(A) WORK, ENERGY AND POWER, THEIR MEASUREMENTS AND UNITS

- Work is some activity that requires physical or mental effort. But according to physics, the definition of work is more precise and unambiguous. In Physics, if a force displaces an object, the work is said to be done.
  The SI unit of work done = Newton(N) X metre(m) = joule(J)
- Energy is the capacity to do work. Energy is the cause and work is an effect. Therefore both work and energy have the same units, which is joule (J) in the SI system and erg in the CGS system. Kinetic energy and potential energy are the two main types of energy.
- Power is the work done in a unit of time. In other words, power is a measure of how quickly work can be done.
  The unit of power is the Watt = 1 Joule/ 1 second.

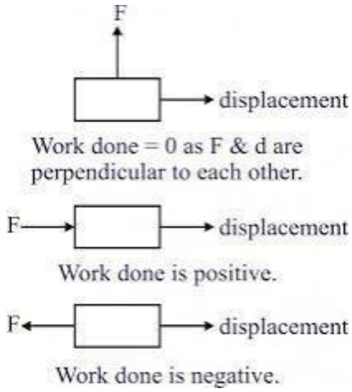
Work is said to be done only when the force is applied on a body makes the body moves in the direction of force applied.
The amount of work done by a force is equal to the product of the force and the displacement of the point of application of the force in the direction of force
$W = F \times S$, It is a scalar quantity
Note:
The amount of work done by a force depends on, the magnitude and direction of the force & displacement it produces, If a force acts on a body and the body does not move, no work is done
Expression of work
Work done W = force × component of displacement in the direction of force, $W = F \times S \cos \theta$

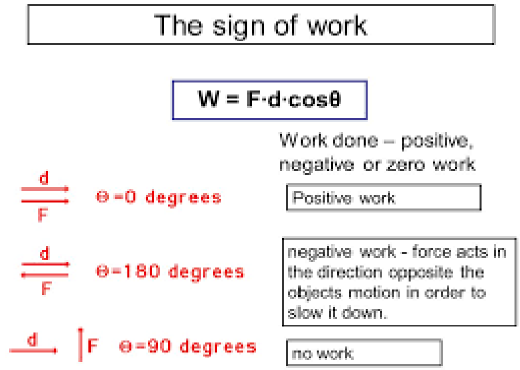
- **Different conditions**

➢ If the displacement is in the direction of the force i.e., $\theta=0^\circ$ then, $\cos 0^\circ= 1$, $W = F \times S$,
The work done is maximum and positive.
example: *When an object moves on horizontal surface, force and displacement acts in forward direction. So, work done is positive.*

➢ Condition for the work done by a force to be zero
(i) When there is no displacement i.e., $S = 0$,
$W = 0$
example: *A man pushing wall.*
(ii) When the angle between displacement and force i.e. $\theta = 90^\circ$ then, $\cos 90^\circ= 0$,
$W = 0$
example: *When we hold an object and walk, the force acts in downward direction whereas displacement acts in forward direction.*

➢ If the displacement is in a direction opposite to the force, i.e., $\theta=180^\circ$
$W = F \times S \cos 180^\circ= – F \times S$,
Work done is negative.
example: *If a ball is thrown in upwards direction, its displacement would be in upwards direction but the force due to earth's gravity is in the downward direction.*





- *Work done by the force of gravity*

W = F × S = mgh

The work done by the force of gravity is the same whether a man comes down from a certain height (h) using a staircase or along the slope or he comes down from the same height using a lift or elevator

Unit of work

S.I. unit of work is newton metre (Nm) or joule (J)

1 J is the amount of work done on an object when a force of 1N displaces it by 1m along the line of action of force.

C.G.S unit of work is dyne centimetre or erg, 1 J = 10^7 erg

Power

Power is defined as the rate of doing work or the rate of transfer of energy

P = w x t ⇒ P = F × v = force × average speed.

The S.I. unit of power is watt and its symbol is W, 1 watt = 1Joule/Sec or 1W = $1Js^{-1}$, 1 H.P. = 746 W = 0.746 kW

The C.G.S unit of power is erg per second (erg s^{-1}), 1W = $1Js^{-1}$ = 10^7 erg s^{-1}

Factors on which power spent by a source depends on:

- The amount of work done by the source.
- The time taken by the source to do the said work.

Difference between work and power

Work	Power
W = F × S	P = w x t
It does not depend on time	It depends on the time in which work is done
S.I. unit of work is joule (J)	S.I. unit of power is watt (W)

Energy

The energy possessed by an object is measured in terms of its capacity of doing work

Like work, energy is also a scalar quantity.

The unit of energy is, therefore, the same as that of work, that is, joule (J)

1 J is the energy required to do 1 joule of work.

Unit of energy

The energy used in households, industries and commercial establishments are usually expressed in kilowatt hour

kW h = 1 kW × 1 h = 1000 W × 3600 s = 36,00,000 J = 3.6 x 10^6 J

Difference between energy and power

Energy	Power
It is the capacity to do work	It is the energy spent by a body in 1 s.

It does not depend on time	It depends on the time in which work is done
S.I. unit of work is joule (J)	S.I. unit of power is watt (W)

(B) DIFFERENT FORMS OF ENERGY

Energy is the ability to do work and work is defined as the transfer of energy.
Objects can have energy by virtue of their motion (kinetic energy), by virtue of their position (potential energy), or by virtue of their mass.
Mechanical energy (potential energy or kinetic energy or a combination of both), electrical energy, light energy, thermal energy, nuclear energy, sound energy etc are some of the forms of energy.

Various forms of energy.

Mechanical Energy

The energy possessed by a body due to its state of rest or of motion is called the mechanical energy.
The two forms of mechanical energy are;

- Kinetic energy
- Potential energy

Kinetic energy

The kinetic energy of a body moving with a certain velocity is equal to the work done on it to make it acquire that velocity, $KE = 1/2\ mv^2$ J
The kinetic energy possessed by an object of mass, m and moving with a uniform velocity,
Example: A fast moving stone has the capacity of breaking a window pane on striking it and thus it has the kinetic energy.

Work-energy Theorem

**** follow your book for its derivation.**

$KE = 1/2mv^2$

Forms of kinetic energy

Translational kinetic energy: The kinetic energy of the body due to motion in straight line.
Rotational kinetic energy: The kinetic energy of the body due to rotational motion.
vibrational kinetic energy: The kinetic energy of the body due to vibrational motion.

Potential energy

The potential energy possessed by the object is the energy present in it by virtue of its position or configuration.
It is denoted by the symbol U
Example: A body placed at a height above the ground.

Forms of potential energy

Gravitational potential energy: The potential energy due to changed position.
Elastic potential energy: The potential energy due to changed configuration.

Potential energy = work done on the object, of mass m, against gravity to raise it through a height h
PE= Force × displacement = mg × h = mgh J (Derivation included)

Different forms of energy (go through qualitative discussion)

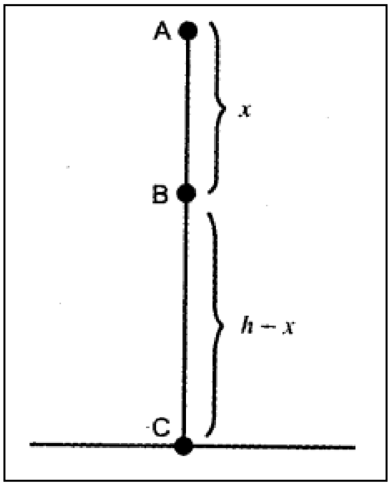
- Solar energy
- Heat energy
- Light energy
- Chemical or fuel energy
- Hydro energy
- Electrical energy
- Nuclear energy
- Geo thermal energy
- Wind energy
- Sound energy
- Magnetic energy

Inter-conversion of energy

Rubbing both hands together for warmth	Kinetic Energy to Thermal Energy
A falling object speeding up	Gravitational Potential Energy to Kinetic Energy
Using battery-powered torchlight	In the battery: Chemical to Electrical Energy In the bulb: Electrical to Radiant Energy
In Geothermal Power Plant	Heat Energy to Electrical Energy
In Thermocouple	Heat Energy to Electrical Energy
In Hydroelectric Dams	Gravitational potential energy to Electric Energy
In Electric Generator	Kinetic energy / Mechanical work to Electric Energy
In Windmills	Wind Energy to Mechanical Energy or Electric Energy
In OTEC	Heat Energy to Electric Energy or Mechanical Energy
Using Microphone	Sound Energy to Electric Energy
Photosynthesis in Plants	Solar Energy to Chemical Energy
In Electric lamp	Electric Energy to Heat and Light Energy
Burning of wood	Chemical energy to Heat and Light Energy
In Fuel cells	Chemical Energy to Electric Energy
In steam engine	The heat energy to Mechanical Energy
In Electric heater	Electric Energy to Heat

(C) *CONSERVATION OF ENERGY*

Conservation of energy: It is the principle that energy is not created or destroyed; it only moves from one place to another – from one type of energy to another.



Theoretical verification for a freely falling body

(i) It states that for a body falling freely the total mechanical energy remains conserved.
(ii) Suppose a ball of mass 'm' falls under the effect of gravity as shown in figure.

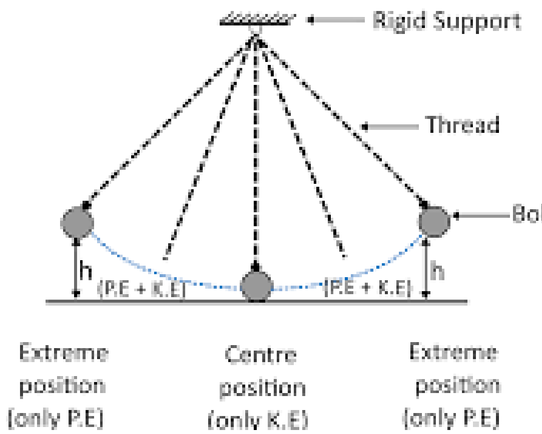
Let us find the kinetic and the potential energy of the ball at various points of its free fall.
Let the ball fall from point A at a height h above the surface of the earth.
At Point A: At point A, the ball is stationary; therefore, its velocity is zero.
Therefore, kinetic energy, T = 0 and potential energy, U = mgh
Hence, total mechanical energy at point A is
E = T + U = 0 + mgh = mgh … (i)

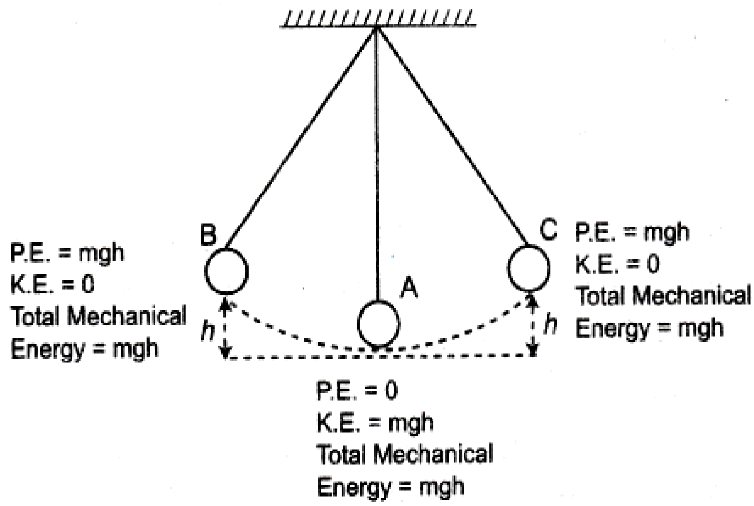
At Point B : Suppose the ball covers a distance x when it moves from A to B.
Let v be the velocity of the ball point B. Then by the equation of motion $v^2-u^2 = 2aS$,

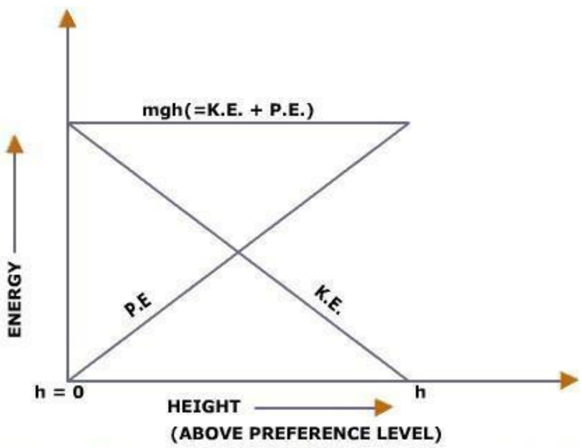
we have
$v^2 - 0 = 2gx$ or $v^2 = 2gx$ Therefore,
Kinetic energy, $T = 1/2\ mv^2 = 1/2 \times m \times (2gx)$
= mgx
And Potential energy, U = mg (h - x)
Hence, total energy at point B is
E = T + U = mgx + mg(h-x) = mgh …(ii)

At Point C : Suppose the ball covers a distance h when it moves from A to C. Let V be the velocity of the ball at point C just before it touches the ground. Then by the equation of motion $v^2 - u^2 = 2aS$, we have $V^2 - 0 = 2gh$ or $V^2 = 2gh$.
Therefore,
Kinetic energy,
$T = 1/2\ mV^2 = 1/2 \times m \times (2gh) = mgh$
and Potential energy, U = 0
Hence, total energy at point E = T + U
= mgh + 0 = mgh … (iii)
Thus, it is clear from equations (i), (ii) and (iii), that the total mechanical energy of a freely falling ball remains constant.

Law of Conservation of Energy in Pendulum







Variation of kinetic energy and potential energy with height

<u>**Exercise 2(A)**</u>

Question: 1

Define work. When is work said to be done by a force?

<u>Solutions</u>:

When the force applied on a body makes the body move, then the work is said to be done. It is a scalar quantity.

Question: 2

How is the work done by a force measured when

(i) force is in direction of displacement,

(ii) force is at an angle to the direction of displacement?

<u>Solutions</u>:

(i) Work done when force is in direction of displacement,

$W = F \times S$

(ii) Work done when force is at an angle to the direction of displacement,

$W = F S \cos \theta$

Question: 3

A force F acts on a body and displaces it by a distance S in a direction at an angle θ with the direction of force.

(a) Write the expression for the work done by the force.

(b) What should be the angle between force and displacement so that the work done is
(i) zero,
(ii) maximum?
Solutions:
(a) Work done when force is at an angle θ to the direction of displacement,
$W = F\,S \cos\theta$
(b) (i) The angle between force and displacement should be 90^0 as $\cos 90^0 = 0$ for zero work done.
$W = F\,S \cos 90^0$
$= FS \times 0$
(ii) The angle between force and displacement should be 0^0 as $\cos 0^0 = 1$ for maximum work done.
Then, $W = FS \cos 0^0$
$= FS$
Question: 4
A body is acted upon by a force. State two conditions when the work done is zero.
Solutions:
When the work done is zero, the two conditions are:
(i) When there is no displacement,
$S = 0$ and
(ii) To the direction of force when the displacement is normal,
$\theta = 90^0$
Question: 5
State the condition when the work done by a force is (i) positive, (ii) negative. Explain with the help of examples.
Solutions:
(i) The work done is positive, if the body's displacement is in the direction of force,
Therefore $W = F \times S$
Example: When the coolie raises the load up against the force of gravity, then the work done by coolie on the load. Both the displacement and the force exerted by coolie are in upward direction.
(ii) The work done is negative, if the body's displacement is in the direction opposite to the force,
Therefore $W = -F \times S$
Example: The force of friction between the body and the surface is in direction opposite to the motion of the body, when a body moves on a surface and hence work done by the force of friction is negative.
Question: 6
A body is moved in a direction opposite to the direction of force acting on it. State whether the work is done by the force or work is done against the force.
Solutions:
Work is done against the force when a body is moved in a direction opposite to the direction of force acting on it.

Question: 7
When a body moves in a circular path, how much work is done by the body? Give reason.
Solutions:
No work is done when a body moves in a circular path, since the force on the body is directed towards the centre of circular path (the body is acted upon by the centripetal force), while at all instants the displacement is along the tangent to the circular path, i.e normal to the direction of force.
Question: 8
A satellite revolves around the earth in a circular orbit. What is the work done by the satellite? Give reason.
Solutions:
As the force of gravity acting on the satellite is perpendicular to the displacement of the satellite, we get that,
Work done by the force of gravity is zero
Question: 9
State whether work is done or not by writing yes or no, in the following cases?
(a) A man pushes a wall.
(b) A coolie stands with a box on his head for 15 min.
(c) A boy climbs up 20 stairs.

Solutions:
(a) No, work is done by a man
(b) No, work is not done by a coolie
(c) Yes, work is done by a boy climbing up a stairs

Question: 10
A coolie X Carrying a load on his head climbs up a slope and another coolie Y carrying the identical load on his head move the same distance on a frictionless horizontal platform. Who does more work? Explain the reason.
Solutions:
The capacity to do work is energy and the energy spent is equal to the work done. The coolie X will do more work as the work done by him will involve a change in potential energy, kinetic energy and loss of energy due to friction whereas the work done by the coolie Y carrying the load in horizontal frictionless surface does not involve change in potential energy and work done by the friction is also zero.
Question: 11
The work done by a fielder when he takes a catch in a cricket match, is negative. Explain.
Solutions:
The work done by a fielder is negative when he takes a catch because the force applied by the fielder is in opposite direction of displacement of ball.
Question: 12
Give an example when work done by the force of gravity acting on a body is zero even though the body gets displaced from its initial position.
Solutions:
The displacement is in the horizontal direction when a coolie carries a load walking on a ground while the force of gravity acts vertically downward. Hence the work done by the force of gravity is zero.
Question: 13
What are the S.I. and C.G.S. units of work? How are they related? Establish the relationship.
Solutions:
The S.I unit of work is Joule and C.G.S unit of work is erg
Relation between joule and erg:
1 joule = 1N × 1m
But 1 N = 10^5 dyne and 1 m = 10^2 cm
Therefore 1 joule = 10^5 dyne × 10^2 cm
= 10^7 dyne × cm
= 10^7 erg
∴1 joule = 10^7 erg
Question: 14
State and define the S.I. unit of work.
Solutions:
The S.I unit of work is Joule. When a force of 1 newton displaces a body through a distance of 1 metre in its own direction then 1 joule of work is said to be done.

Question: 15
Express joule in terms of erg.
Solutions:
1 joule = 1N × 1m
But 1 N = 10^5 dyne and 1 m = 10^2 cm
Therefore 1 joule = 10^5 dyne × 10^2 cm
= 10^7 dyne × cm
= 10^7 erg
∴1 joule = 10^7 erg
Question: 16
A body of mass m falls down through a height h. Obtain an expression for the work done by the force of gravity.
Solutions:

Let a body of mass m falls down through a height h either vertically or inclined plane. For example: a hill, slope or staircase. The force of gravity on the body is F = mg acting vertically downwards and the vertical displacement in the direction of force is S = h. Therefore the work done by the force of gravity is
W = FS = mgh

Question: 17
A boy of mass m climbs up a stairs of vertical height h.
(a) What is the work done by the boy against the force of gravity?
(b) What would have been the work done if he uses a lift in climbing the same vertical height?
Solutions:
Let a boy of mass m climb up through a vertical height h either through a staircase or using a lift. F = mg is the force of gravity acting vertically downwards and the vertical displacement in the direction opposite to the force is
S = – h
Therefore the work done by the force of gravity on a boy is
W = FS = – mgh or
The work W = mgh is done by a boy against the force of gravity.
Question: 18
Define the term energy and state its S.I unit.
Solutions:
The term energy is defined as 'the energy of a body is its capacity to do work'. The S.I unit of energy is Joule.
Question: 19
What physical quantity does electron volt (eV) measure? How is it related to the S.I. unit of that quantity?
Solutions:
The energy of atomic particles is measured in electron volt (eV)
1 eV = charge on an electron × 1 volt
= 1.6×10^{-19} coulomb × 1 volt
= 1.6×10^{-19} J
Question: 24
State two factors on which power spent by a source depends. Explain your answer with examples.
Solutions:
The power spent by a source depends on two factors
(i) The amount of work done by a source and
(ii) The time taken by the source to do the said work.
For example:
If a coolie A takes 1 minute to lift a load to the roof of a bus and a coolie B takes 2 minutes to lift a load to the roof of a same bus. The work done by both the coolies remain same, but the power spent by the coolie A is twice the power spent by the coolie B because coolie A does the work faster than B.

NUMERICALS

Question: 1
A body, when acted upon by a force of 10 kgf, gets displaced by 0.5 m. Calculate the work done by the force, when the displacement is
(i) in the direction of force,
(ii) at an angle of 60° with the force, and
(iii) normal to the force. ($g = 10 Nkg^{-1}$)
Solutions:
Force acting on the body = 10 kgf
= 10 × 10 N
= 100 N
Displacement, S = 0.5 m
Work done = force × displacement in the direction of force
(i) W = F × S
W = 100 × 0.5
= 50 J

(ii) Work = force × displacement in the direction of force
W = F × S cos θ
W = 100 × 0.5 cos 60^0
W = 100 × 0.5 × 0.5 [cos 60^0 = 0.5]
W = 25 J
(iii) Normal to the force
Work = force × displacement in the direction of force
W = F × S cos θ
W = 100 × 0.5 cos 90^0
W = 100 × 0.5 × 0 [cos 90^0 = 0]
W = 0
Question: 2
A boy of mass 40kg climbs up the stairs and reaches the roof at a height 8m in 5 s. Calculate:
(i) The force of gravity acting on the boy,
(ii)The work done by him against gravity,
(iii)The power spent by boy.
(take g= $10ms^{-2}$)
Solutions:
Given
Mass of a boy = 40 kg
Vertical height moved by a boy, h = 8 m
Time taken by a boy, t = 5 s
(i) Force of gravity acting on the boy
F = mg
= 40 × 10
= 400 N
(ii) Work done by a boy against the force of gravity while climbing,
Work done by a boy = Force × distance moved in the direction of force
W = F × S
W = 400 × 8
W = 3200 J
(iii) Power spent = (work done / time taken)
= 3200 / 5
= 640 W
Question: 3
A man spends 6.4 kJ energy in displacing a body by 64 m in the direction in which he applies force, in 2.5 s. Calculate: (i) the force applied and (ii) the power spent (in H.P) by the man.
Solutions:
Given
Work done by man = 6.4 kJ
Distance moved, S = 64 m
(i) Work done by the man = Force × distance moved in direction of force
Work, W = F × S
6.4×10^3 = F × 64
F = (6.4×10^3) / 64
F = 100 N
(ii) Power spent = (6.4×10^3) / 2.5
= 2560 W
1 H.P = 746 W
1 W = 1 / 746 H.P
2560 W = 2560 / 746 H.P
= 3.43 H.P
Question: 4

A weight lifter lifted a load of 200 kgf to a height of 2.5 m in 5 s. Calculate: (i) the work done, and (ii) the power developed by him. Take g =10N/kg^{-1}.

Solutions:

Force = mg

= 200 × 10

= 2000 N

Distance, S = 2.5 m

Time, t = 5 s

(i) Work done, W = FS

W = 2000 × 2.5 m

W = 5000 J

(ii) Power developed = (work done) / (time taken)

= 5000 J / 5 s

= 1000 W

Question: 5

A machine raises a load of 750N through a height of 16m in 5 s. Calculate:

(i) the energy spent by the machine.

(ii) the power of the machine if it is 100% efficient.

Solutions:

(i) Energy spent by machine or work done = FS

Work, W = 750 × 16

W = 12000 J

(ii) Power spent = work done / time taken

= 12000 J / 5s

= 2400 W

Question: 6

An electric heater of power 3 kW is used for 10 h. How much energy does it consume?

Express your answer in

(i) kWh

(ii) joule.

Solutions:

Energy consumed = power × time

(i) Energy = 3 kW × 10 h

= 30 kWh

(ii) 1 kilowatt hour (kWh) = 3.6 × 10^6 J

30 kWh = 30 × 3.6 × 10^6 J

= 1.08 × 10^8 J

Question: 7

A water pump raises 50 litres of water through a height of 25m in 5 s. Calculate the power of the pump required. (Take g= 10N kg^{-1} and density of water =1000kg m^{-3}).

Solutions:

Volume of water = 50 L

= 50 × 10^{-3} m^3

Density of water = 1000 kgm^{-3}

Mass of water = Volume of water × density of water

= 50 × 10^{-3} × 1000

= 50 kg

Work done in raising 50 kg water to a height of 25 m against the force of gravity is

W = mg × h

W = mgh

Power P = (work done) / (time taken)

= mgh / t

= 50 × 10 × 25J / 5 s

= 2500W

Question: 8
A pump is used to lift 500kg of water from a depth of 80m in 10s. Calculate:
(a) The work done by the pump,
(b) The power at which the pump works, and
(c) The power rating of the pump if its efficiency is 40%. (Take g= 10m s^{-2}).
Solutions:
Work done in raising a 500 kg mass to a height of 80 m against the force of gravity is:
(a) W = mg × h = mgh
W = 500 × 10 × 80
= 4×10^5 J
(b) Power at which pump works = work done / time taken
= mgh / t
= (500 × 10 × 80J) / 10 s
= $(4 \times 10^5) / 10$
= 40 kW
(c) Efficiency = useful power / power input
Efficiency = 40 %
= 0.4
0.4 = 40 kW/ power input
Power input = 40 kW/0.4
= 100 kW
Question: 9
An ox can apply a maximum force of 1000N. It is taking part in a cart race and is able to pull the cart at a constant speed of 30m/s^{-1} while making its best effort. Calculate the power developed by the ox.
Solutions:
Given
Force = 1000 N
Velocity = 30 m/s
Power, P = force × velocity
P = 1000 × 30
= 30,000W
= 30 kW
Question: 10
The power of a motor is 40kW. At what speed can the motor raise a load of 20,000 N?
Solutions:
Given
Power = 40 kW
Force = 20,000 N
Power = force × velocity
Velocity = power / force
= 40 kW/ 20,000
= 40,000 / 20,000
= 2 m / s
= 2 ms^{-1}
Question: 11
Rajan exerts a force of 150 N in pulling a cart at a constant speed of 10 m s^{-1}. Calculate the power exerted.
Solutions:
Power exerted by Rajan due to force is
P = Fv
P = 150 × 10
P = 1500 W
Question: 12
A boy weighing 350 N climbs up 30 steps, each 20 cm high in 1 minute. Calculate:
(i) the work done, and

(ii) the power spent.

Solutions:

Total distance covered in 30 steps, S = 30 × 20 cm
= 600 cm
= 6 m
Work done by the boy in climbing = Force × distance moved in direction of force
Work, W = F × S
= 350 × 6
= 2100 J
Power developed = work done / time taken
= 2100 J / 60 s
= 35 W

Question: 13

It takes 20 s for a person A of mass 50 kg to climb up the stairs, while another person B of same mass does the same in 15 s. Compare the
(i) work done and
(ii) power developed by the persons A and B.

Solutions:

(i) The work done by two persons A and B is independent of time. Hence both will do the same amount of work.
Hence,
Work done by A / work done by B
= 1 / 1
= 1: 1
(ii) The power developed by the persons A and B is calculated as shown below:
A takes 20 s to climb the stairs while B takes 15 s to do the same work. Hence, B does the work at a faster rate than A. Therefore more power is spent by B.
Power developed = 1 / time (amount of work done by A and B is same)
Power developed by A / Power developed by B = 15 / 20
= 3 / 4
= 3: 4

Question: 14

A boy of weight 40 kgf climbs up the 15 steps, each 15 cm high in 10 s and a girl of weight 20 kgf does the same in 5 s. Compare :
(i) the work done, and
(ii) the power developed by them. Take g = 10 N kg^{-1}.

Solutions:

(i) Work done is
W = Fs = mgh
(Weight of boy) / (weight of girl) = 40 / 20
= 2 / 1
= 2: 1
(ii) Power developed is
P_{boy} / P_{girl} = [(m_{boy}gh) / t] / [(m_{girl}gh) / t]
= (40 / 10) / (20 / 5)
Thus P_{boy} / P_{girl} = (40 / 10) × (5 / 20)
= 1: 1

Question: 15

A man raises a box of mass 50kg to a height of 2m in 20s, while another man raises the same box to the same height in 50s.
(a) Compare: (i) the work done, and (ii) the power developed by them.
(b) Calculated: (i) the work done, and (ii) the power developed by each man. Take g = 10N kg-1.

Solutions:

(a) (i) Work done to raise the box of mass 50 kg is same for both

(ii) Power = work done / time taken
The power taken by the first man is less. Hence powered developed is more.
(b) (i) Work done = 50 × 10 × 2
= 1000 J
(ii) Power developed by first man = 1000 / 20
= 50 W
Power developed by second man = 1000 / 50
= 20 W
Question: 16
A boy takes 3 minutes to lift a 20 litre water bucket from a 20 m deep well, while his father does it in 2 minutes.
(a) Compare: (i) the work, and (ii) power developed by them. (b) How much work each does? Take density of water = 10^3 kg m^{-3} and g = 9.8 N kg^{-1}.
Solutions:
(a) (i) Both the people carry same weight of water to the same height. So, work done is same for both. Hence,
Work = 1: 1
(ii) Power developed is
$P_{boy} / P_{father} = [(W / t_{boy}) / (W / t_{father})]$
$= t_{father} / t_{boy}$
∴ $P_{boy} / P_{father} = 2 / 3$
= 2: 3
(b) Mass of water lifted by both is
$m_w = p \times V$
$= 10^3$ kg / $m^3 \times 20 \times 10^{-3}$ m^3
= 20 kg
So, the work done is
$W = m_w gh$
= 20 × 9.8 × 20
W = 3920 J
W = 3.92 kJ

Exercise 2(B)

Question: 9
(a) A body of mass m is moving with a velocity v. Write the expression for its kinetic energy.
(b) Show that the quantity $2K/v^2$ has the unit of mass, where K is the kinetic energy of the body.
Solutions:
(a) The expression for a body of mass m moving with a velocity v is given by
Kinetic energy = 1 / 2 × mass × $(\text{velocity})^2$
$= 1 / 2\ mv^2$
(b) $2K / v^2$ = Joules / $(ms^{-1})^2$
$= (kgms^{-2} \times m) / m^2s^{-2}$
= kg
Kg is the unit of mass
Question: 10
State the work–energy theorem.
Solutions:
According to the work theorem, the work done by a force in the same direction on a moving body is equal to the increase in its kinetic energy.
Question: 11
A body of mass m is moving with a uniform velocity u. A force is applied on the body due to which its velocity increases from u to v. How much work is being done by the force?
Solutions:
Let a body of mass m moving with an initial velocity u. When force is applied on the body along its direction of motion, an acceleration ‘a’ is produced and the velocity of the body changes from u to v in moving a distance S.
So,
Work done by the force = force × displacement

$W = F \times S$ (1)
From relation $v^2 = u^2 + 2aS$
Displacement, $S = (v^2 – u^2) / 2a$
Force, $F = ma$
Substituting the values of F and S in equation (1), we get
$W = F \times S$
$W = ma \times (v^2 – u^2) / 2a$
$= 1 / 2\ mv^2 – 1 / 2\ mu^2$
$W = k_f – k_i$
Hence, work done on the body is equal to increase in kinetic energy.
$W = 1 / 2\ m (v^2 – u^2)$

Question: 12

A light mass and a heavy mass have equal momentum. Which will have more kinetic energy?

Solutions:

Kinetic energy and momentum are related as
$K = p^2 / 2m$ where p is momentum and k is kinetic energy
Both masses have same momentum p. The kinetic energy k is inversely proportional to mass of the body
Hence, a body of light mass has more kinetic energy because smaller the mass, larger is the kinetic energy.

Question: 13

Two bodies A and B of masses m and M (M≫ m) have same kinetic energy. Which body will have more momentum?

Solutions:

Kinetic energy is related to momentum and mass as
$p = \sqrt{2mk}$
Since the kinetic energy of both bodies are same, momentum is directly proportional to square root of mass
Mass of body B is greater than that a body A
Therefore body B will have more momentum than body A.

Question: 17

When an arrow is shot from a bow, it has kinetic energy in it. Explain briefly from where does it get its kinetic energy?

Solutions:

When the string of a bow is pulled, the work done is stored in the deformed state of the bow which is in the form of its elastic potential energy. When the string is released to shoot an arrow, the potential energy of the bow changes into the kinetic energy of the arrow which makes to move.

Question: 18

A ball is placed on a compressed spring. What form of energy does the spring possess? On releasing the spring, the ball flies away. Give a reason.

Solutions:

Due to the compressed state, the compressed spring has elastic potential energy. The potential energy of the spring changes into kinetic energy when it is released, which does work on the ball if placed on it and changes into kinetic energy of the ball due to which it flies away.

Question: 19

A pebble is thrown up. It goes to a height and then comes back on the ground. State the different changes in form of energy during its motion.

Solutions:

When the pebble is thrown upwards, the kinetic energy in it is converted to potential energy. Its kinetic energy is completely converted into potential energy at the top point in its motion. The potential energy is converted into kinetic energy while coming down and at the bottom the potential energy is completely converted to kinetic energy.

Question: 20

In what way does the temperature of water at bottom of a waterfall differ from the temperature at the top? Explain the reason.

Solutions:

During the fall of water from the height, the potential energy stored in water at a height changes into the kinetic energy. On striking the ground, a part of kinetic energy of water changes into the heat energy which increase the temperature of water.

Question: 24

Energy can exist in several forms and may change from one form to another. For each of the following, state the energy changes that occur in:

(a) the unwinding of a watch spring
(b) a loaded truck when started and set in motion,
(c) a car going uphill,
(d) photosynthesis in green leaves,
(e) charging of a battery,
(f) respiration,
(g) burning of a match stick,
(h) explosion of crackers.

Solutions:

(a) Potential energy of a watch spring converts into kinetic energy
(b) Chemical energy of diesel or petrol converts into mechanical energy
(c) Kinetic energy converts into potential energy
(d) Light energy converts into chemical energy
(e) Electrical energy converts into chemical energy
(f) Chemical energy converts into heat energy
(g) Chemical energy converts into heat and light energy
(h) Chemical energy converts into heat, light and sound energy

Question: 25

State the energy changes in the following cases while in use:

(a)Loudspeaker
(b)A steam engine
(c)Microphone
(d)Washing machine
(e)A glowing electric bulb
(f)Burning coal
(g)A solar cell
(h)Bio-gas burner
(i)An electric cell in a circuit
(j)A petrol engine of a running car
(k)An electric iron
(l)A ceiling fan
(m)An electromagnet.

Solutions:

(a) Electrical energy changes into sound energy
(b) Heat energy changes into mechanical energy
(c) Sound energy changes into electrical energy
(d) Electrical energy changes into mechanical energy
(e) Electrical energy changes into light energy
(f) Chemical energy changes into heat energy
(g) Light energy changes into electrical energy
(h) Chemical energy changes into heat energy
(i) Chemical energy changes into electrical energy
(j) Chemical energy changes into mechanical energy
(k) Electrical energy changes into heat energy
(l) Electrical energy changes into mechanical energy
(m) Electrical energy changes into magnetic energy

Question: 26

Name the process used for producing electricity from the nuclear energy.
Solutions:
The process used for producing electricity from the nuclear energy is nuclear fission
Question: 27
Is it practically possible to convert a form of energy completely into the other useful form? Explain your answer.

Solutions:
No. Because, whenever there is a conversion of energy completely into other useful form, a part of energy is dissipated in the form of heat which is lost to the surroundings.
Question: 28
What is degraded energy?

Solutions:
During the transformation of energy from one form to another, a part of energy gets convert to some undesirable form or a part of it is lost to the surroundings due to the friction or radiations which cannot be used for productive purpose. This is known as dissipation of energy or degradation of energy.
Question: 29
What do you mean by degradation of energy? Explain it by taking one example of your daily life.
Solutions:
During the transformation of energy from one form to another, a part of energy gets convert to some undesirable form or a part of it is lost to the surroundings due to the friction or radiations which cannot be used for productive purpose. This is known as dissipation of energy or degradation of energy.
Example: During the glow of light bulb, a major part of electrical energy utilised is converted to heat energy while some part is converted to useful light energy.

NUMERICALS

Question: 1
Two bodies of equal masses are placed at heights h and 2h. Find the ratio of their gravitational potential energies.
Solutions:
Height H_1 = h
Height H_2 = 2h
Mass of body 1 = m
Mass of body 2 = m
Gravitational potential energy of body 1 = mgH_1
= mgh
Gravitational potential energy of body 2 = mgH_2
= mg(2h)
Ratio of gravitational potential energies = mgh / mg(2h)
= mgh / 2mgh
= 1 / 2
= 1: 2
Question: 2
Find the gravitational potential energy of 1kg mass kept at a height of 5m above the ground if g =$10ms^{-2}$.
Solutions:
Given
Mass, m = 1 kg
Height, h = 5 m
Gravitational potential energy = mgh
= 1 × 10 × 5
= 50 J
Question: 3

A box of weight 150 kgf has gravitational potential energy stored in it equal to 14700 J. Find the height of the box above the ground.

Solutions:

Gravitational potential energy = 14700 J
Force of gravity = mg
= 150 × 9.8 N/kg
= 1470 N
Gravitational potential energy = mgh
14700 = 1470 × h
h = 10 m

Question: 4

A body of mass 5 kg falls from a height of 10 m to 4 m. Calculate:
(i) the loss in potential energy of the body,
(ii) the total energy possessed by the body at any instant? (Take g = 10 ms^{-2}).

Solutions:

(i) Mass of the body, M = 5 kg
Potential energy at height 10 m = mgh
= 5 × 10 × 10
= 500 J
Potential energy at height 4 m = mgh
= 5 × 10 × 4
= 200 J
Loss in potential energy = (500 – 200) J
= 300 J
(ii) The total energy possessed by the body at any instant remains constant for free fall
It is equal to the sum of P.E and K.E
Thus, at height 10 m, K.E = 0
Therefore total energy = P.E + K.E
Total energy = 500 + 0
= 500 J

Question: 5

Calculate the height through which a body of mass 0.5 kg is lifted if the energy spent in doing so is 1.0 J. Take g = 10m/s^{-2}.

Solutions:

Given
Mass = 0.5 kg
Energy = 1 J
Gravitational potential energy = mgh
1 = 0.5 × 10 × h
1 = 5h
h = 1 / 5
h = 0.2 m

Question: 6

A boy weighing 25 kgf climbs up from the first floor at height of 3 m above the ground to the third floor at height of 9 m above the ground. What will be the increase in his gravitational potential energy?
(Take g=10 N kg^{-1}).

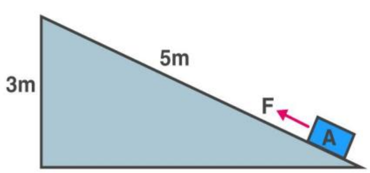
Solutions:

Force of gravity on boy = mg
= 25 × 10
= 250 N

Increase in gravitational potential energy = Mg $(h_2 - h_1)$
= 250 × (9 – 3)
= 250 × 6
=1500 J

Question: 7
A vessel containing 50 kg of water is placed at a height 15m above the ground. Assuming the gravitational potential energy at ground to be zero, what will be the gravitational potential energy of water in the vessel? (g = $10ms^{-2}$).
Solutions:
Given
Mass of water, m = 50 kg
Height, h = 15 m
Gravitational potential energy = mgh
= 50 × 10 × 15
= 7500 J
Question: 8
A man of mass 50 kg climbs up a ladder of height 10m. Calculate: (i) the work done by the man, (ii) the increase in his potential energy.
(g= $9.8m\ s^{-2}$).

Solutions:
Given
Mass of man = 50 kg
Height of ladder, h_2 = 10 m
(i) Work done by man = mgh_2
= 50 × 9.8 × 10
= 4900 J
(ii) Increase in his potential energy
Height, h_2 = 10 m
Reference point is ground, h_1 = 0 m
Gravitational potential energy = Mg $(h_2 - h_1)$
= 50 × 9.8 × (10 – 0)
= 50 × 9.8 × 10
= 4900 J
Question: 9
A block A, whose weight is 100N, is pulled up a slope of length 5m by means of a constant force F (=100N) as illustrated.



(a) What is the work done by the force F in moving the block A, 5m along the slope?
(b) What is the increase in potential energy of the block A?
(c) Account for the difference in the work done by the force and the increase in potential energy of the block.
Solutions:
F = 100 N
Work done by the force in moving the block 5m along the slope = Force × displacement in the direction of force
= 100 × 5
= 500 J
The potential energy gained by the block U = mgh (where h = 3m)
= 100 × 3
= 300 J

– is the potential energy gained by the block
The difference i.e 200 J energy is used in doing work against the force of friction between the block and the slope, which will appear as heat energy.

Question: 10

Find the kinetic energy of a body of mass 1kg moving with a uniform velocity of 10m s^{-1}.

Solutions:

Mass, m = 1 kg
Velocity, v = 10 m / s
Kinetic energy = 1 / 2 × mass × $(velocity)^2$
= 1 / 2 × 1 × $(10)^2$
= 1 / 2 × 1 × 100
= 50 J

Questions: 11

If the speed of a car is halved, how does its kinetic energy change?

Solutions:

The kinetic energy decreases, if the speed is halved keeping the mass same. Since kinetic energy is proportional to the square of velocity, it becomes one-fourth.

Question: 12

Calculate the decrease in the kinetic energy of a moving body if its velocity reduces to half of the initial velocity.

Solutions:

Kinetic energy is directly proportional to the square of velocity.
Hence, velocity is reduced is half its original value. We get,
$\Delta K = K - K_{new} = 1 / 2\ mv^2 - 1 / 2\ m\ (1 / 2\ v)^2$
Hence, $\Delta K = 1 / 2\ mv^2 - 1 / 2\ mv^2\ (1 / 4)$
$= 1 / 2\ mv^2 - 1 / 8\ mv^2$
$= 3 / 8\ mv^2$
$= 3 / 4 \times 1 / 2\ mv^2$
= 3 / 4K

Question: 13

Two bodies of equal masses are moving with uniform velocities v and 2v. Find the ratio of their kinetic energies.

Solutions:

Given
Velocity of first body $v_1 = v$
Velocity of second body, $v_2 = 2v$
Masses are same, so kinetic energy is directly proportional to the square of the velocity ($K \alpha v^2$)
Hence, ratio of their kinetic energies is
$K_1 / K_2 = (v_1)^2 / (v_2)^2$
$= v^2 / (2v)^2$
$= v^2 / 4v^2$
= 1 / 4
= 1: 4

Question: 14

A car is running at a speed of 15 km h^{-1} while another similar car is moving at a speed of 45 km h^{-1}. Find the ratio of their kinetic energies.

Solutions:

$KE = mv^2$
$KE\ \alpha\ v^2$
$KE_1 / KE_2 = v_1^2 / v_2^2$
$KE_1 / KE_2 = (15 / 45)^2$
$KE_1 / KE_2 = (1 / 3)^2$
$KE_1 / KE_2 = 1 / 9$
$KE_1 / KE_2 = 1: 9$

Question: 15

A ball of mass 0.5 kg slows down from a speed of $5 m/s^{-1}$ to that of $3 m/s^{-1}$. Calculate the change in kinetic energy of the ball.

Solutions:

Given

Mass of ball = 0.5 kg

Initial velocity = 5 m / s

Initial kinetic energy = 1 / 2 × mass × $(velocity)^2$

= 1 / 2 × 0.5 × $(5)^2$

= 1 / 2 × 0.5 × 25

= 6.25 J

Final velocity of the ball = 3 m / s

Final kinetic energy of the ball = 1 / 2 × mass × $(velocity)^2$

= 1 / 2 × mass × $(velocity)^2$

= 1 / 2 × 0.5 × $(3)^2$

= 1 / 2 × 0.5 × 9

= 2.25J

So, change in the kinetic energy of the ball = 2.25 J – 6.25 J

= – 4J

Hence, there is a decrease in the kinetic energy of the ball.

Question: 16

A canon ball of mass 500g is fired with a speed of $15 m/s^{-1}$. Find:

(i) its kinetic energy and

(ii) its momentum.

Solutions:

Given

A mass of cannon ball = 500 g

= 0.5 kg

Speed, v = 15 m / s

(a) Kinetic energy of ball = 1 / 2 × mass × $(velocity)^2$

= 1 / 2 × 0.5 × $(15)^2$

= 1 / 2 × 0.5 × 225

= 56.25J

(b) Momentum of the ball = mass × velocity

= 0.5 × 15

= 7.5 kgm/s

Question: 17

A body of mass 10 kg is moving with a velocity $20 m\ s^{-1}$. If the mass of the body is doubled and its velocity is halved, find: (i) the initial kinetic energy, and (ii) the final kinetic energy.

Solutions:

Let initial Mass, m_1 = 10 kg and

Velocity, v_1 = 20 m / s

Final mass, m_2 = 2 × 10 kg and

Velocity, v_2 = 20 / 2

= 10 m / s

Initial kinetic energy, K_1 = 1 / 2 × mass × $(velocity)^2$

= 1 / 2 × 10 × $(20)^2$

= 1 / 2 × 10 × 20 × 20

= 2000J

Final kinetic energy, K_2 = 1 / 2 × mass × $(velocity)^2$

$= 1 / 2 \times 20 \times (10)^2$
$= 1 / 2 \times 20 \times 10 \times 10$
= 1000J
Therefore $K_1 / K_2 = 2000 / 1000$
= 2 / 1
= 2: 1

Question: 18

A truck weighing 1000 kgf changes its speed from 36 km/h^{-1} to 72 km/h^{-1} in 2 minutes. Calculate:
(i) the work done by the engine and
(ii) its power.
(g =10 m/s^{-2})

Solutions:

u = 36 km / h = 36 × 1000m / 3600s
= 10 m / s and
v = 72 km / h = 72 × 1000m / 3600s
= 20 m / s
Given
Mass of truck = 1000 kg
(i)
$W = 1 / 2 \times 1000 \times (20^2 - 10^2)$
W = 500 × (400 – 100)
W = 500 × 300
W = 150000J
$W = 1.5 \times 10^5$J
(ii)
Power = work done / time taken
$= 1.5 \times 10^5$ J / 120s
$= 1.25 \times 10^3$ W

Question: 19

A body of mass 60 kg has the momentum 3000 kgm/s^{-1}. Calculate:
(i) the kinetic energy and
(ii) the speed of the body.

Solutions:

Given
Mass of body = 60 kg
Momentum, p = 3000 kgm / s
(a) Kinetic energy = $p^2 / 2m$
$= (3000)^2 / 2 \times 60$
= (3000 × 3000) / 120
= 75000J
$= 7.5 \times 10^4$J
(b) Momentum = mass × velocity
3000 = 60 × velocity
Velocity = 3000 / 60
Velocity = 50 m / s

Question: 20

How much work is needed to be done on a ball of mass 50g to give it a momentum of 5 kg m s^{-1}?

Solutions:

Momentum, p = 500 gcm / s
= 0.005 kgm / s
Mass of ball = 50 g

= 0.05 kg
Kinetic energy of the ball = $p^2 / 2m$
= $(0.005)^2 / 2 \times 0.05$
= 250J

Question: 21

How much energy is gained by a box of mass 20 kg when a man
(a) carrying the box waits for 5 minutes for a bus?
(b) runs carrying the box with a speed of 3 m/s^{-1} to catch the bus?
(c) raises the box by 0.5 m in order to place it inside the bus? (g=10 m/s^{-2})

Solutions:

Given
Mass of box = 20 kg
(a) As there is no displacement of the man, so zero work is done
(b) Work done, Kinetic energy of man = 1 / 2 × mass × $(\text{velocity})^2$
= 1 / 2 × 20 × $(3)^2$
= 1 / 2 × 20 × 9
= 90J
(c) Work done in raising the box, Potential energy = mgh
U = 20 × 10 × 0.5
= 100J

Question: 22

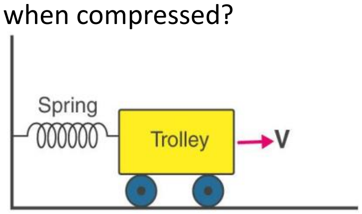
A bullet of mass 50g is moving with a velocity of 500m/s^{-1}. It penetrates 10 cm into a still target and comes to rest. Calculate:
(a) the kinetic energy possessed by the bullet, and
(b) the average retarding force offered by the target.

Solutions:

Given
Mass of bullet = 50 g
= 0.05 kg
Velocity = 500 m / s
Distance penetrated by the bullet = 10 cm
= 0.1 m
(a) Kinetic energy of the bullet = 1 / 2 × mass × $(\text{velocity})^2$
= 1 / 2 × 0.05 × $(500)^2$
= 1 / 2 × 0.05 × 500 × 500
= 6250J
(b) Work done by the bullet against the material of the target = resistance force × distance
6250 = resistance force × 0.1 m
Resistance force = 62500N

Question: 23

A spring is kept compressed by a small trolley of mass 0.5 kg lying on a smooth horizontal surface as shown. When the trolley is released, it is found to move at a speed of v = 2 m/s^{-1}. What potential energy did the spring possess when compressed?



Solutions:

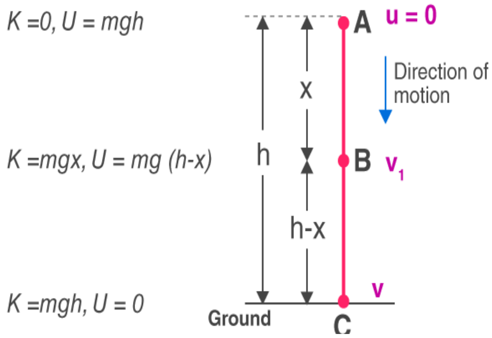
Given
Mass of trolley = 0.5 kg
Velocity = 2 m / s
When the compressed spring is released, its potential energy is converted into kinetic energy completely.
Potential energy of compressed spring = kinetic energy of moving trolley

Kinetic energy of trolley = 1 / 2 × mass × $(\text{velocity})^2$
= 1 / 2 × 0.5 × $(2)^2$
= 1 / 2 × 0.5 × 2 × 2
= 1J
So, potential energy of compressed spring = 1.0J

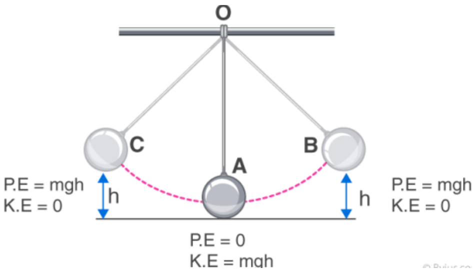
Exercise 2(c)

Question: 1
State the Principle of conservation of energy.
Solutions:
According to the principle of conservation of energy, energy can neither be created nor can it be destroyed. It only changes from one form to the other.
Question: 2
What do you understand by the conservation of mechanical energy? State the condition under which the mechanical energy is conserved.
Solutions:
The law of conservation of mechanical energy states that, whenever there is an interchange between the potential energy and kinetic energy, the total mechanical energy remains constant i.e K + U = constant when there are no frictional forces.
When there are no frictional forces for a given system only then the mechanical energy is conserved i.e between body and air. Hence, conservation of mechanical energy is strictly valid only in vacuum, where friction due to air is absent.
Question: 3
Name two examples in which the mechanical energy of a system remains constant.
Solutions:
The two examples in which the mechanical energy of a system remains constant are motion of a simple pendulum and motion of a freely falling body.
Question: 4
A body is thrown vertically upwards. Its velocity keeps on decreasing. What happens to its kinetic energy as its velocity becomes zero?
Solutions:
When a body is thrown vertically upwards, its kinetic energy changes into potential energy and its velocity becomes zero.
Question: 5
A body falls freely under gravity from rest. Name the kind of energy it will possess
(a)At the point from where it falls.
(b)While falling
(c)On reaching the ground.
Solutions:
(a) An energy possessed by the body at the point from where it falls is potential energy.
(b) The energy possessed by the body while falling are potential energy and kinetic energy.
(c) The energy possessed by the body on reaching the ground is kinetic energy.
Question: 6
Show that the sum of kinetic energy and potential energy (i.e., total mechanical energy) is always conserved in the case of a freely falling body under gravity (with air resistance neglected) from a height h by finding it when
(i) the body is at the top,
(ii) the body has fallen a distance x,
(iii) the body has reached the ground.

Solutions:
Let a body of mass m be falling freely under gravity from a height h above the ground (i.e from position A). Now calculate sum of kinetic energy K and potential energy U at various positions, say at A (at height h above the ground), at B (when it has fallen through a distance x) and at C (on the ground).



(i) At the position A (at height h above the ground):
Initial velocity of body = 0 (since body is at rest at A)
Therefore Kinetic energy K = 0
Potential energy U = mgh
Hence total energy = K + U
= 0 + mgh
= mgh (1)
(ii) At the position B (when it has fallen a distance x):
Let v_1 be the velocity acquired by the body at B after falling through a distance x. Then u = 0, s = x, a = g
From equation $v^2 = u^2 + 2aS$
$V_1^2 = 0 + 2gx$
$= 2gx$
∴ Kinetic energy $K = 1 / 2\ mv_1^2$
$= 1 / 2\ m\ (2gx)$
= mgx
Now at B, height of body above the ground = h – x
∴ Potential energy U = mg (h – x)
Hence, total energy = K + U
= mgx + mg (h – x)
= mgh (2)
(iii) At position C (on the ground):
Let the velocity acquired by the body on reaching the ground be v. Then u = 0, s = h, a = g
From equation: $v^2 = u^2 + 2aS$
$v^2 = 0^2 + 2gh$
$v^2 = 2gh$
or Kinetic energy $K = 1 / 2\ mv^2$
$= 1 / 2\ m\ (2gh)$
= mgh
And potential energy U = 0 (at the ground when h = 0)
So, total energy = K + U
= mgh + 0
= mgh (3)
Thus from equation (1), (2) and (3) we note that the total mechanical energy i.e the sum of kinetic energy and potential energy always remain constant at each point of motion and it is equal to the initial potential energy at height h.
Question: 7
A pendulum is oscillating on either side of its rest position. Explain the energy changes that take place in the oscillating pendulum. How does the mechanical energy remain constant in it? Draw necessary diagram.
Solutions:
The kinetic energy decreases and the potential energy becomes maximum at B where it is momentarily at rest, when the bob swings from A to B.



From B to A, again the potential energy changes into kinetic energy and this process repeat again and again. So, while swinging, the bob has the potential energy at the extreme position B or C and kinetic energy at resting position A. The bob has both the kinetic energy and potential energy at an intermediate position (between A and B or between A and C) and the sum of both the energies (i.e the total mechanical energy) remains constant throughout the swing.

Question: 8

A pendulum with bob of mass m is oscillating on either side from its resting position A between the extremes B and C at a vertical height h above A. What is the kinetic energy K and potential energy U when the pendulum is at positions

(i) A,

(ii) B and

(iii) C?

Solutions:

(i) At position A: pendulum has maximum kinetic energy and its potential energy is zero at its resting position. So, K = mgh and U = 0

(ii) At position B: The kinetic energy decreases and the potential energy increases. So, K = 0 and U = mgh

(iii) At position C: kinetic energy K = 0 and potential energy U = mgh.

Question: 9

Name the type of energy possessed by the bob of a simple pendulum when it is at

(a) the extreme position,

(b) the mean position, and

(c) between the mean and extreme positions.

Solutions:

(a) Energy possessed by the bob of a simple pendulum at extreme position is potential energy

(b) Energy possessed by the bob of a simple pendulum at mean position is kinetic energy

(c) Energy possessed by the bob of a simple pendulum between mean and extreme position are both kinetic energy and potential energy.

NUMERICALS

Question: 1

A ball of mass 0.20 kg is thrown vertically upwards with an initial velocity of $20 m/s^{-1}$ Calculate the maximum potential energy it gains as it goes up.

Solutions:

Potential energy at the maximum height = initial kinetic energy

$= 1 / 2\ mv^2$

$= 1 / 2 \times 0.20 \times 20 \times 20$

= 40J

Question: 2

A stone of mass 500 g is thrown vertically upwards with a velocity of $15 m/s^{-1}$. Calculate:

(a) the potential energy at the greatest height,

(b) the kinetic energy on reaching the ground

(c) the total energy at its half way point.

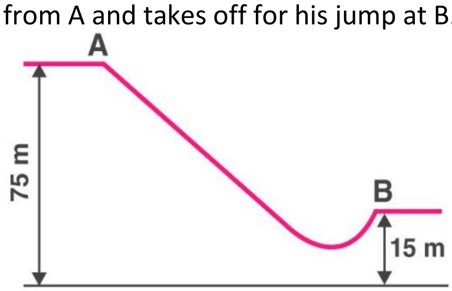
Solutions:

(a) Potential energy at maximum height = initial kinetic energy

$mgh = 1 / 2\ mv^2$

$= 1 / 2 \times 0.500 \times 15 \times 15$

= 56.25J
(b) Kinetic energy on reaching the ground = potential energy at the greatest height
= 56.25J
(c) Total energy at its half way point = 1 / 2 (K + U)
= 56.25J
Question: 3
A metal ball of mass 2kg is allowed to fall freely from rest from a height of 5m above the ground.
(a) Taking g = $10 m/s^2$, calculate:
(i) the potential energy possessed by the ball when it is initially at rest.
(ii) the kinetic energy of the ball just before it hits the ground?
(b)What happens to the mechanical energy after the ball hits the ground and comes to rest?
Solutions:
(a)
(i) Potential energy of the ball = mgh
= 2 × 10 × 5
= 100J
(ii) Kinetic energy of the ball just before hitting the ground = initial potential energy = mgh
= 2 × 10 × 5
= 100J
(b) Mechanical energy converts into heat and sound energy after the ball hits the ground and comes to rest.
Question: 4
The diagram given below shows a ski jump. A skier weighing 60kgf stands at A at the top of ski jump. He moves from A and takes off for his jump at B.



(a)Calculate the change in the gravitational potential energy of the skier between A and B.
(b)If 75% of the energy in part (a) becomes the kinetic energy at B, calculate the speed at which the skier arrives at B.
(Take g = 10 m s^{-2}).
Solutions:
(a) Mass of skier = 60 kg
Loss in potential energy = mg $(h_1 – h_2)$
= 60 × 10 × (75 – 15)
= 60 × 10 × 60
= 3.6×10^4J
(b) Kinetic energy at B = 75 / 100 × 3.6×10^4
= 27000J
= 2.7×10^4J
Kinetic energy = 1 / 2 mv^2
27000 = 1 / 2 mv^2
27000 = 1 / 2 × 60 × v^2
v^2 = 27000 / 30
= 900
= 30 m / s
Question: 5
A hydro electric power station takes its water from a lake whose water level is 50m above the turbine. Assuming an overall efficiency of 40%, calculate the mass of water which must flow through the turbine each second to produce power output of 1MW.
(g=10 m s^{-2}).

Solutions:
Potential energy = mgh
Efficiency = 40%
Useful work done = 40% of potential energy
= 40 / 100 (mgh)
= 0.4 (m × 10 × 50)
= 200 m
Power = work done per second
1MW = 200 × mass of water flowing each second
1×10^6W = 200 × mass of water flowing each second
mass of water flowing each second = $(1 \times 10^6) / 200$
= 5000 kg

Question: 6

The bob of a simple pendulum is imparted a velocity of 5m s^{-1} when it is at its mean position. To what maximum vertical height will it rise on reaching at its extreme position if 60% of its energy is lost in overcoming the friction of air?
(Take g = 10 m s^{-2}).

Solutions:
Total kinetic energy at mean position = $1 / 2\ mv^2$
= $1 / 2\ m \times 5^2$
Energy lost = $1 / 2\ m \times 5^2 \times 60 / 100$
Energy available = $1 / 2\ m \times 5^2 \times 40 / 100$
According to energy conservation
$1 / 2\ m \times 5^2 \times 40 / 100 = mgh$
5 = 10 × h
h = 0.5m

Assignment :

- **Selina Book Exercise work. (first you all try to solve all and then finally check with answers provided to you in the study materials whether correct or not)**
- **Solve last 12 years Board Question Papers related to chapter-2.**

Note:

- **Materials provided to you are strictly based on board syllabuses as provided.**
- **Remember concept related to the chapter are more important so, understand it, do not go through only reading. While going through study materials or your book if you face any problem in understanding write it in your notebook ask during class hour as school reopen, doubts will be surely clarify.**
- ***I will be appearing to you all with a short video next online class explaining synopsis of the chapter 1 and 2 and with few revision assignment.***

See you all soon till then stay at home with your family members, stay safe, keep well and obviously study hard maintaining a daily routine made by you.
Thank you.