MODULE-01

WORK & ENERGY

Work

WORK & ENERGY

Concept of work

- **Unit of work (S.I & CGS)**
- **Define 1J**

1. Define work.

Work is said to be done whenever a force acts on a object and it displaces in the direction of applied force.

2.How work ,force and displacement are related to each other.

$$\therefore \text{Work} = \text{Force} \times \text{Displacement}$$

$$W = F \times s$$

MODULE-02

3. Write M.K.S & C.G.S unit of work, if

Work = force x displacement

M.K.S 1 joule (J) = 1 newton (N) × 1 meter

4. Define 1 J

The amount of *Work* done when a *Force* of 1N acts on an object displaces *Displacement* through a distance of 1m

Along it's own direction.

is said to be 1J.

1 dyne

1 cm

1 erg

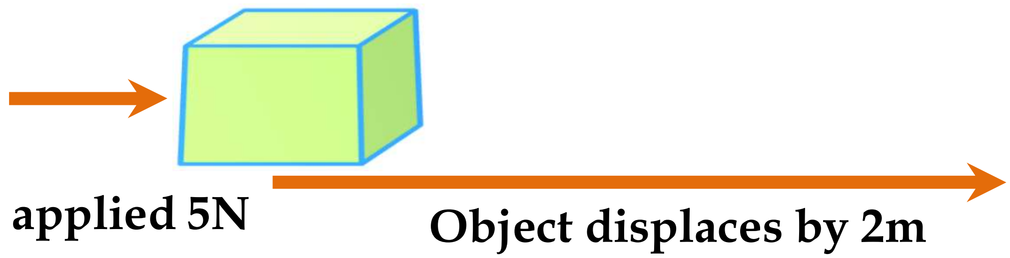
C.G.S 1 erg = 1 dyne × 1 centimeter

Define 1 erg (classroom activity)

1 A Force of 5 N is acts on an object and the object is displaced to a distance of 2 m in the direction of the force. Find the work done?

Given : Force(F) = 5 N

Distance travelled by object(s) = 2 m



To find : Work done(W) = ?

Formula : $W = F \times s$

Solution : $W = F \times s$

$\therefore W = 5 \times 2$

$\therefore W = 10\ J$

Ans : Thus the work done in given condition is 10 J.

MODULE-03

WORK & ENERGY

Does energy and work has same unit

- **Positive work**
- **Negative work**
- **Neutral work**

Does energy and work has same units? YES

UNITS

S.I
joule(J)
{N-m}

C.G.S
erg
{dyne-cm}

Relation between S.I and C.G.S units of energy :

1 joule = 1 N x 1 m ($1\ N = 10^5$ dyne , $1\ m = 100$ cm)

= 10^5 dyne x 10^2 cm

= 10^7 dyne - cm

1 joule = 10^7 erg

1. How does the angle between the force applied and the displacement of an object effects the nature of work done

Product of the given factors are of two types

Dot (·)

A dot product is a cos product

example, a.b = ab cos θ

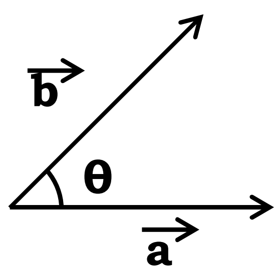
a and b are the given vect nd ‘θ’ is the angle between the vect

Cross (×)

A cross product is a sin product

a × b = ab sin θ

Where cos and sin are the trigonometric ratios



MODULE-04

Thus Work $= F.s$

$W = F\,s\cos\theta$

Case i.

When 'F' and 's' are in the same direction i.e., F ॥ s and 'θ' = 0⁰

parallel

$W = F\,s\cos 0^0$

$W = F\,s\,(1)$

$\boxed{W = F\,s}$

[cos 0⁰ = 1]

Thus work done is positive.

Since F॥S so 'θ' is 0⁰

Case ii.

When Force 'F' and displacement 's' are in opposite direction i.e. 'θ' is 180⁰

$W = F\,s\cos\theta$

$W = F\,s\cos 180^0$

$W = F\,s\,(-1)$

$\boxed{W = -F\,s}$

[cos180⁰ = −1]

Thus work done is negative.

Case iii.

When Force 'F' and displacement "s" are normal to each other i.e., $\theta = 90^0$

$W = F\ s \cos \theta^0$

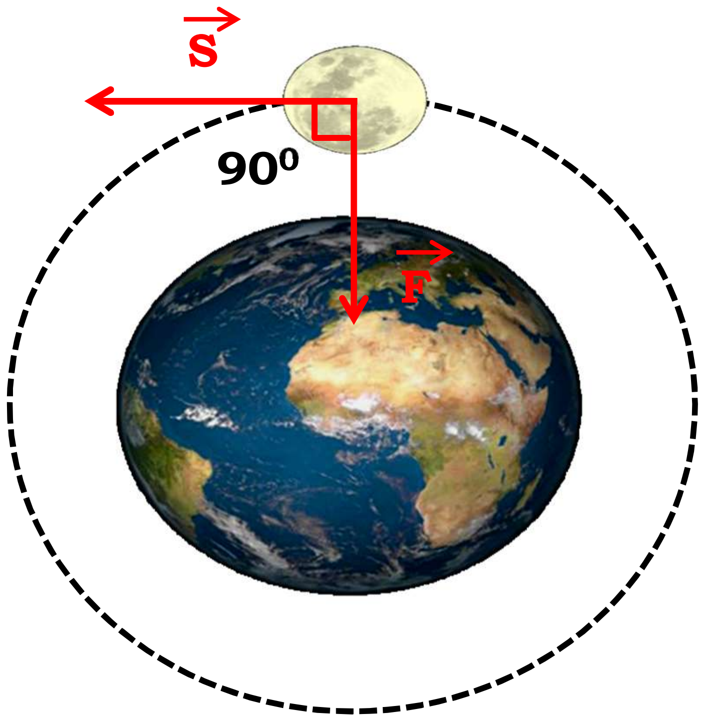
$W = F\ s \cos 90^0$

$W = F\ s\ (0)$

$\boxed{W = 0}$

$\cos 90^0 = 0$

Thus work done is neutral or no work is done when the force applied and displacement are normal to each other.



MODULE-05

WORK & ENERGY

Numerical based on neutral work

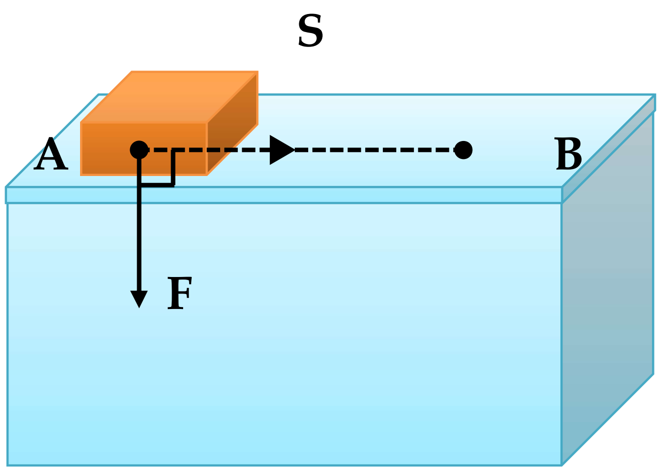
- **Types of energy**

1

A mass of 10 kg is at a point A on the table. It moved to a point B. If the line joining A and B is horizontal, what is the work done on the object by the gravitational force? Explain your answer.

Given : Mass (m) = 10 kg

Displacement (AB) is horizontal



To find : Work done on the object by the gravitational force = ?

Formula : Work done = F S cos 90^0

Solution : Force of gravitation acts downwards

The angle between the force and displacement is 90^0

Work done = F S cos 90^0

= F S × 0 [cos 90^0 = 0]

= 0 J

Ans : Thus work done is zero.

2 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?

Given : Force (F) = 140 N

Displacement (s) = 15 m

To find : Work done = ?

Formula : Work done $= F \times S$

Solution : Work done $= F \times S$

$= 140 \times 15$

$= 2100$ J

Ans : Thus work done in ploughing the field is 2100 J

Types of ENERGY

Heat Energy

Wind Energy

Sound Energy

Electrical Energy

Light Energy

Tidal Energy

Define energy.

It is the capacity to do work.

Mechanical Energy

Kinetic Energy

The energy possessed by virtue of it's motion

Potential Energy

The energy possessed by virtue of it's position or shape.

MODULE-06

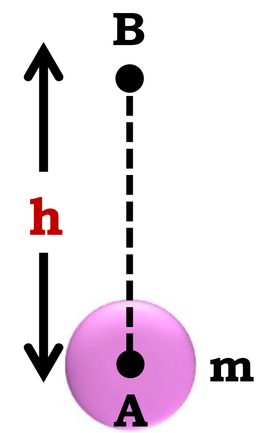
WORK & ENERGY

Work done in lifting an object.

- **Work done against gravity is independent of path followed by the object.**

Derive an expression for the work done in lifting an object of mass ‘m’ to a height ‘h’.

Let us consider an object of mass ‘m’.



Thus the work done in lifting the object of mass ‘m’ to a height ‘h’.

Work done = Force × Displacement

= F × s

ma

= ma h

Height – ‘h’

W = mgh

due to gravity

(a) = g

Thus the work done is given by the equation

$$W = mgh$$

Where W = work done

m = Mass of the object

g = Acceleration due to gravity

h = Height to which the object is raised

This work done is stored in the form of Gravitational potential energy.

1 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. ($g = 10 ms^{-2}$)

Given : Mass of luggage (m) = 15 kg
Displacement (s) = 1.5 m

To find : Work done (W) = ?

Formula : $F = m \times g$
$W = F \times s$

Solution :

$F = m \times g$

$\therefore F = 15 \times 10$

$\therefore F = 150$ N

$W = F \times s$

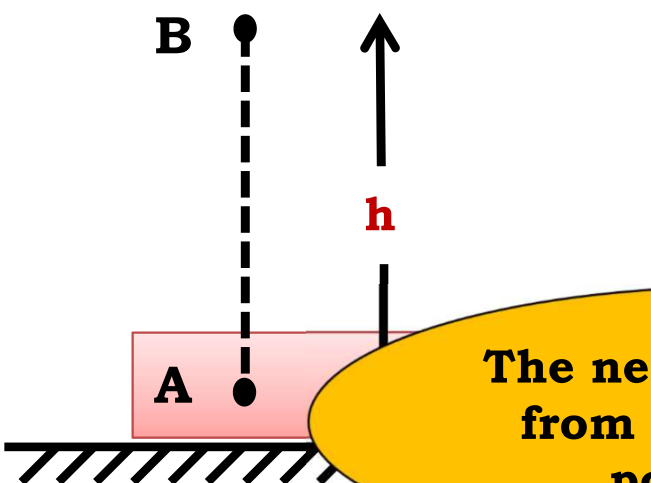
$\therefore W = 150 \times 1.5$

$\therefore W = 225$ J

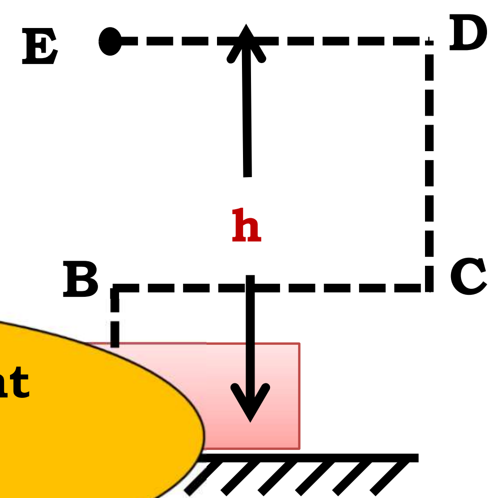
Ans : The work done is 225 J.

Thus the work done against gravity is independent of the path along which the body is moved & it depends only on the initial & final positions of the body.

Case i



Case ii



The net displacement from initial & final position (h)

Work done in moving the bod
the path AB to rise it to a height ‘h’

$$W = F \times S$$
$$= mg\,h$$
$$W = P.E$$

in moving the body along
the pa E to rise it to a height ‘h’

$$W = F \times S$$
$$= mg\,h$$
$$W = P.E$$

1 An object of mass 12 kg is at a certain height above the ground. If the potential energy of the object is 480 J, find the height at which the object is with respect to the ground. Given, $g = 10\ m\ s^{-2}$.

Given : Mass (m) = 12 kg

Potential Energy (P.E.) = 480 J

g = $10\ m\ s^{-2}$

To find : Potential energy = ?

Formula : Potential energy = mgh

Solution : Potential energy = mgh

$$\therefore \quad 480 = 12 \times 10 \times h$$

$$\therefore \quad h = \frac{480}{120}$$

$$\therefore \quad h = 4\ m$$

Ans : The object is at the height of 4 m.

2 Find the energy possessed by an object of mass 10 kg when it is at a height of 6 m above the ground. Given, $g = 9.8 \text{ m s}^{-2}$.

Given : Mass (m) = 10 kg

Displacement (h) = 6 m

(g) = 9.8 m s^{-2}

To find : Potential energy = ?

Formula : Potential energy = mgh

Solution : Potential energy = mgh

$= 10 \times 9.8 \times 6$

$= 588$ J

Ans : The potential energy is 588 J.

MODULE-07

WORK & ENERGY

Work done in terms of change in K.E

- **To find the work done by the force in case of change in K.E**

1. Derive an expression of work done in terms of change in kinetic energy

Work = Force ×displace

= F × S

F = m

$\left(\dfrac{v^2 - u^2}{\right)$

$v^2 = u^2 + 2as$

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

$s = \dfrac{v^2 - u^2}{2a}$

The work done is equal to the kinetic energy when an object starts from rest.

$= \dfrac{1}{2} m v^2 - \boxed{0\ J}$

$\therefore K.E = \dfrac{1}{2} mv^2$ (when $u = 0 ms^{-1}$)

$= K.E_{(final)} - K.E_{(initial)}$

Thus, **Work done = Change in kinetic energy**

1 An object of mass 15 kg is moving with a uniform velocity of 4 m s^{-1}. What is the kinetic energy possessed by the object?

Given : Mass (m) = 15 kg

Velocity (v) = 4 m s^{-1}

To find : K.E. = ?

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

Solution :

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

$$= \frac{1}{2} \times 15 \times (4)^2$$

$$= \frac{1}{\cancel{2}_{1}} \times 15 \times \cancel{4}^{2} \times 4$$

$$= 15 \times 2 \times 4$$

$$= 120 \text{ J}$$

Ans : The kinetic energy of the object is 120 J.

2 Certain force acting on a 20 kg mass changes its velocity from 5 m s^{-1} to 2 m s^{-1}. Calculate the work done by the force.

Given : Mass (m) = 20 kg

Initial velocity (u) = 5 ms^{-1}

Final velocity (v) = 2 ms^{-1}

To find : Work done (W) = ?

Formula : $F = m \times g$

Solution : Work done(W) = Change in K.E

$$= K.E_{(final)} - K.E_{(initial)}$$

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

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

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

$$= \frac{1}{\cancel{2}_{1}} \times \cancel{20}^{10} [4 - 25]$$

$$= 10 \times (-21)$$

$$\therefore \quad W = -210 \text{ J}$$

Ans : The work done by the force is 210 J and the negative sign indicates the applied force is retarding in nature.

MODULE-08

Give reason kinetic energy is always positive.

- **Formula : $\frac{1}{2} mv^2$**
- **Mass is always positive.**
- **'v' can be either positive or negative but v^2 is always positive.**

K.E exists in only one form - POSITIVE

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

Given : Mass of the car (m) = 20 kg

Initial velocity (u) = 60km/h

$$= \cancel{60}^{10} \times \frac{5}{\cancel{18}_{3}} \text{ m s}^{-1} = \frac{50}{3} \text{ ms}^{-1}$$

Final velocity (v) = 0 ms^{-1}

To find : The work required to be done to stop the car.

Formula : $F = m \times g$

Solution : Work done(W) = Change in K.E

$$= K.E_{(final)} - K.E_{(initial)}$$

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

$$\therefore \quad W = \frac{1}{2} m(0)^2 - \frac{1}{2} mu^2$$

$$\therefore \quad W = -\frac{1}{2} mu^2$$

$$\therefore \quad W = -\frac{1}{2} \times 1500 \times \left(\frac{50}{3}\right)^2$$

$$= -\frac{1}{\cancel{2}} \times \overset{250}{\cancel{\overset{500}{\cancel{1500}}}} \times \frac{50}{\cancel{3}} \times \frac{50}{3}$$

$$= -\frac{250 \times 50 \times 50}{3}$$

$$= \frac{-625000}{3}$$

$$\therefore \quad W = -208333.3 \text{ J}$$

Ans : Thus the work done to stop the moving car is 208333.3 J

4 What is the work to be done to increase the velocity of a car from 30 km h^{-1} to 60 km h^{-1} if the mass of the car is 1500 kg?

Given : Initial velocity (u) = 30 km h^{-1}

$$= \cancel{30}^{5} \times \frac{5}{\cancel{18}_{3}} \text{ m s}^{-1} = \frac{25}{3} \text{ ms}^{-1}$$

Final velocity (v) = 60 km h^{-1}

$$= \cancel{60}^{10} \times \frac{5}{\cancel{18}_{3}} \text{ m s}^{-1} = \frac{50}{3} \text{ ms}^{-1}$$

Mass (m) = 1500 kg

To find : Work done (W) = ?

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

Solution : Work done(W) = Change in K.E

$= K.E_{(final)} - K.E_{(initial)}$

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

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

$$= \frac{1}{\cancel{2}_{1}} \times \cancel{1500}^{750} \times \left[\left(\frac{50}{3}\right)^2 - \left(\frac{25}{3}\right)^2\right]$$

$$= 750 \times \left[\frac{2500}{9} - \frac{625}{9}\right]$$

$$= 750 \times \left[\frac{2500 - 625}{9}\right]$$

250 625

1

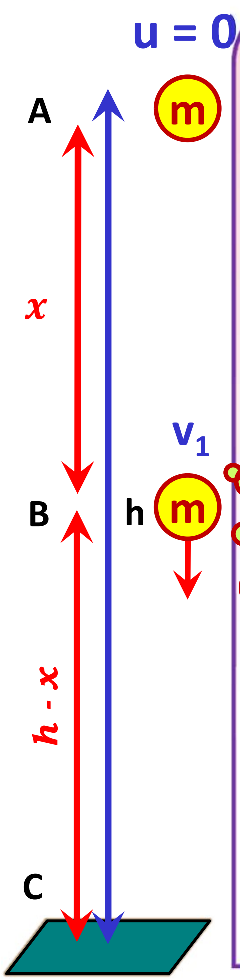
Ans : The work done to increase the velocity of the car is 156250 J

MODULE-09

WORK & ENERGY

Verification of Law of conservation of energy in case of a free fall.

In a freely falling body total energy remains constant at each point.



At point A,

K.E = ½ mv^2 = 0

P.E = mgh

T.E = P.E + K.

= mgh +

T.E = m

In

Fi

a distance x

At point B,

According to 3^{rd} equation of motion

nce on substituti

P.E = mg (h – x)

x + mgx

Displacement

2gx,

= ½ m × 2g(x)

K.E = mg$x$

At B above the ground level (h - x)

At point C,

According to 3^{rd} equation of motion

$v^2 = u^2 + 2as$

u = 0, a = g, s = h

Hence on subs. we get,

v^2 = 2gh

mv^2

v^2 = 2gh,

× 2gh

d level h = 0

h = 0

T.E = P.E + K.E

= 0 + mgh

$\boxed{\text{T.E = mgh}}$

But Total Energy at every point always remains CONSTANT

KINETIC ENERGY increases as ball moved from point A→B→C

POTENTIAL ENERGY decreases as ball moved from point A→B→C

Show that energy in case of free fall of a body is conserved.

Potential energy of the object at 'A'

P.E $= mgh$ J

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

$= \boxed{0\ J}$

The object travels a distance 'x' from the top

at a height 'h' from the surface.

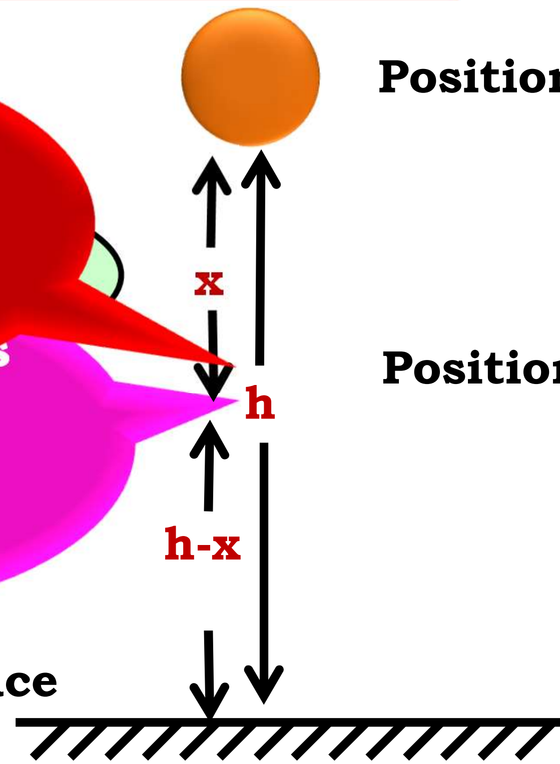
Thus

Total energy $(T.E)_A$ = P.E +

$= mgh + 0$

$T.E_A = \boxed{mgh}$

Position 'A'



Position 'B'

Height of the object at position 'B' from the surface of the earth $= (h-x)$

P.E of the object at point 'B'

$P.E_{(B)} = mg(h-x)$

$P.E_{(B)} = mgh - mgx$

To find K.E of the object at point 'B' K.E $= \frac{1}{2} mv^2$

To find K.E at point ‘B’ let’… first

$V^2 = u^2$ …

$V^2 = 0$ …

$V^2 = \boxed{2g\,x}$

The object travels a distance ‘x’ from the top

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

$v^2 = 2gx$

$= \frac{1}{\cancel{2}} m (\cancel{2}gx)$

$= \boxed{mgx}$

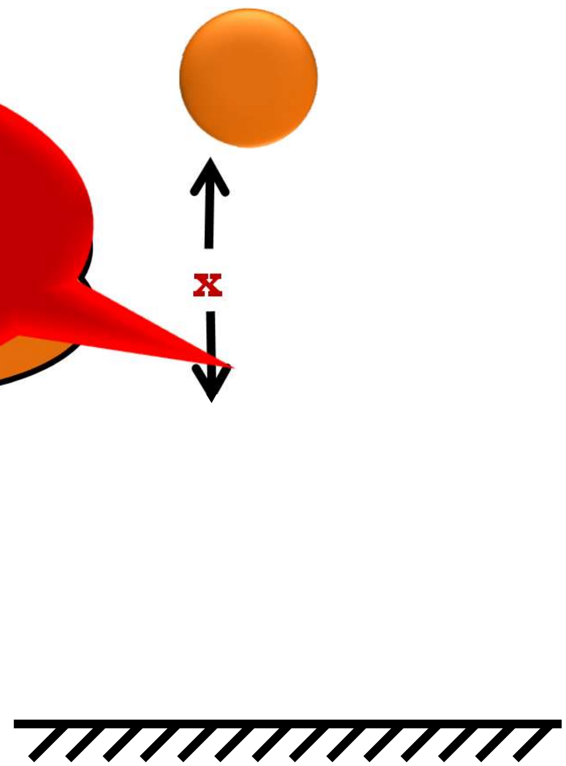
Thus

$T.E_{(B)} = P.E_{(B)} + K.E_{(B)}$

$= (mgh - mgx) + mgx$

$= mgh - \cancel{mgx} + \cancel{mgx}$

$T.E_{(B)} = \boxed{mgh}$



MODULE-10

To find K.E at point 'C' let's find 'v' first

$V^2 = u^2 +$

$V^2 = 0 +$

$V^2 = \boxed{2g\,h}$

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

$= \frac{1}{\cancel{2}} m (\cancel{2}gh)$

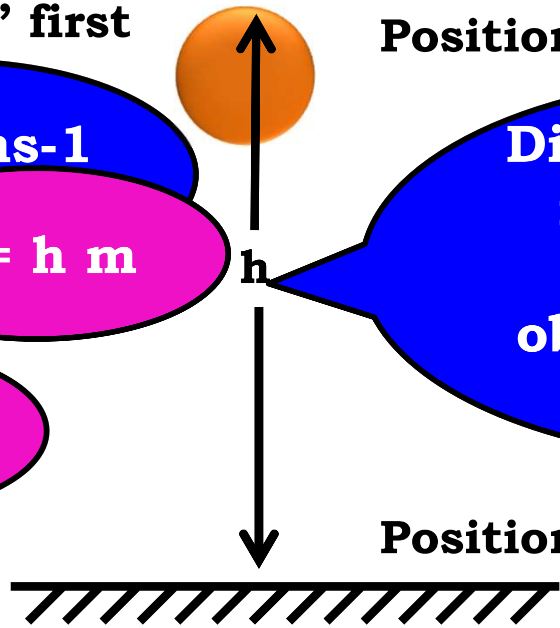
$= \boxed{mgh}$

u = 0 ms-1

s = h m

v² = 2gh

Position 'A'



Distance travelled is equal to the height of the object from point 'A'

Position 'C'

Thus K.E$_{(c)}$ = mgh

Now Potential energy at point 'C' P.E$_{(C)}$ = mgh

$= mg \times 0$

Potential energy at point 'C' P.E$_{(C)}$ = 0 J

Thus total energy at point 'C' $T.E_{(C)} = P.E_{(C)} + K.E_{(C)}$

$= 0 + mgh$

$T.E_{(C)} = \boxed{mgh}$

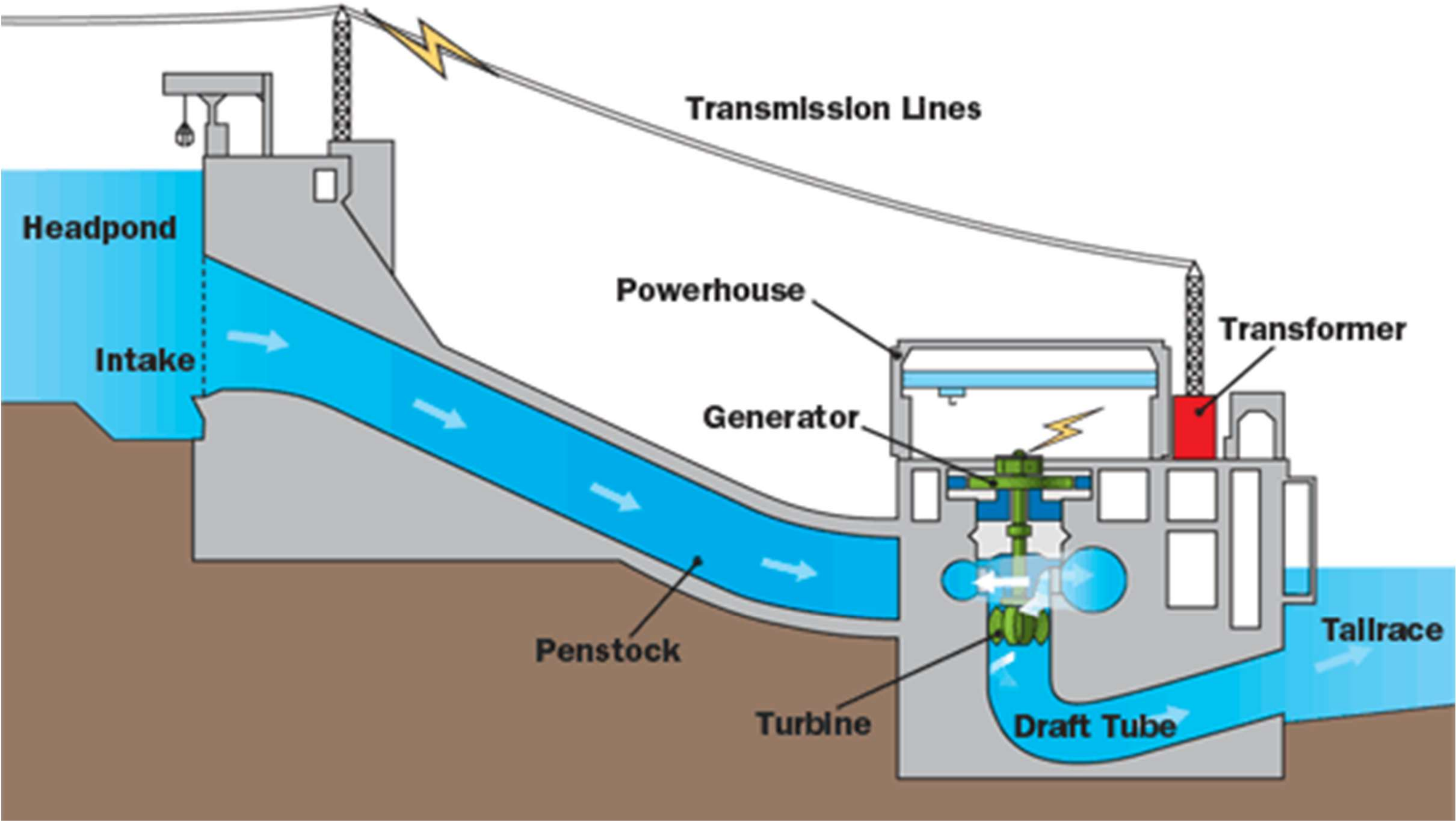
Thus the total energy of the body is constant and is equal to mgh.

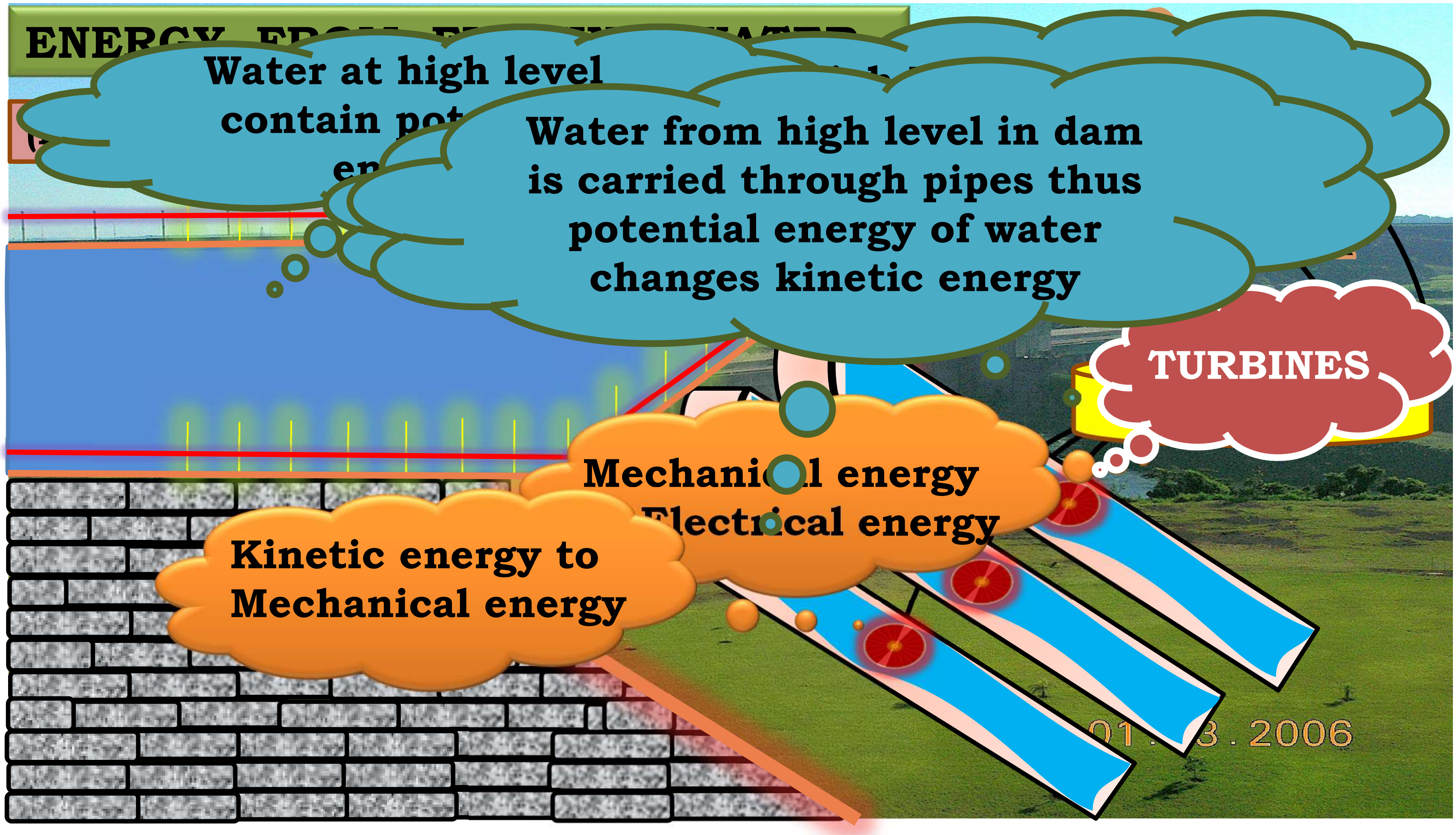
This verifies the law of conservation of energy.

MODULE-12

WORK & ENERGY

Law of conservation of energy


Transmission Lines
Headpond
Intake
Powerhouse
Transformer
Generator
Penstock
Turbine
Draft Tube
Tailrace


ENERGY FROM ...
Water at high level contain pot...
Water from high level in dam is carried through pipes thus potential energy of water changes kinetic energy
TURBINES
Mechanical energy
Electrical energy
Kinetic energy to Mechanical energy
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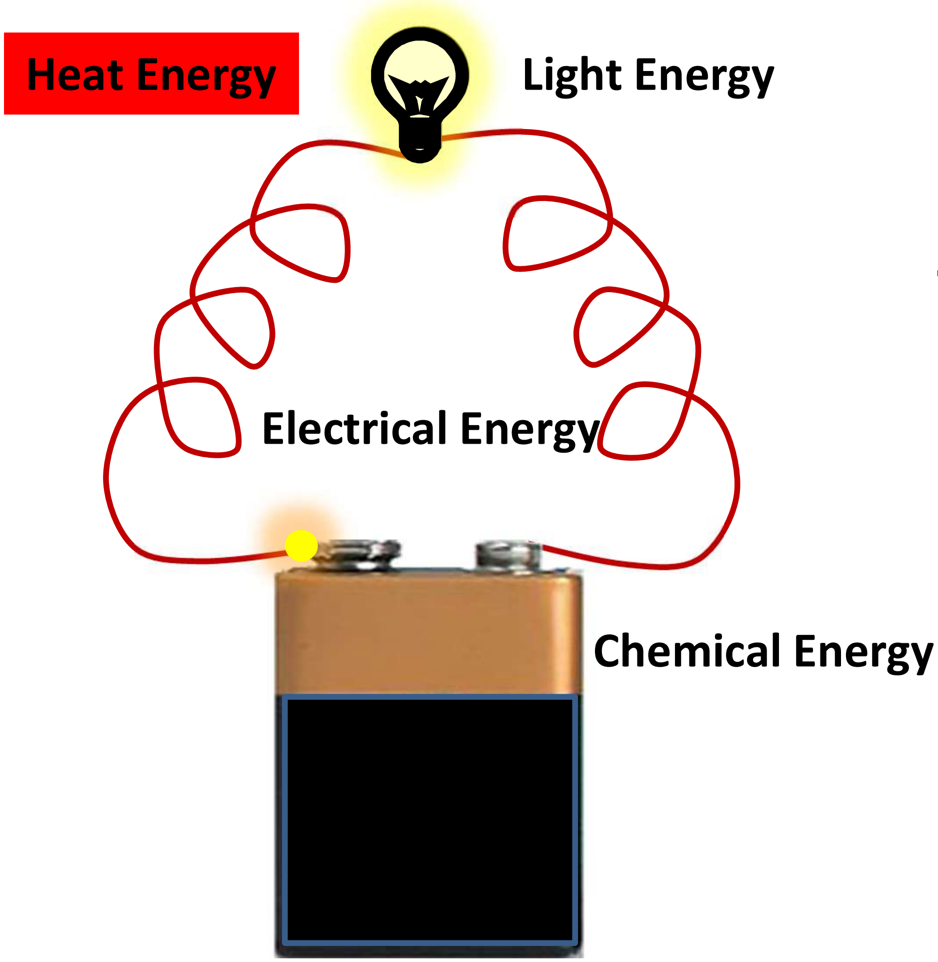
Law Of Conservation Of Energy



Energy can neither be created nor destroyed. It changes from one for to another.

The total amount of energy in the universe always remains constant.

MODULE-13

WORK & ENERGY

Electrical power

- **Commercial unit of electrical energy**
- **Define 1J**

POWER

Power is defined as the work done per unit time

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

Power is a scalar quantity

Units

S.I.

$$1 \text{ watt} = \frac{1 \text{ Joule}}{1 \text{ Sec}}$$

(W)

C.G.S.

$$\frac{\text{Erg}}{\text{Sec}}$$

1 watt Power developed or used is one watt when one joule of work is done in 1 sec

Higher units **kilowatt** (1 kilowatt = 1000 watt)

Commercial unit of energy

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

$$\text{Power} = \frac{\text{Energy Used}}{\text{Time}}$$

Energy Used = Power X Time

Watt changes to kW
Second changes to Hour (hr)

ENERGY USED = kW-hr

1 unit

Horsepower

1 horsepower =	746 watt

MODULE-14

WORK & ENERGY

- **Electrical energy used,**
- **Heat energy = Power x time**
- **$H = P\,t$**

1

A bulb of 40 W is used for 12.5 h each day for 30 days. Calculate the electrical energy consumed.

Given : Power of the lamp (P) = 40 W

Time for which bulb is used for each day = 12.5 h

To find : Energy consumed (H) = ?

Formula : $H = P \times t$

Solution : H = Power in watt × Time in hours

$\therefore H = 40 \times 12.5$

$\therefore H = 500\ \text{Wh} = \dfrac{500}{1000}\ \text{kWh} = 0.5\ \text{kWh}$

Electrical energy consumed in 30 days $= 0.5\ \text{kWh} \times 30\ \text{Wh}$

$= 15\ \text{kWh}$

Ans : The electrical energy consumed by the bulb for 30 days is 15 kWh

2 An electric iron is rated at 750 W, 230 V. Calculate the electrical energy consumed by the iron in 16 hours.

Given : Power (P) = 750 W = $\frac{750}{1000}$ kW = 0.75 kW

Time (t) = 16 h

To find : Energy used (H) = ?

Formula : $H = P \times t$

Solution : H = Power × Time

= 0.75×16

= 12 kWh

Ans : The electrical energy consumed by the iron in 16 hours is 12 kWh

3

An electric bulb of 60 W is used for 6 h per day. Calculate the 'units' of energy consumed in one day by the bulb.

Given : Power (P) = 60 W

= 0.06 kW

Time (t) = 6 h

To find : Energy = ?

Formula : $H = P \times t$

Solution : Energy = Power × Time taken

= 0.06×6

= 0.36 kW h

$\therefore$ Energy = 0.36 units

Ans : The energy consumed by the bulb is 0.36 'units'.

MODULE-15

Work , Energy and Power

- Relation between commercial & SI unit of energy
- Numerical based on Electrical Power

Relation between Commercial & S.I. unit of work

WORK = Power X Time

S.I. unit - Joule = Watt x Second

Commercial unit = kW-hr

1kW - hr = 1ooo W x 3600 s

1kW - hr = 36×10^5 W.s

1 kW - hr = 36×10^5 JOULE

$$\boxed{1\ kW - hr = 3.6 \times 10^6\ J}$$

1

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

Given : Unit of energy used = 250 units

To find : Energy used in joules = ?

Formula : 1 unit = 1 kWh

1 kW = 1000 W

1 h = 3600 sec.

$\therefore$ 1kWh = 3.6×10^6 J

Solution : 1 unit of energy = 1kWh

$= 3.6 \times 10^6$J

250 units of energy $= 250 \times 3.6 \times 10^6$

$= 25 \times 3.6 \times 10^7$ J

$= 90 \times 10^7$ J

$= 9 \times 10^8$J

Ans : Thus the amount of energy used in 250 units is 9×10^8J

MODULE-16

Work , Energy and Power

- **Numerical based on Electricity bill calculation**

1

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

Given : Electrical power of the heater = 1500 W

= 1.5 kW

Time = 10 hours

$$\frac{1500}{1000} = 1.5\text{kW}$$

To find : Energy used in kWh = ?

Formula : Energy used = Power × Time

Solution : Energy used = Power × Time

= 1.5 × 10

= 15 kWh

Ans : Energy used in 10 hours is 15 kWh

2 Find the energy in kWh consumed in 10 hours by 4 devices of power 500 W each.

Given : Power of each device = 500 W

No of device = 4

Total power = 4 × 500

= 2000 W = 2 kW

$$\frac{2000}{1000} = 2kW$$

To find : Energy used = ?

Formula : Energy used = Power × Tim

Solution : Energy used = Power

= 2 × 10

= 20 kWh

Ans : The energy consumed by four devices of 500 W each operated for 10 hours a day is 20 kWh.

MODULE-17

Work , Energy and Power

- **Numerical based on Electricity bill calculation**

WORK & ENERGY

TYPE -A

VSA ,1 Mark questions

- **For section- A from Q. No. 1 - 3**

1

A car and track are moving with the same velocity of 60 km/hr. which of them has more kinetic energy

Ans : K.E is directly proportional to m
Thus the truck has more K.E

2

Define 1 joule of work .

Ans : 1 joule – The amount of work done when a force of 1N acts on an object displace it to a distance of 1m along the direction of force , the magnitude of work is said to be 1J.

3

Seema tried to push a heavy rock of 100 kg for 200 sec but could not move it. Find the work done by Seema at the end of 200s.

Ans : **Since displacement is zero**
Thus work done is zero.

4

How much work is done by a weight lighter when he holds a weight of 80kg on his shoulders for two minutes?

Ans : **Since displacement is zero**
Thus work done by the weight lifter is zero

5 When displacement is in a direction opposite to the direction of applied , what is the type of work.

Ans : When Force 'F' and displacement 's' are in opposite direction i.e. 'θ' is 180^0

$W = F s \cos\theta$

$W = F s \cos 180^0$

$W = F s (-1)$

$\boxed{W = - F s}$

[$\cos 180^0 = -1$]

Thus work done is negative.

6 Write the observed energy transformation that takes place at hydroelectric power plant.

Ans : P.E. $\rightarrow$ K.E. $\rightarrow$ M.E. $\rightarrow$ Electrical energy

7 How many joules makes 1 kilowatt hour?

Ans : kWhr = 3.6×10^6 J

8 When a player hits a football it moves along a curved path and then falls to the ground. Calculate the work done by the force of gravity on the football.

Ans : When a player hits a football it rises up along the curve path and then falls to the ground then the work done by the force of gravity is,

$$W = mgh \quad h = 0\ m$$

$$= mg \times 0$$

Thus, no work is done as displacement is zero.

MODULE-18

WORK & ENERGY

TYPE -B

SA-I , 2 Mark questions

- **For section- A from Q. No. 4 - 7**

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

1 A man weighing 500 N carries a load of 100 N up a height of stairs 4 m high in 5 seconds. What is his power ?

Given : Total Weight = Weight of man + Weight of the load

$= (500 + 100)$

$= 600\text{ N}$

Weight = Force

Force (F) = 600 N

Displacement (s) = 4m

Time (t) = 5 s

To find : Power of the man = ?

Formula : $\text{Power} = \dfrac{\text{Work done}}{\text{time}}$

Solution : $\text{Power} = \dfrac{\text{Work done}}{\text{time}}$

$= \dfrac{F \times s}{t}$

$\therefore \text{Power} = \dfrac{\overset{120}{\cancel{600}} \times 4}{\underset{1}{\cancel{5}}}$

$= 120 \times 4 = 480\text{ W}$

Ans : The power of the man is 480 W

MODULE-19

WORK & ENERGY

SA-I, 2 Mark questions

- **For section- A from Q. No. 4 - 7**

$$\text{Power} = \frac{\text{P.E}}{\text{Time}}$$

1

A boy of mass 50 kg runs up a staircase of 45 steps in 9 s. If the height of each step is 15 cm, find his power. Take $g = 10\ m\ s^{-2}$.

Given :

Mass of boy (m) = 50 kg

Height of staircase (h) = Height of each step × No . of steps

= 15 × 45

= 675 cm = $\frac{675}{100}$ = 6.75 m

Time taken to climb (t) = 9 s

Acceleration due to gravity (g) = $10\ m\ s^{-2}$

To find : Power (P) = ?

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

Solution : $P = \frac{P.I}{t}$

$= \frac{m \times g \times h}{t}$

× 10 × 6.75 / 9

= 375 / 9 = 375 W

Work done = P.E.

Ans : The power of the boy is 375 W

2 Calculate the power of a pump which can lift 100 kg of water to store it in a water tank at a height of 19 m in 25 sec. [Take $g = 10 \text{ m s}^{-2}$]

Given :

Mass (m) = 100 kg

Height (h) = 19m

time (t) = 25 sec

$g = 10 \text{ms}^{-2}$

To find : Power of the pump = ?

Formula : $\text{Power} = \dfrac{\text{Work done}}{\text{time}}$

Solution : $\text{Power} = \dfrac{\text{Work done}}{\text{time}}$

$\therefore \quad \text{Power} = \dfrac{\text{P. E.}}{\text{time}}$

$\therefore \quad \text{Power} = \dfrac{mgh}{t}$

$= \dfrac{\cancel{100}^{4} \times 10 \times 19}{\cancel{25}_{1}}$

$= 4 \times 10 \times 19$

$= 40 \times 19$

$= 760 \text{ W}$

Ans : Thus the power of the pump is 760W

MODULE-20

1 Two girls, each of weight 400N, climb up a rope through a height of 8m. We name one of the girl as 'A' & other as 'B'. Girl 'A' takes 20 seconds while 'B' tales 50 seconds to accomplish this take. What is the power expended by each girl ?

Given : Weight of girls (mg) = 400N

Height (h) = 8m

Time taken by girl A (t_a) = 20s

Time taken by girl B (t_b) = 50s

To find : Power (P_A) and (P_B)=

Formula : $\text{Power} = \frac{\text{Work done}}{\text{Time}}$

Work done = P.E.

Solution : $\text{Power}_{(A)} = \frac{\text{Work done}}{\text{Time}}$

mg = Weight

$= \frac{\text{P.E}}{\text{Time}} = \frac{mgh}{t_a}$

$= \frac{40\cancel{0} \times \cancel{8}^{\,4}}{{}_{1}\,\cancel{2}\cancel{0}}$

$= 40 \times 4 = 160\text{ W}$

$\text{Power}_{(B)} = \frac{\text{P.E}}{\text{Time}} = \frac{mgh}{t_b}$

$= \frac{{}^{8}\cancel{4}\cancel{0}\cancel{0} \times 8}{{}_{1}\,\cancel{5}\cancel{0}}$

$= 8 \times 8 = 64\text{ W}$

Ans : Power expended by girl A is 160 W and girl B is 64 W.

MODULE-21

WORK & ENERGY

SA –I , 2 Mark questions

- **For section- A from Q. No. 4 - 7**

$v^2 = u^2 + 2gs$

1 If a 5kg ball is thrown upwards with a speed of $100ms^{-1}$ then calculate the maximum height attained by it (take $g = 10ms^{-2}$).

Given :

Mass (m) = 5kg

Initial speed (u) = $10ms^{-1}$

Final velocity (v) = $0ms^{-1}$

$g = 10ms^{-2}$

To find : maximum height attained (s) = ?

Formula : $v^2 = u^2 + 2gs$

Solution :

$$v^2 = u^2 + 2gs$$

$$(0)^2 = (10)^2 + 2\,(-10)\,s$$

$$0 = 100 - 20\,s$$

$$20s = 100$$

$$s = \frac{\overset{5}{\cancel{100}}}{\underset{1}{\cancel{20}}}$$

$$= 5m$$

$g = -10ms^{-2}$
against gravity

i) $v = u + gt$

ii) $s = ut + \frac{1}{2}gt^2$

iii) $v^2 = u^2 + 2gs$

Ans : The maximum height attained by it is 5m

MODULE-22

WORK & ENERGY

SA-I , 2 Mark questions

- **For section- A from Q. No. 4 - 7**

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

1 A lamp used 100 J electrical energy in 10s. What is it's power?

Given : Energy used (H) = 1000J

time (t) = 10s

To find : Power of the lamp (P) = ?

Formula : $\text{Power} = \dfrac{\text{Energy used}}{\text{time}}$

Solution : $P = \dfrac{H}{t}$

$= \dfrac{100\cancel{0}}{1\cancel{0}}$

$= 100\ W$

Ans : Power used by the lamp is 100 W

MODULE-23

WORK & ENERGY

SA-I , 2 Mark questions

- **For section- A from Q. No. 4 - 7**

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

1 The kinetic energy of an object of mass 'm' moving with a velocity of $5 ms^{-1}$ is 25J. Calculate it's kinetic energy when the velocity is doubled. What will be its kinetic energy when its velocity is increased three times?

Given :

Mass = m kg

Initial velocity (v_1) = $5\ m\ s^{-1}$

Initial K.E.$_1$ = 25 J

To find : K.E.$_2$ when the velocity is doubled = ?

K.E.$_3$ when the velocity is tripled = ?

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

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

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

$K.E._2 = \frac{1}{2} mv_2^2$

$= \frac{1}{2} m(2v$

$= \frac{1}{2} m4v_1$

$= 4\left(\frac{1}{2} mv_1^2\right.$

$K.E._3 = \frac{1}{2} mv_3^2$

1

$= \frac{1}{2} m9v_1^2$

$= 9\left(\frac{1}{2} mv_1^2\right)$

× 25 J

= 225 J

$v_2 = 2v_1$

$3v_1$

$\frac{1}{2} mv_1^2 = K.E_I$

$\frac{1}{2} mv_1^2 = K.E_I = 25J$

Ans : A velocity doubles, K.E.

As velocity triples, K.E. increases 9 times

MODULE-24

WORK & ENERGY

SA-I , 2 Mark questions

- **For section- A from Q. No. 4 - 7**

Law of conservation of energy

1

A ball of mass 0.2 kg is thrown vertically upwards with an initial velocity of 20 ms^{-1}. Calculate the maximum potential energy it gains as it goes up.

Given : Mass (m) = 0.2 kg

Initial Velocity (u) = 20 $m\ s^{-1}$

To find : P.E. = ?

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

Solution : According to the law of conservation of energy

At max. height the P.E will be equal to the initial K.E.

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

$$K.E. = \frac{1}{2} \times 0.2 \times (20)^2$$

$$= \frac{1}{\cancel{2}_{1}} \times \cancel{0.2}^{0.1} \times 400$$

$$= 0.1 \times 400$$

$$\therefore \quad K.E. = 40\ J$$

Ans : Thus the maximum P.E. it gains as it goes up is equal to 40 J.

2

An object of mass 40 kg is raised to a height of 5 m above the ground. What is its potential energy? If the object is allowed to fall, find its kinetic energy when it is half-way down

Given : Vertical displacement (h) = 5 m

Mass of the object (m) = 40 kg

Acceleration due to gravity (g) = $9.8\ m\ s^{-2}$

To find : Potential energy (P.E.) = ?

Formula : $W = mgh$

Solution :

$$W = mgh$$
$$= 40 \times 5 \times 9.8$$
$$= 1960\ J$$

At half-way down, the potential energy of the object will be $= \frac{1960}{2}$

$= 960\ J$

At this point, the object has an equal amount of potential and kinetic energy.

This is due to the law of conservation of energy.

Hence, half-way down, the kinetic energy of the object will be 980 J.

MODULE-25

WORK & ENERGY

SA-I , 2 Mark questions

- **For section- A from Q. No. 4 - 7**

Law of conservation of energy

3 A stone of mass 500g is thrown vertically upwards with a velocity of $15 ms^{-1}$. Calculate potential energy at the greatest height, kinetic energy on reaching the ground and the total energy at it's half way point.

Given : Mass (m) = 500 g = 0.5 kg

Velocity (u) = $15\ m\ s^{-1}$

(g) = $9.8\ m\ s^{-2}$

To find : P.E. at the greatest height.

K.E. on reaching the ground.

T.E. at it's half way point.

Formula : $$P.E = \frac{1}{2} mu^2$$

Solution : (a) P.E at the greatest height

According to the law of conservation of energy

P.E at maximum height = Initial kinetic energy

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

$$= \frac{1}{2} \times 0.5 \times (15)^2$$

$$= \frac{1}{2} \times 0.5 \times 225$$

$$= 0.5 \times 225$$

$$= 56.25\ J$$

Thus P.E at the greatest Height Is 56.25J

3

A stone of mass 500g is thrown vertically upwards with a velocity of 15ms^{-1}. Calculate potential energy at the greatest height, kinetic energy on reaching the ground and the total energy at it's half way point.

(b) According to the law of conservation of energy K.E of the stone on reaching the ground

= P.E. at the maximum height

= 56.25J

(c) According to the law of conservation of energy

Energy at every point is conserved.

Thus the total energy at it's half way point = 56.25J

MODULE-26

WORK & ENERGY

SA-I , 2 Mark questions

- **For section- A from Q. No. 4 - 7**

$$P = mg \cdot v$$

1 An elevator weighing 500 kg is to be lifted up at a Constant velocity of $0.4 ms^{-1}$. What should be the minimum horsepower of motor to be used? [$g = 9.8\ m\ s^{-2}$]

Given : Mass (m) = 500 kg

Velocity (u) = $0.4\ m\ s^{-1}$

(g) = $9.8\ m\ s^{-2}$

To find : The minimum horse power of motor to be used (P) = ?

Formula : $\text{Power} = \frac{\text{Work}}{\text{Time}}$

Solution : $\text{Power} = \frac{\text{Work}}{\text{Time}}$

$$\text{Power} = \frac{\text{Force} \times \text{Displacement}}{\text{Time}}$$

$\therefore$ Power = mg × v

= 500 × 9.8 × 0.4

= 500 × 3.92

$\therefore$ Power = 1960.00 W

1 H.P. = 746W

$\therefore$ $1\ W = \frac{1\ H.P.}{746}$

$\therefore$ $1960\ W = \frac{1960\ H.P.}{746}$

$\therefore$ 1960 W = 2.62 H.P.

Ans : Thus the minimum horsepower of the motor to be used is 2.62 H.P.

MODULE-29

WORK & ENERGY

SA-II , 3 Mark questions

- **For section- A from Q. No. 8 - 19**

Energy Used = Power $\times$ Time

1

Five bulbs each having 100 W power are used for 4 hours, a heater having 1500 W power is used for 2 hours an electric iron of power 1000 W is used for 5 hours.

a) Calculate the total energy used in KWh.

b) Convert this energy into joules.

(a)

No. of appliance	Power of each appliance (W)	Power in kW	Duration in hour (t)	Energy consumed in kWh
5	100 W	0.1 kW	4	$5 \times 0.1 \times 4 = 2.0$ kWh
1	1500 W	1.5 kW	2	$1 \times 1.5 \times 2 = 3.0$ kWh
1	1000 W	0.1 kW	5	$1 \times 1 \times 5 = 5$ kWh
				Total energy = 10 kWh

Ans : Thus the total energy used is 10 KWh.

1

Five bulbs each having 100 W power are used for 4 hours, a heater having 1500 W power is used for 2 hours an electric iron of power 1000 W is used for 5 hours.

a) Calculate the total energy used in KWh.

b) Convert this energy into joules.

(b) We know that,

$$1\ \text{kWh} = 3.6 \times 10^{6}\ \text{J}$$

$$\text{Thus } 10\ \text{kWh} = 3.6 \times 10^{6}\ \text{J} \times 10$$

$$= 3.6 \times 10^{7}\ \text{J}$$

$$1\text{KWhr} = 1000\ \text{W}\ 3600\ \text{sec}$$

$$= 10^{3}\ \text{W} \times 36 \times 10^{2}\ \text{sec}$$

$$= 36 \times 10^{5}\ \text{W sec}$$

$$= 36 \times 10^{5}\ \text{J}$$

$$= 3.6 \times 10^{6}\ \text{J}$$