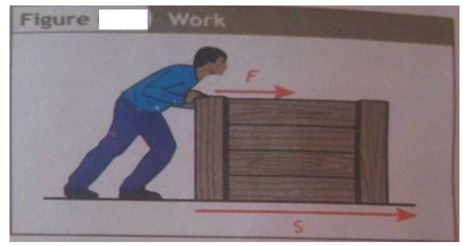
Chapter = 06

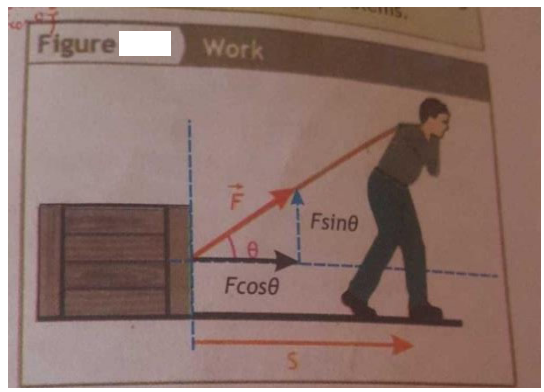
WORK AND ENERGY

WORK

Definition:- Work is said to be done when a force displaces a body in its own direction. OR
The dot product of force and displacement is known as work. OR
The scalar product of force and displacement .



Symbol:- It is denoted by "W".
Mathematical Form:-
Work = Force . Displacement
W = $\vec{F} \cdot \vec{S}$ …………………… (1)
When the force and displacement are not in same direction, then the eq (1) becomes.
W = FS cosθ ……………… (2)



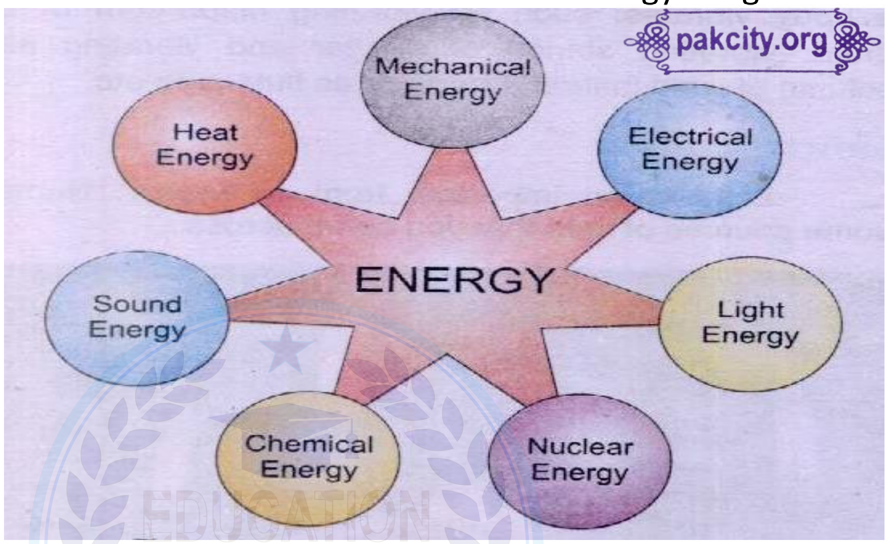
Unit:- Its SI unit is Joule(J).
Quantity:- It is a scalar quantity.
Nature:- It is a derived quantity.
Factors: - From eq (2)it is cleared that the magnitude of work done depends upon the following factors (i) The magnitude of force acting on the body ($\vec{F}$).
(ii) Displacement covered by the body ($\vec{S}$).
(iii) Angle between the force and displacement (θ).

Joule:-
Definition:- When a force of one newton moves a body through a distance of one meter in the direction of force the work done is equal to one joule. OR
The amount of work is one joule when a force of one newton displaces a body through one meter in the direction of force.
Symbol:-It is denoted by "J".
1Joule =(1 newton) (1 meter) OR 1J = 1 Nm.
Some bigger units of work:-
1 kilo joule = 1000 J = 10^3 J.
(b) 1 mega joule = 1000000 J = 10^6 J.

ENERGY AND ITS FORMS

Definition:- The ability of a body to do some work is known as energy. OR

The capability of a body to do some work is known as work.
Unit:- Its SI unit is joule (J).
Quantity:- It is a scalar quantity.
Nature:- It is a derived quantity.
Forms of energy:-
Energy exist in various forms. Some of the main forms of energy are given below.



(1)Mechanical Energy:-
Definition:- The energy possessed by a body both due its position or motion is known as mechanical energy.
Examples:-
(i) The energy possessed by a stretched bow.
(ii) The energy possessed by a raised up hammer etc.
(2)Heat Energy:-
Definition:- The energy that travel (flow) from hot body to cold body is known as heat energy.
Examples:-
(i) The energy obtained from fire.
(ii) The energy obtained from thermal radiation etc.
Examples:-
(3) Sound Energy:-
Definition:- The energy which is produced due to the vibrations of a body is sound energy.
Examples:-
(i) The energy which is produced by the vibrations of string of a sitar.
(ii) The energy which is produced by the vibrations of tuning fork etc.
(4) Chemical Energy :-
Definition:- The energy contained within the bonds between the atoms is known as chemical

energy.

Examples:-

(i) The energy which is produced by the burning of wood.

(ii) The energy which is produced by the burning of gas etc.

(5) Radiant Energy:-

Definition:- The energy which travels as an electromagnet (light) waves is known as radiant waves.

Examples:- (i) Radio waves.(ii) X-rays etc.

(6)Electrical Energy:-

Definition:- The energy associated with the charges is known as electrical energy.

Examples:-

(i) The energy which is produced from electric generators.

(ii) The energy which is produced from dry cells etc.

(8) Nuclear Energy:-

Definition:- The energy in the nucleus of an atom

Examples:-

(i) The energy produced during the fission reactions.

(ii) The energy produced during the fusion reactions etc.

KINETIC ENERGY

Definition:-The energy possessed by a body due to its **motion** is known as kinetic energy.

OR

The energy of an object due to its **motion** is known as kinetic energy.

Abbreviation:- It is abbreviated by **"K.E".**

Symbol:- It is denoted by "$\boldsymbol{K_E}$".

Mathematical Form:- $K_E = \frac{1}{2} mv^2$ .... (1)

Unit:- Its SI unit is **joule** (J).

Quantity:- It is a **scalar** quantity.

Nature:- It is a **derived** quantity.

Factors:- From eq(1) it is cleared that the value of kinetic energy depends upon the following two factors.

(i) Mass of body.

(ii) Velocity of body.

Examples:-

(i) The energy of moving car.

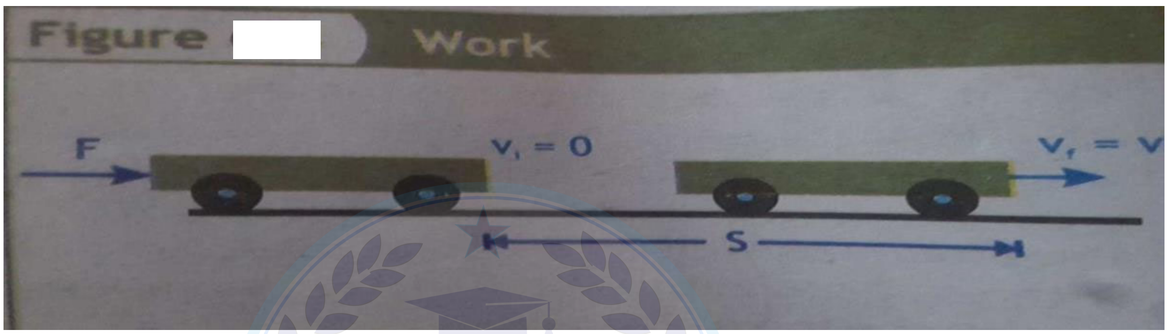
(ii) The energy rotating wheel a bus.

(iii) The energy fast moving bullet etc.

Show that $E_k = \frac{1}{2}mv^2$

Derivation of $K_E = \frac{1}{2}mv^2$

Consider a cart which is initially at rest **(v_i = 0 m/s)**. A horizontal force **"F"** is applied to it comes it to move through a displacement **"S"** and achieve a final velocity of V_f = **V** as shown in figure.



During this process the amount of work done "W" appears as the kinetic energy. Such as

$$W = K_E = F \cdot S \quad \text{..................... (1)}$$

<u>For "F"</u> :- From Newton second law of motion F=ma .... (2)

<u>For S</u>:- From figure

Initial Velocity = V_i = 0

Final velocity = V_f = V

Acceleration= a

Displacement = S

By third equation of motion

$$2aS = V_f^2 + V_i^2 \quad \text{................ (3)}$$

Now by the values of V_f and V_i in equation (3) we get.

$$2aS = V^2 - 0 \quad \text{OR} \quad 2aS = V \quad \text{.............. (4)}$$

By rearranging the eq (4) becomes.

$$S = \frac{V^2}{2a} \quad \text{............................... (5)}$$

By putting Eq (2) and (5) In eq (1) we get

$$K_E = ma \times \frac{V^2}{2a}$$

$$K_E = \frac{m\,V^2}{2}$$

$$K_E = \frac{1}{2}mv^2 \quad \text{........................ (6)}$$

So eq (6) is the required proof.

Results:- From equation (6) :-

(i) $K_E \propto m$.

(ii) $K_E \propto V^2$.

POTENTIAL ENERGY

Definition:- The energy possesses by a body by virtue of its **position** or **configuration** in a force field is known as potential energy. OR

The energy possessed by virtue of its **state** is known as potential energy.

Abbreviation:- It is abbreviated by **P.E**.

Symbol:- It is denoted by E_p.

Unit:- Its SI unit is **joule(J).**

Quantity:- It is a **scalar** quantity.

Nature:- It is a **derived** quantity.

Examples:-

(i)The energy possessed by a raised up hammer.

(ii) The energy possessed by water stored in a dam etc.

Mathematical Form:-

Types of potential Energy:-

(1) Elastic Potential Energy.

(2) Gravitational Potential Energy.

(1) Elastic Potential Energy:-

Definition:- The energy possessed by a spring due to its **compressed or starched state** is known as Elastic Potential Energy

Examples:-

(i) The energy possessed by the winding spring of toys.

(ii) The energy possessed by the starched bow etc.

(2) Gravitational Potential Energy:-

Definition:- The potential energy possessed by a body due to its **position** in the gravitational field of the earth is known as gravitational potential energy. OR

The energy of a body due to its position in the gravitational field is known as gravitational potential energy.

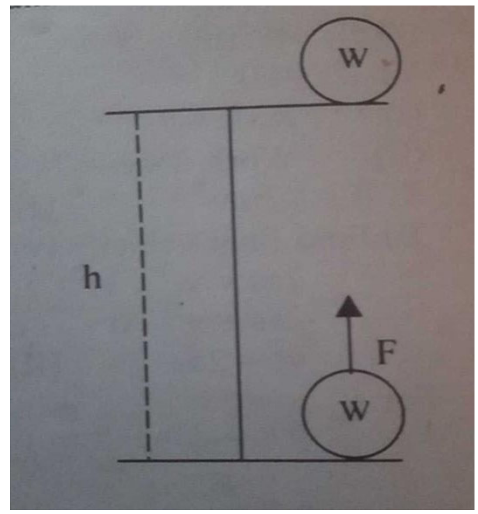
Examples:-

(i) The energy possessed by a raised up hammer.

(ii) The energy possessed by water stored in a dam etc.

Symbol:- It is denoted by $E_{G.P.E}$.
Mathematical From:- $E_{G.P.E}$ = mgh
Factors:-
(i) Mass of body(m).
(ii) Gravitational acceleration (g).
(iii) Height of body from the surface of earth (h).

SHOW THAT $E_{G.P.E}$ = m gh



Derivation:- Consider an object of mass **"m"** being lifted vertically by a force **"F"** (equal to its weight) to **"h"** as shown in figure.

The work done by the force **"F"** is given by equation.

Work = Gravitational Potential energy = F . S

W = $E_{G.P.E}$ = F . S

OR $E_{G.P.E}$ = F . S .... (1)

As F = w=mg and S = h then equation (1) becomes

$E_{G.P.E}$ = mg .h = mg h

OR

$E_{G.P.E}$ = mg h .... (2)

Equation (2) is required proof.

Results:- From equation(2):-

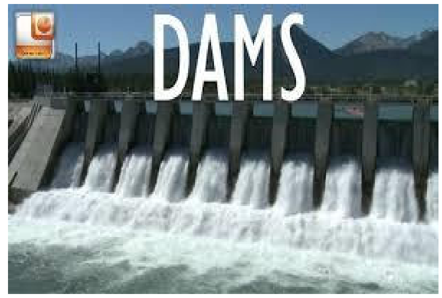
(i) $E_{G.P.E} \propto$ **m**.
(ii) $E_{G.P.E} \propto$ **g.**
(iii) $E_{G.P.E} \propto$ **h**

LAW OF COSERVATION OF ENERGY

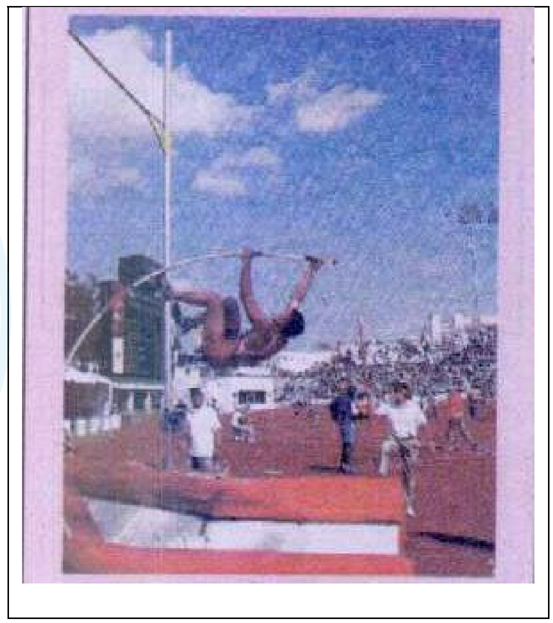
History:- This law was presented by a **German** Scientist **J.R Mayer** in **1842**.
Statement:- Energy can neither be created nor destroyed in any process , it can be converted from one form to another , but the total amount remains constant ".
Mathematical Form:- **Total Energy = P.E + K.E = Constant**
Examples of law of conservation:-
(**1)A diver on a spring board**:- Stored chemical energy in the body of the diver allows him

to bend the diving board. This cause the bent diving board to store elastic potential energy which is then converted into kinetic energy as an upward push.

(2) **Generation of Electricity**:- Potential energy of water which is stored at a certain height is converted into kinetic energy by making it fall on turbine to produce electricity.



(3) **Pole Vault**:- A pole vaulter uses a flexible vaulting pole made of special material. It is capable to store all the vaulter's kinetic energy while bending in the form of potential energy.The vaulter runs as fast as possible to gain speed. The kinetic energy gained by the vaulter due to the speed helps him / her to rise up as the vaulter straightens. Thus he attains height as the pole returns the potential energy stored by the vaulter in the pole.



MASS – ENERGY EQUIALENSE

History: - This relation was presented by a **British Physicist Albert Einstein in 1905**.

Purpose:- To show the relationship between **mass and energy**.

Statement:- " Matter and energy are interchangeable". OR

" Mass and energy are the same physical entities and can be changed into each other ".

Mathematical Form:-

Energy = Mass x The speed of light squared

$$E = mc^2 \quad \text{.....................................} \quad (1)$$

Were

(i) E = Energy (Measured in joule "**J**") .

(ii) m = mass (measured in kilogram "**Kg**").

(iii) C=The speed of light (**3×10^8 m/s**).

Examples: -

(i) Pair production.

(ii) Photosynthesis.
(iii) Respiration etc.

MAJOR SOURCES OF ENERGY

(1):NON-RENEWABLE SOURCES:-

Definition:- Those sources of energy which cannot be renewed are known as non-renewable sources of energy.

Other Name: - They are also called **conventional** sources of energy.

Notes:- Over **85%** of the energy used in the world is from non-renewable supplies.

Examples:-

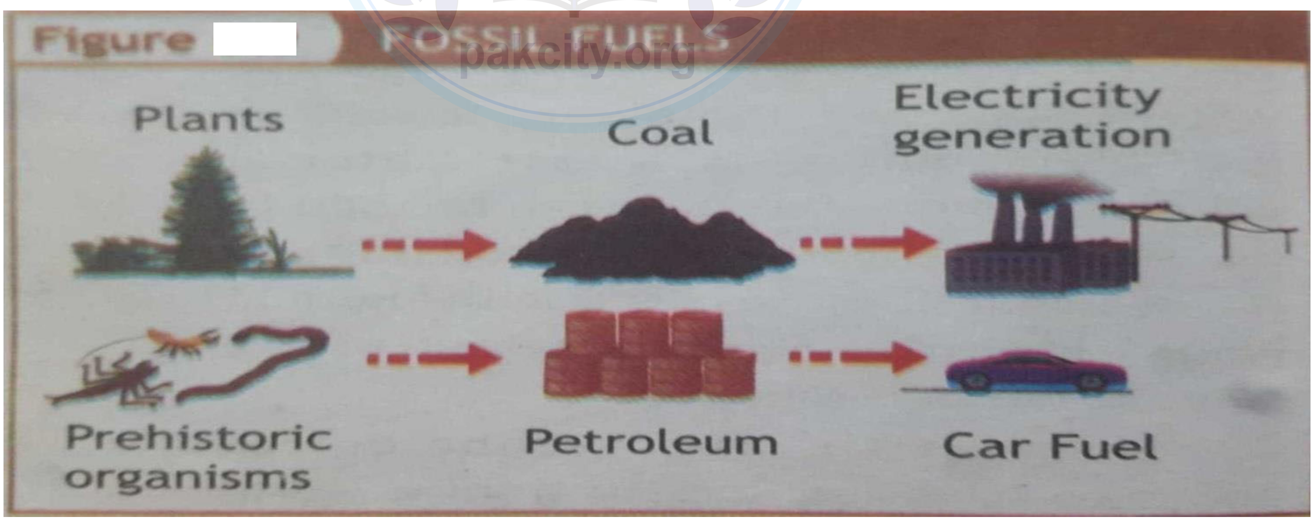
(A) Fossil Fuels.
(B) Nuclear Fuels.

(A) FOSSIL FUELS:-

Definition:- "They are usually hydrocarbons (compounds of carbon and hydrogen)".

Formation:-They formed from the remains of plants and tiny sea creatures which lived millions of years.

Explanation:-When they are burnt, they combine with oxygen from the air. The carbon becomes carbon dioxide, hydrogen becomes hydrogen oxide called water while energy is released as heat. They are very concentrated source of energy.



Examples:-

(1) COAL: - It is the most abundant fossil fuel in the world, with an estimated reserve of one million metric tons.

In Case of Coal:-

Carbon + Oxygen Carbon dioxide + Heat Energy

(2) <u>OIL</u>: - Crude oil is refined into many different energy products such as gasoline, jet fuel and heating oil.

<u>In Case of Oil</u>:-

Hydrocarbon + Oxygen Carbon dioxide + Water + Heat Energy

(3) <u>NATURAL GAS</u>:- Natural gas is often a by product of oil. It is a mixture of gases the most common of which is methane.

<u>In Case Gas</u>:-

Hydrocarbon + Oxygen Carbon dioxide + Water + Heat Energy

<u>Waste Products Release from Fossil Fouls and their Side Effects</u>:

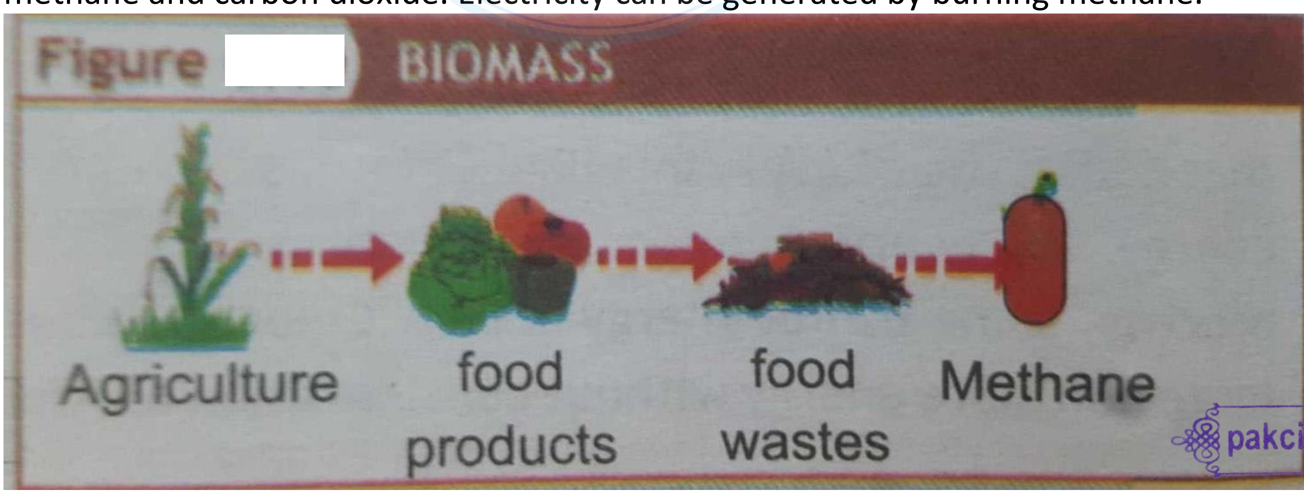
Fossil fuels release harmful waste products. These wastes include carbon mono-oxide and other harmful gases, which pollute the environment. This causes serious health problems such as headache, tension, nausea, allergic reactions, irritation of eyes, nose and throat. Long exposure of these harmful gases may cause asthma, lungs cancer, heart diseases and even damage to brain, nerves and other organ of our body.

<u>Uses of Fossil Fuels</u>:- We use fossil fuels such as coal, oil and gas to heat our houses and run industry and transport.

(B) <u>Bio-mass</u>:-"Biomass is plant of animal wastes that can be burnt as fuel. Other forms of biomass are garbage, farm wastes, sugarcane or plants".

<u>Process of Generating Electricity from Biomass</u>:-

When animal dung, dead plants and dead animals decompose, they give off a mixture of methane and carbon dioxide. Electricity can be generated by burning methane.



<u>Uses of Biomass Energy</u>:-

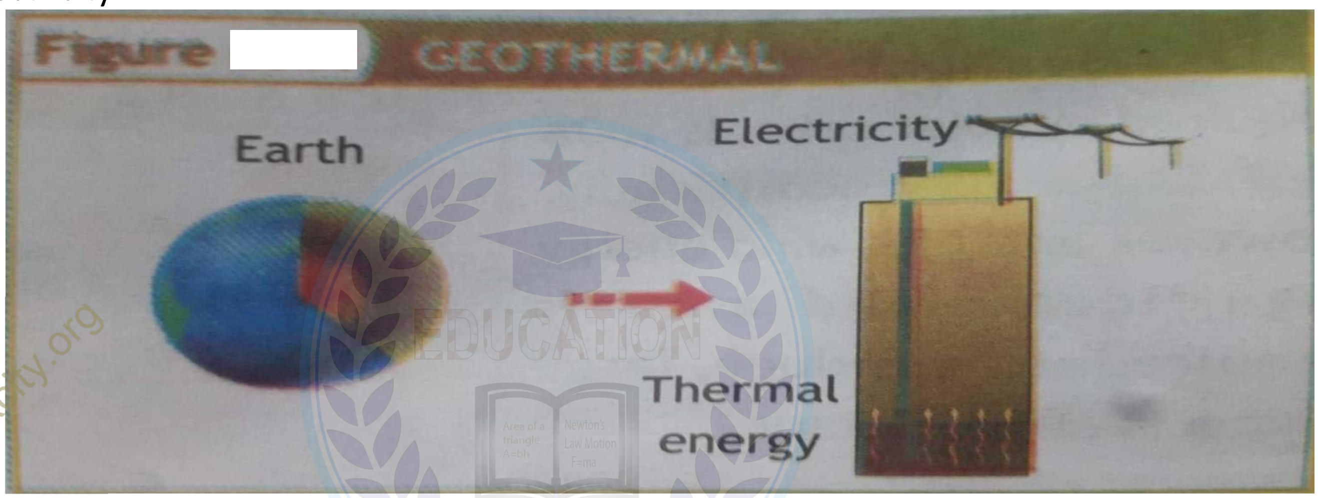
These wastes are used to run power plants. Many industries that used forest products get half of their electricity burning bark and other wood wastes. Biomass can server as another energy source, but problems are there in its use.

(C) Geothermal Energy:- "Water reaching close to the magma changes to steam due to high temperature of magma. This energy is called geothermal energy".

Magma:-"There is hot molten part, deep in the earth called magma".

Process to Obtain Geothermal Energy:-

In some parts of the world, the earth provides us hot water from geysers and hot springs. Geothermal well can be built by drilling deep near hot rocks at places, where magma is not very deep. Water is then pushed down into the well. The rocks quickly heat the water and change it into steam. It expands and moves up to the surface. The steam can be piped directly into houses and offices for heating purposes or it can be used to generate electricity.



(D) Wind Energy:- "Wind energy has been used as a source of energy for centuries".

Uses of Wind Energy:-

i. It has powered sailing ships across the oceans.
ii. It has been used by wind mills to grind grains and pump water.
iii. More recently, wind power is used to wind turbines.

Wind Power Plant:- "When many wind machines are grouped together on wind farms, they can generate enough power to operate a power plant".

Interesting Information:-

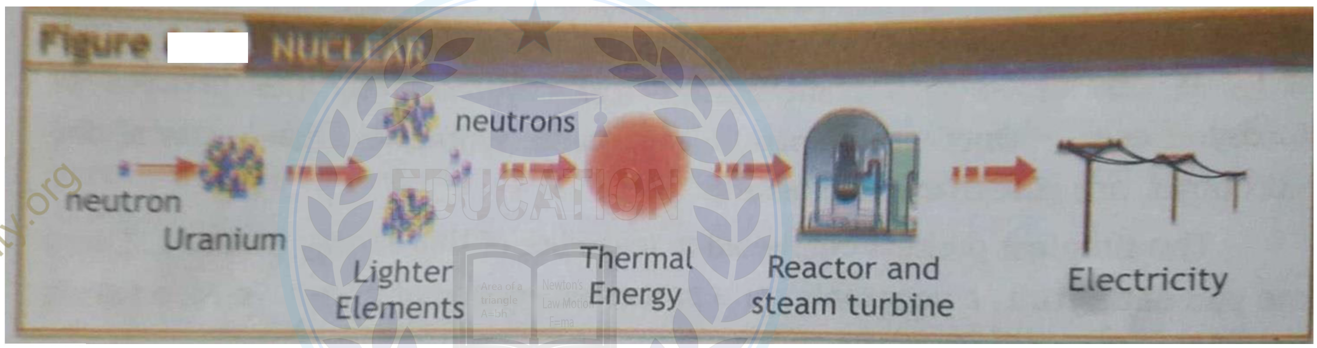
i. In the United States, some wind farms generate more than 1300 MW of electricity a day.

ii. In Europe, many wind farms routinely generate hundred megawatts or more electricity a day.

(E) Nuclear Energy (Fuels):- "In nuclear power plants, we get energy as a result of fission reaction".

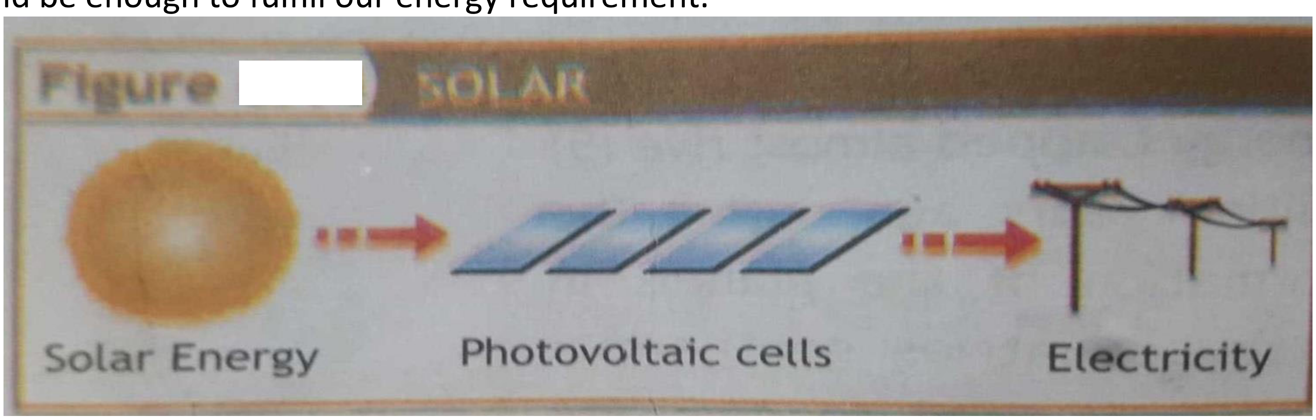
Fission Reaction:- "In fission reaction heavy atoms, such as Uranium atoms, split up into smaller parts releasing a large amount of energy".

Explanation:- Nuclear power plants give out a lot of nuclear radiations and vast amount of heat. A part of this heat is used to run power plants while a lot of heat goes waste into the environment.



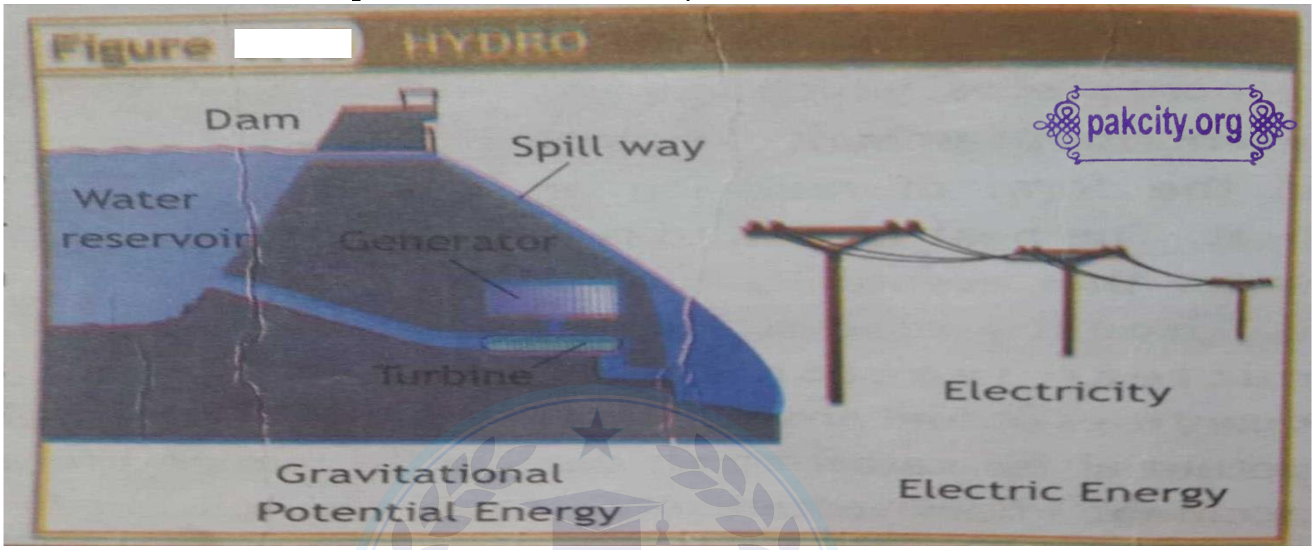
(F) Energy from Sun:- "Solar energy is the energy coming from Sun and used directly and indirectly".

Explanation:- Sunlight does not pollute the environment in any way. The sunrays are the ultimate source of life on the earth. We are dependent on the Sun for all our food and fuel. If we find a suitable method to use a fraction of solar energy reaching the earth, then it would be enough to fulfill our energy requirement.



Uses of Solar Energy:- Solar energy is used in solar cookers, solar distillation plants, solar power plant, etc.

(G) Energy from Water:- "Energy from water power is very cheap. Dams are being constructed at suitable locations in different parts of the world".



Advantages of Dams:

Dams serve many purposes:-

i. They help to control floods by storing water.

ii. The water stored in dams is used for irrigation and also to generate electrical energy without creating much environmental problems.

RENEWALBLE SOURCES OF ENERGY	NON-RENEWALBLE SOURCES OF ENERGY
Those sources of energy which can be renewed.	Those sources of energy which cannot be renewed.
They are also called **non-conventional** sources of energy.	They are also called **conventional** sources of energy.
They be used again and again.	They be used only by for a limited time and rate.
Their life is infinite.	Their life is finite and vanishes one day.
They are in unlimited quantity.	They are in limited quantity.
These sources have carbon emission.	These sources have carbon emission.
Examples:- Water, solar energy etc.	Examples:- Coal, Petroleum, Natural gas etc.

SOME IMPORTANT TERMS

Machine:-

Definition:- It is device which helps us to do work more conveniently. OR

It is a device which makes our work easy and speed.

Input:- The work done on a machine is known as input.
Output:- The work done by a machine is known as output.

EFFICIENCY

Definition:- The ratio of useful output to input is known as efficiency. OR
The ratio between output and input of a machine is known as efficiency.
Symbol: - It is denoted by "η" (eta).

Mathematical Form:- Efficiency = $\frac{Output}{Input}$ .... (1)

Quantity:- It is a **scalar** quantity.

Nature:- It is a **derived** quantity.
Unit:- It has no unit because it is the ratio between two similar quantities.
Note:- (i) It is always expressed in percentage So equation (1) becomes.

$$\eta = \frac{Output}{Input} \times 100\ \%$$

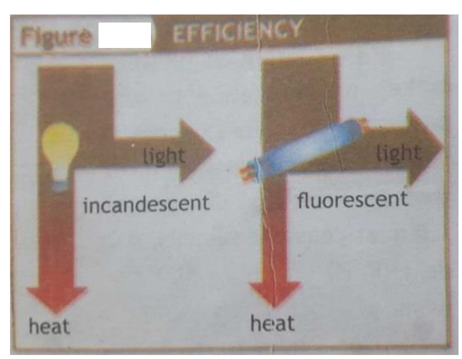
(ii) For real machine the efficiency is always less than 100%.
(iii) For ideal machine the efficiency is equal to 100%.

Why the efficiency of an engine of an engine cannot be 100% ?

Answer:- Statement:- The efficiency of an engine cannot be 100% **.**
Reason:- Because the force of friction lowers the efficiency of a machine.
Explanation:- As we know that

$$\text{Efficiency} = \frac{Output}{Input} \quad .... (1)$$

Practically the work output of a machine is always less than the work input due to frictional forces which dissipates the input energy. The dissipated energy is transferred into heat energy.
Conclusion: - So as a result we can conclude that the efficiency of an engine of an engine cannot be 100%**.**



POWER:-
Definition:- The time rate of doing work is known as power.
Symbol:-It is denoted by "P".

Mathematical Form:- Power = $\frac{work\ done}{Time\ taken}$

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

Quantity:- It is a scalar quantity.
Nature:- It is a derived quantity.
Unit:- Its SI unit is watt (W).
Note:- It is a measures of how fast work is done or how fast energy is being converted from

one form to another.

Watt:-

Definition:- One joule work done by a body in one second.

Symbol:- It is denoted by "W".

Mathematically:- 1 watt = $\frac{1\ joule}{1\ second}$

1 watt = $1Js^{-1}$.

NOTE:-

(i) In British system the unit of power is the foot-pound second (ft.lb/s).

(ii) For practical purposes a larger unit is often used horse power (hp).

(iii) one horse power (hp) is define as 550 ft.lb/s which is equals 746W.

(iv) 1 hp = 746 W.

(v) 1 kWh = 3.6×10^6 J.

SHOW THAT 1 kWh = 3.6×10^6 J

Proof:- As we know that

1k Wh = 1×10^3 W x 3600 sec = 1×10^3 W x 3.600×10^3 sec

1k Wh = $1 \times 3.600 \times 10^3 \times 10^3$

1k Wh = $3.600 \times 10^{3+3}$

1k Wh = 3.6×10^6 J

(i) 1 hour = 3600 sec = 3.600×10^6 sec

(ii) Kilo = k = 10^3

SHOW THAT P = $\vec{F} . \vec{V}$

Proof:- As we know that W = $\vec{F} . \vec{S}$ .... (1)

We also know that P = $\frac{W}{t}$ .... (2)

Now by putting eq (1) in eq (2) we get

$$P = \frac{\vec{F} . \vec{S}}{t} \quad OR \quad P = \vec{F} . \frac{\vec{V}}{t}$$

$$P = \vec{F} . \vec{V} \quad .... (3)$$

$\vec{V} = \frac{\vec{S}}{t}$

Equation (3) is the required proof.

Conclusion:- So as a result we can conclude that For same height larger and smaller satellites must have same orbital speeds.

CONCEPTUAL QUESTIONS

(1)Can a centripetal force ever do work on an object? Explain

Ans:- Statement:- No the centripetal force do not work on an object .

Reason:- It is because of $\theta = 90^0$ between the force and displacement.

Explanation:- In case of circular motion the centripetal force and displacement are mutually perpendicular. As we know that

$$W = FS \cos \theta \text{ .... (i)}$$

$\cos (90^0) = 0$

As $\theta = 90^0$ then eq (i) becomes.

$$W = FS \cos \theta = FS \cos (90^0)$$

$$W = FS (0)$$

$$W = 0$$

Result:- As a result We can conclude that the centripetal force do not work on an object .

(2) What happen to the kinetic energy of a bullet when it penetrates into a sand bag?

Ans:- Statement:- When a fast moving bullet penetrates into a sand bag its kinetic energy is converts into heat and sound energy.

Reason:- It is due to force of friction.

Explanation:- As we know that when the bullet strikes the sand bag it penetrates into it and comes to rest after covering a small distance . Most of K.E is used up in doing work against the friction of the sand and the rest of the energy is converted into heat and sound energy.

Conclusion:- As a result we conclude that When a fast moving bullet it penetrates into a sand bag its kinetic energy is converts into heat and sound energy.

(3) A meteors enters into earth's atmosphere and burns. What happens to its kinetic energy?

Ans:- **Statement:-** When a meteors enters into earth's atmosphere and burns its K.E converts into heat and light energy.

Reason:- It is due to force of friction.

Explanation:- As we know that When a meteors enters into earth's atmosphere with very high speed. There is a large force of friction of the air on it. In doing work against this large force of friction the meteors burns and its K.E is converts into other forms of energy.

Conclusion:- As a result we conclude that When a meteors enters into earth's atmosphere and burns its K.E converts into heat and light energy.

(4) Two bullets are fired at the same time with same kinetic energy. If one bullet has twice the mass of the other which has the greater speed and by what factor? Which can do the most work?

Ans:- Statement:- Two bullets are fired at the same time with the same K.E. If one bullet has twice the mass of the other .The bullet having low mass will move with high speed by a factor of $\sqrt{2}$ **.**

Reason:-

Explanation:- As we known that

$$K.E = \frac{1}{2} mV^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

(a) **For Kinetic Energy of First bullet :-** Equation (i) becomes

$$(K.E)_1 = \frac{1}{2} m_1 V_1^2 \quad \ldots\ldots\ldots\ldots\ldots (ii)$$

(b) **For Kinetic Energy of First bullet :-** Equation (i) becomes

$$(K.E)_2 = \frac{1}{2} m_2 V_2^2 \quad \ldots\ldots\ldots\ldots\ldots (iii)$$

Condition:- $m_2 = 2m_1$ then eq (iii) becomes

$$(K.E)_2 = \frac{1}{2} (2m_1 V_2^2) \quad \ldots\ldots\ldots\ldots\ldots (iii)$$

Both have same K.E then

$$(K.E)_1 = (K.E)_2$$

$$\frac{1}{2} m_1 V_1^2 = \frac{1}{2} (2m_1 V_2^2)$$

OR $$\frac{1}{2} m_1 V_1^2 = 2 (\frac{1}{2} m_1 V_2^2)$$

OR $$\frac{1}{2} m_1 (V_1^2) = \frac{1}{2} m_1 (2 V_2^2)$$

OR $$V_1^2 = 2 V_2^2$$

OR $$\sqrt{V_1^2} = \sqrt{2V_2^2}$$

OR $$V_1 = \sqrt{2}\ V_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

Conclusion:- From Eq (iv) we can conclude that the first body will move with greater velocity by a factor of $\sqrt{2}$.

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(5) Can an object have different amounts of gravitational potential energy if it remains at the same elevation?

Ans:- Statement:- Yes an object have different amounts of gravitational potential energy if it remains at the same elevation.

Reason:- It is because the value P.E depends upon the reference point.

Explanation:- The potential energy of a 20 kg piano.

(1) **Resting on the floor will be**:-

$$P.E = mgh \ldots\ldots\ldots\ldots\ldots (i)$$

As $g = 10\ m/s^2$, m = 20 kg and h= 0m then eq(i) becomes.

$$P.E = mgh= 20 \times 10 \times 0 = 0j$$

(2) **With respect to the basement floor 3 below**:- Then eq (i) becomes

P.E = mgh= 20 x 10 x 3 = 600j .... (ii)

Conclusion:- So from eq (i) and (ii) we can conclude that it is possible for an object have different amounts of gravitational potential energy if it remains at the same elevation.

(6) Why do roads leading to the top of a mountain wind back and forth?

Ans:- Statement:- The roads leading to the top of a mountain wind back and forth.

Reason:- It is due to reduce the angle of inclination.

Explanation:- This reduces the instantaneous energy required to climb up the mountain against the acceleration of gravity. The winding road acts like a pulley system that makes work easier of climbing the mountain. Even though it may take longer distance, the energy expended will be lower in magnitude than climbing straight up the mountain.

Conclusion:- As a result we conclude that the roads leading to the top of a mountain wind back and forth.

(7) Which would have greater effect on the kinetic energy of an object doubling the mass or doubling the velocity?

Ans:- Statement:- Doubling the velocity have greater effect on the kinetic energy of an object than doubling the mass.

Reason:- It is because (a) K.E $\propto V^2$

(b) K.E $\propto$ m

Explanation:- As we know that

K.E = K.E = $\frac{1}{2}mV^2$ .... (i)

For doubling the velocity:- V = 2V then eq(i) becomes

K.E = $\frac{1}{2}m(2V)^2 = \frac{1}{2}m \times 4 (V)^2$

OR K.E =4 ($\frac{1}{2}mV^2$)

K.E = 4 K.E .... (ii)

For doubling the mass:- **m = 2m** then eq(i) becomes

K.E = $\frac{1}{2}\boldsymbol{x}\ \mathbf{2}mV^2$

K.E = 2 ($\frac{1}{2}mV^2$)

K.E = 2 K.E .... (iii)

Conclusion:- So from Eq(ii) and (iii) we can conclude by doubling the velocity have greater effect on the kinetic energy of an object than doubling the mass.

(8) If the speed of a particle triples by what factor does its kinetic energy increases?

Ans:- Statement:- If the speed of a particle triples then its K.E increases 9-times of its initial value.

Reason:- It is because K . E $\propto \boldsymbol{V^2}$

Explanation:- As we know that

$K.E = \frac{1}{2} mV^2$ .... (i)

Condition:- **V = 3V** then eq (i) becomes

$K.E^/ = \frac{1}{2} m\,(3V)^2 = \frac{1}{2} m\,(9V^2)$

$K.E^/ = 9 \times (\frac{1}{2} m V^2)$............. (ii)

$K.E^/ = 9\,(K.E)$.................... (iii)

Conclusion:- So from eq(iii) we can conclude that If the speed of a particle triples then its K.E increases 9-times of its initial value.

(9) **The motor of a crane uses power "P" to lift a steel beam. By what factor must the motor's power increase to lift the beam twice as high in half the time?**

Ans:- Statement:- The power of the motor of crane will be becomes 4-time when we double the height and half the time.

Reason:- It because that **(i)** $P \propto \frac{1}{t}$ **(ii)** $P \propto h$

Explanation:- As we know that

$P = \frac{W}{t} = \frac{mgh}{t}$ .... (i)

As h = 2h and $t = \frac{1}{2}$ **(t)** eq (i) becomes

$P^/ = \frac{mgh}{t} = \frac{mg \times 2h}{\frac{1}{2}t} = \frac{2 \times mg \times 2h}{t} = \frac{2\,mgh}{t}$

$P^/ = 4P$

Conclusion:- As a result we can conclude that the power of the motor of crane will be becomes 4-time when we double the height and half the time.

NUMERICAL QUESTIONS

Q # 01:- Determine the work done in each of the following cases:- (a) Kicking a soccer ball forward with a force of 40 N over a distance of 15 cm .(b) Lifting a 50-kg barbell straight up 1.95m.

Ans:- **Solution**:-

(a) Given data:-

Force = F = 40 N

Distance = S = 15 cm = $\frac{15}{100}$ m = 0.15m

Required data :-

Work = W_1 = ?

Formula:- As we know that

$W_1 = F \, . \, S$ ……………… (i)

Calculation:- By putting values in equation (i) we get

$W_1 = 40 \times 0.15 = 6$ J

(b)**Given data:-**

Mass = m = 50 kg

Height = h = 1.95m

Required data:-

Work = W_2 = ?

Formula:- As we know that

$W_2 = F \, . \, h = mg \times h = mgh$ ……………. (ii)

Calculation:- By putting values in equation (ii) we get

$W_2 = 50 \times 9.8 \times 1.95 = 955.5$ J $= 9.555 \times 10^2$ J.

Result: - So as a result (i) the work done by kicking soccer ball is W_1 = 6 J .(ii) By lifting a 50kg barbell up 1.95m is W_2 = = 955.5 J = 9.555×10^2 J.

Q # 2:- Calculate the velocity of a 1.2 kg falling star (meteorite) with 5.5×10^8 J of energy.

Ans:-Solution:-

Given data:-

Mass of star = m = 1.2 kg

Kinetic Energy = K.E = **5.5×10^8 J**

Required data:-

velocity = v = ?

Formula:- As we know that

$$K.E = \frac{1}{2} m V^2 \quad OR \quad V^2 = \frac{2 \times K.E}{m} \ .... (i)$$

Calculation:- By putting values in equation (i) we get.

$$V^2 = \frac{2 \times 5.5 \times 10^8}{1.2} = \frac{11 \times 10^8}{1.2} = 9.16 \times 10^8 \text{ m/s}$$

$$\sqrt{V^2} = \sqrt{9.1 \times 10^8} \quad OR \quad V = 3.01 \times 10^4 \text{ m/s.}$$

Result:- So as a result the velocity of the star will be V = 3.01 x 10^4 m/s.

Q # 03:- Calculate the gravitational potential energy of a piano of a mass 200 kg piano (a) Resting on the floor .(b) With respect to the basement floor 1.9m below.

Ans:-Solution:-

Given data:-

Mass of piano = m =2000kg.

Gravitational acceleration = g = 9.8 m/s $^{-2}$.

(a)When the Piano is at Resting on the floor :-

Condition:- Height = h = 0m

Required data:-

Gravitational Potential Energy= P.E = ?

Formula:- As we know that

P.E = m g h .... (i)

Calculation:- By putting values in equation (i) we get

P.E = 2000 x 9.8 x 0 = 0 J

(b)Potential Energy of Piano with respect to basement: -

Condition:- Depth = h = 1.9 m

Formula: - As we know that

P.E = m g h .... (ii)

Calculation:- By putting values in equation (ii) we get

P.E = 2000 x 9.8 x 1.9 = 37240 J = 3.7240 x 10^4 J

Result:- So as a result:- (i)The potential Energy of the Piano resting at the floor is = P.E = 0 J. (ii) Potential Energy of Piano with respect to basement of depth 1.9m is 37240 J = 3.7240 x 10^4 J

Q#04:- An elevator weighting 5000N is raised to a height of 15.0 m in 10.0 s How much power is developed?

Ans:-Solution:-

Given data:-

Weight of elevator = $\vec{W}$ = mg = 500N

Height = h = 15.0 m

Time = t = 10.0 sec

Required data:-

Power = P = ?

Formula:- As we know that

$$P = \frac{W}{t} = \frac{F\ .\ S}{t} = \frac{mg\ .\ h}{t} \quad \text{OR} \quad P = \frac{mgh}{t} \quad \text{..................... (i)}$$

Calculation:- By putting values in equation (i) we get

$$P = \frac{500\ x\ 15.0}{10.0} = 7500 \text{ watt}$$

Result:- So as a result the developed Power is = P = 7500 watt

Q # 05:- what power is required for a ski –hill chair lift that transports 500 people (average mass 65 kg) per hour to an increased elevation of 1200m?

Ans:-Solution:-

Given data:-

Number of People = N = 500

Mass of each person = m = 65 kg

Total mass = M = N x m = 500 x 65 = 32500 kg

Required data:-

Power = P = ?

Formula:- As we know that

$$P = \frac{W}{t} = \frac{F\ .\ S}{t} = \frac{Mg\ .h}{t} \quad \text{OR} \quad P = \frac{Mgh}{t} \quad \text{........................... (i)}$$

Calculation:- By putting values in equation (i) we get

$$P = \frac{32500\ x\ 9.8\ x\ 1200}{3600} = \frac{382200000}{3600} = 106166.66 = 1.0616666 \times 10^{5}$$

$P = 1.06 \times 10^5$ watt.

Result: - So as a result the developed power is $P = 1.06 \times 10^5$ watt.

Q#06:- How long will it take a 2750-W motor to lift a 385- kg sofa set ta a sixth- story window 16.0 m above?

Ans:-Solution:-

Given data:-

Power = P = 2750 W

Mass = m = 385 kg

Height = h = 16.0 m

Required data:-

Power = P = ?

Formula:- As we know that

$$P = \frac{w}{t} = \frac{F \cdot S}{t} = \frac{m \, x \, g \, x \, h}{t} \quad \text{OR} \quad t = \frac{mgh}{P} \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Calculation:- By putting values in equation (i) we get

$$t = \frac{385 \, x \, 9.8 \, x \, 16.0}{2750} = \frac{60368}{2750} = 21.955 \text{ sec} = 22 \text{ sec}$$

Result:-So as a result the required time is = t = 22 sec

Q # 07:- How much work can a 2.0-hp motor do in 1.0 h ?

Ans:-Solution:-

Given data:-

Power = P = 2.0 hp = 2.0 x 746 = 1492 watt

Time = t = 1.0 h = 1.0 x 3600 = 3600 sec

Required data:-

work = W = ?

Formula:- As we know that

$$P = \frac{W}{t} \quad \text{OR} \quad W = P \times t \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Calculation:- By putting values in equation (i) we get

W = 1492 x 3600 = 5371200 J = 5.371200 x 10^6 J

Result:- So as a result the work done is = W = 5371200 J = 5.371200 x 10^6 J.