/s. Find its maximum potential energy.

[Board, 2012]

Maximum kinetic energy of the body = Maximum potential energy of the body.

Given,

Mass of the body, m = 2kg

Speed, v = 25m/s

Therefore, K.E. = $\frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times 25 \times 25$

= 625 J.

Q.14 Define work. How is work done measured?

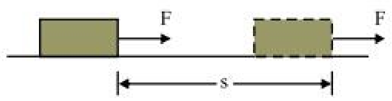
[CBSE, 2012]

Work is said to be done whenever a force acts on a body causing its motion in the direction of the force.

Work done = Force × Displacement

For example, when a force F acts on a body it moves through a distance‘s’ in the direction of the force.

Therefore, the work done, W = F × s

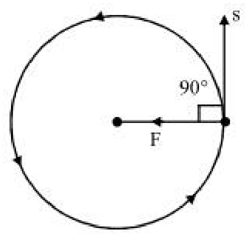


Q.15 Is there any work done on a body in uniform circular motion? Justify your answer.

[CBSE, 2012]

If a body moves in uniform circular motion, the centripetal force ‘F’ acts along the radius towards the Centre and the displacement ‘s’ acts along the tangent to the circle. Thus, the angle between ‘F’ and‘s’ is 90°. Therefore,

$W = F\,s\cos 90° = 0$ (When $\theta = 90°$, then $\cos 90° = 0$)



Since W= 0, no work is done by the body in uniform circular motion.

Q.16 Given below is a few situations, study them and state in which of the given cases work is said to be done. Give reason for your answer.

(a) A person pushing hard a huge rock but the rock does not move.

(b) A bullock pulling a cart up to 1 km on road.

(c) A girl pulling a trolley for about 2m distance.

(d) A person standing with a heavy bag on his head.

[CBSE (CCE), 2012]

(a) Work done = 0,

Reason- As the rock has not moved so displacement is zero.

(b) Work done = Positive

Reason – As the motion is in the direction of force applied.

(c) Work done = Positive

Reason – As the trolley is moving in the same direction in which force is applied.

(d) Work done = 0

Reason – As there is no movement in the position of the bag, therefore displacement is zero.

Q.17 What is power? What is its SI unit ?

[MSE, 2009]

The rate at which work is done is called power.

Power = work done / time.   Its SI unit is Watt.

3 Marks Questions

Q.18 When a force retards the motion of a body, what is the nature of work done by the force? State reason. List two examples of such a situation.

[Board, 2014, 2013]

The work done by the force is negative because this force acts opposite to the direction of movement of the body, thereby hindering the motion.

Example:

1. Work done by the force of friction acting opposite to the direction of football.
2. Work done in Tug of war by losing team.

Q.19 A lift carries a maximum weight of 2400 N to a height of 10 m with constant speed of 2 m/s. Find out the power and work done.

[Board, 2013]

Given,

Force,F= 2400N

Height, h = 10 m

Speed, v = 2 m/s

Therefore, Work done = F × s

= 2400 × 10 = 24000 J

And, Power = F × v

= 2400 × 2 = 4800 W

Q.20 What is meant by work done by a force? When do we call work done to be positive or negative? In a game of 'tug of war' state the type of work done by the winning and the losing teams.

[CBSE, 2013]

When force applied on a body causes the body to move then the work is said to be done by the force.

Positive work done: when the body is displaced in the same direction that of the force then work done is positive. That is the angle between the force applied and displacement is 0^o.

Negative work done: when the body is displaced in the direction opposite to that of the force then work done is negative. Here the angle between the force applied and displacement is 180^o.

In the game of ‘tug of war’ work done by the winning team is positive and the work done by the losing team is negative.

Q.21 Four persons jointly lift a 250 kg box to a height of 1 m and hold it.

(a) Calculate the work done by the persons in lifting the box.

(b) How much work is done for just holding the box?

(c) Why do they get tired while holding it? ($g = 10\ m/s^2$).

[Board, 2012]

(a) Given,

Force, $F = 250 \times 10 = 2500$ N

Displacement, $s = 1$ m

Work done = $F \times s = 2500 \times 1 = 2500$ J

(b) As there is no displacement in just holding the box, so no work is done i.e. Work done is zero.

(c) To hold the box men are applying force against the gravity, which involves their muscles to work, hence they get tired holding it.

Q.22 (a) Name the type of energy possessed by a freely falling body of mass ‘m’ at the highest point 'h'.

(b) Define the energy.

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

[Board, 2012]

(a) Potential energy, P.E. is the energy possessed by a body of mass, m after reaching a height, h. it is given by, P.E. = mgh

(b) The capacity to do work is known as Energy.

(c) K.E. of the object is converted into heat and sound energy.

(c) K.E.of the object is converted into heat and sound energy.

Q.23 Two masses m and 2 m are dropped from heights h and 2h. On reaching the ground, which body will have a greater kinetic energy and why?

[CBSE, 2012]

K.E. of first mass, m = P.E. lost by mass m = mgh

K.E. of second mass, 2 m = P.E. lost by mass 2 m

= 2 m × g × 2h = 4 mgh

Therefore, mass 2 m will have 4 times greater kinetic energy on reaching the ground.

Q.24 Water is falling on the blades of a turbine at the rate of 8×10^2 kg per minute, height of fall is 50 m. Calculate the power given to turbine. (g = 10 m/s^2).

[CBSE (CCE), 2012]

Given,

Height of fall, h = 50 m

Acceleration due to gravity, g = 10 m/s^2

Mass of water, m = 8×10^2 kg

Time taken, t = 1 min = 60 s

Therefore, the power given to turbine =

$$Power = \frac{W}{t} = \frac{mgh}{t} = \frac{8\times10^2\times10\times50}{60}$$

= 6.67×10^3 W.

Q.25 A force applied on a body of mass 4 kg for 5 s changes its velocity from 10 m/s to 20 m/s. Find the power required.

[CBSE, 2010]

Given,

Mass of the body, m = 4kg,

Time taken, t = 5 s,

Initial velocity, u = 10 m/s,

Final velocity, v = 20 m/s,

P =?

$$\text{Power}, P = \frac{W}{t} = \frac{Change\ in\ KE}{Time\ taken}$$

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

$$= \frac{1}{2}\frac{4\left((20)^2 - (10)^2\right)}{5}$$

$$= \frac{1}{2} \times \frac{4 \times 300}{5} = 120\ \ J/s$$

The power required is 120 J/s.

5 Marks Questions

Q.26 75 kg missile is dropped downwards from an air plane, and has a speed of 60 m/s at an altitude of 850 m above the ground. Determine:

(a) The K.E. possessed by the missile at 850 m.

(b) The P.E. possessed by the missile at 850 m.

(c) The total mechanical energy possessed by the missile.

(d) The K.E. and velocity with which it strikes the ground.

[Board, 2013]

(a) Given:

Mass of the missile, m = 75kg

Speed, v = 60 m/s

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

$$= \frac{1}{2} \times 75 \times 60 \times 60 = 13500\ J$$

(b) Given,

Mass of the missile, m = 75kg

Acceleration due to gravity, g = $10 m/s^2$

Height, h =850 m

Therefore, P.E. = m × g × h = 75 × 10 × 850 = 637500 J

(c) Total mechanical energy of the missile = K.E. + P.E.

= 135000 + 637500 = 7.7×10^5 J

(d) K.E. at the ground = 7.7×10^5 J

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

Therefore, v^2 = 2 K.E / m

$$v = \sqrt{(2 \times 7.7 \times 10^5 J/75)}$$

$$\text{Velocity with which missile strikes the ground} = 100\sqrt{2}m/s$$

Q.27 (a) Two bodies of equal masses move with uniform velocities v and 3v respectively. Find the ratio of their kinetic energies.

(b) An electric heater is rated 1500 W. How much energy does it use in 10 h? Express your answer in (i) kWh (ii) Joules

[CBSE (CCE), 2011]

(a) **Kinetic energy α v^2.**

Therefore, for energies KE_1 and KE_2,

$$\frac{KE_1}{KE_2} = \frac{v_1^2}{v_2^2} = \frac{v^2}{(3v)^2} = \frac{v^2}{9v^2}$$

$$\therefore \frac{KE_1}{KE_2} = \frac{1}{9}$$

(b) Given,

Power, P = 1500 W = 1.5 kW, Time, t = 10 h

(i) Energy = Power × time = 1.5 × 10 = 15 kWh

(ii) 15 kWh = $15 \times 3.6 \times 10^6$ J(1 kWh = 3.6×10^6 J)

Q.28 (a) Give reason for the following:

(i) The kinetic energy of a freely falling object increases, yet it holds law of conservation of energy.

(ii) A girl fills up 10 pages of a notebook in order to practice sums, yet she has not done 'work' in terms of Science / Scientific concept.

(iii) Work done by gravitational force on an object moved along a horizontal path, is zero.

(b) Find the energy in kWh consumed in 24 hours by two electric devices, one of 100 W and other of 500 W.

[CBSE(CCE), 2010]

(a)

(i) According to the law of conservation of energy, energy can neither be created nor be destroyed but can be transformed from one form to another. Here, the increase in kinetic energy is due to transformation of potential energy into kinetic energy i.e.

Loss in P.E. = gain in K.E. So, the conservation of energy holds good.

(ii) There has been no displacement of the pages of the book so work done is zero. This is because W = F × s and when s = 0 then W = 0.

(iii) As the angle between the gravitational force and the displacement is 90^0. Hence, W=0.

(b) **Energy consumed= Power × time**

Given,

Power of first device, P_1 = 100W

Power of second device, P_2 = 500W

Time taken for both the devices, t = 24 h

Total energy consumed= $P_1t + P_2t$

= [100 × 24 + 500 × 24]

= [100 + 500] × 24

= 600 × 24

= 14400 Wh

= 14.4 kWh

Q.29 (a) Define kinetic energy of an object. Can kinetic energy of an object be negative? Give reason.

(b) A car weighing 1200 kg is uniformly accelerated from rest and covers a distance of 40 m in 5 s. Calculate the work, the car engine had to do during this time.

[CBSE, 2010]

(a) Kinetic energy of an object is defined as the energy possessed by a body by

virtue of its motion.

It is given by,
$KE = \frac{1}{2}mv^2$

No, the kinetic energy of an object cannot be negative since both mass of the object, m and velocity of a substance, v cannot be negative.

(b) Given,

Mass of the car, m = 1200 kg

Distance covered, s = 40 m

Time taken, t = 5 s

Initial velocity, v = 0

Work done, W =?

Since, W = F × s = ma × s (F = ma)

For calculating work done, acceleration (a) is required.

Therefore, $s = ut + \frac{1}{2}at^2$

$$40 = 0 \times t + \frac{1}{2} \times a \times (5)^2$$

$$a = \frac{40 \times 2}{25} = 3.2\ m/s^2$$

Now, W = F × s = ma × s

= 1200 × 3.2 × 40

= 153600 J

The work needed to be done by the car engine = 153600 J

Q.30 (a) A battery lights a bulb. Describe the energy changes involved in the process.

(b) Calculate the amount of work needed to stop a car of 500 kg, moving at a speed of 36 km/h.

[CBSE (CCE), 2010]

(a) Energy conversion:

Chemical energy of battery → electrical energy → heat and light energy.

(b) Given,

Mass of a car, m = 500 kg,

Speed of car, v = 36 km/h = 10 m/s

Work needed to stop a car = K.E. of the car

Therefore, K.E. $= \frac{1}{2} \times mv^2 = \frac{1}{2} \times 500 \times (10)^2$

= 25000 Joule