WORK AND ENERGY

6

KIPS MULTIPLE CHOICE QUESTIONS

1. **Product of force and distance covered in the direction of force is:**
   a) Acceleration b) Resistance c) Work d) Specific heat
2. **For work ----------- conditions should be fulfilled:**
   a) 1 b) 2 c) 3 d) 4
3. **Work is --------------- quantity:**
   a) Scalar b) Vector c) Base d) None of above
4. **Unit of work is:**
   a) N b) Nm c) J d) Both b & c
5. **Work done will be ------------ if no force act on the body:**
   a) Maximum b) Minimum c) Zero d) All of above
6. **Work done will be maximum if displacement is ----------- to force:**
   a) Parallel b) Perpendicular c) Tangent d) Normal
7. **Work done will be zero if displacement is ----------- to force:**
   a) Parallel b) Perpendicular c) Tangent d) Normal
8. **Work done will be one ---------- if a force of one Newton acts on the body and it covers the distance of 1 meter in the direction of force:**
   a) Watt b) Joule c) Newton d) Coulomb
9. **One Mega joule is equal to:**
   a) 10^6 J b) 10^3 J c) 10^9 J d) 10^2 J
10. **What will be the magnitude of work if a force of 25 N pulls a stone through a distance of 5 m in its direction:**
    a) 25 J b) 50 J c) 75 J d) 125 J
11. **Which unit is equal to kgm^2s^{-2} in the units given below:**
    a) Joule b) Newton c) Watt d) Meter
12. **Rate of doing work with respect to time is known as:**
    a) Energy b) Power c) Momentum d) None of above
13. **Unit of power is:**
    a) Watt b) Joule c) Newton d) Coulomb
14. **How much power is used by a 40 kg athlete by climbing 10m high ladder in 10 s:**
    a) 4 W b) 40 W c) 400 W d) 4000 W
15. **What will be the power of a machine doing 10 J work in 5 seconds?**
    a) 2 W b) 10 W c) 25 W d) 50 W

16. **Ability of a body to do work is known as:**

a) Force b) Momentum c) Power d) Energy

17. **There are ---------- basic kinds of energy:**

a) 1 b) 2 c) 3 d) 4

18. **Energy is --------- quantity:**

a) Vector b) Scalar c) Base d) None of above

19. **Unit of Energy in System International is:**

a) Watt b) Joule c) Newton d) Coulomb

20. **Energy possessed by a body due to its motion is called ---------- energy:**

a) Kinetic b) Potential c) Mechanical d) All of above

21. **A bowler during playing cricket throws a ball of mass 200 g with a velocity of 20 ms^{-1}. Its kinetic energy will be:**

a) 4 J b) 40 J c) 400 J d) 4000 J

22. **What will be the kinetic energy of a body if its velocity is doubled?**

a) Doubled b) Four times c) Eight times d) Half

23. **What will be the kinetic energy of a body if its mass is doubled?**

a) Doubled b) Four times c) Eight times d) Half

24. **What will be the kinetic energy of a car of mass 1000 kg moving with a velocity of 20 ms^{-1}?**

a) 2×10^2 J b) 2×10^3 J c) 2×10^5 J d) 2×10^7 J

25. **Ability of a body to do work due to its position is called --------- energy:**

a) Kinetic b) Potential c) Mechanical d) All of above

26. **Ability of a body to do work due to its height from the surface of earth is called __________energy:**

a) Gravitational Potential b) Elastic Potential

c) Chemical Potential d) Attraction

27. **When a ball is lifted to a height 'h' from the ground, it will posses ------energy:**

a) Kinetic b) Gravitational potential

c) Elastic potential d) Mechanical

28. **Total energy of the system:**

a) Increases b) Decreases c) Remains same d) All of above

29. **For movement of our body ------------ energy is used:**

a) Heat b) Electrical c) Chemical d) Mechanical

30. **For making body molecules ------------ energy is used:**

a) Heat b) Electrical c) Chemical d) Mechanical

31. **For the propagation of signals in our body ---------- energy is used:**

a) Heat b) Electrical c) Chemical d) Mechanical

32. **For maintaining the body temperature ------------ energy is used:**

a) Heat b) Electrical c) Chemical d) Mechanical

33. **Increase in K.E is equal to:**

a) Increase in P.E b) Decrease in P.E c) No effect d) Both a & b

34. **Increase in P.E is equal to:**

a) Increase in K.E b) Decrease in K.E c) No effect d) Both a & b

35. **Decrease in K.E is equal to:**

a) Increase in P.E b) Decrease in P.E c) No effect d) Both a & b

36. **Decrease in P.E is equal to:**

a) Increase in K.E b) Decrease in K.E c) No effect d) Both a & b

37. **A motor lift a weight of 5N up to the height of 2m in 4s. What will be the power of the motor?**

a) 2.5 W b) 5 W c) 20 W d) 10 W

38. **Energy of the water stored in the dam is:**

a) Elastic potential energy b) Gravitational potential energy
c) Kinetic energy d) Mechanical energy

39. **How many types of mechanical energy are?**

a) 1 b) 2 c) 3 d) 4

ANSWER KEY

Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans
1	c	11	a	21	b	31	b
2	b	12	b	22	b	32	a
3	a	13	a	23	a	33	b
4	d	14	c	24	c	34	b
5	c	15	a	25	b	35	a
6	a	16	d	26	a	36	a
7	b	17	b	27	b	37	a
8	b	18	b	28	c	38	b
9	a	19	b	29	d	39	b
10	d	20	a	30	c		

KIPS SHORT QUESTIONS

Q.1 Define work and its unit.

Ans: Definition

Work is done when force acting on a body displaces it in the direction of a force.

OR

The product of force and distance covered in the direction of force is equal to the work done.

Unit of work

In System International, its unit is joule (J).

Joule

"The amount of Work done will be one joule if a force of one Newton displaces a body through a distance of one meter in the direction of the force."

Q.2 Define Energy and write down its unit.

Ans: A body possesses energy if it is capable to do work.

OR

Ability of a body to do work is known as energy.

Quantity

It is a scalar quantity

Unit

Joule is the unit of energy same as that of work.

Types of Energy

Energy exists in various forms such as mechanical energy, heat energy, light energy, sound energy, electrical energy, chemical energy and nuclear energy etc.

Types of Mechanical Energy

Mechanical energy possessed by a body is of two types:

(i) Kinetic Energy

(ii) Potential Energy

Q.3 Define kinetic energy and give at least one example.

Ans: "The energy possessed by a body due to its motion is called kinetic energy"

Example

- Moving water in a river can carry wooden logs through large distances and can also be used to drive turbines for generating electricity.

Q.4 Define Potential Energy and give examples.

Ans: The energy possessed by a body due to its position is known as its potential energy.

Examples

- Stored water in dam
- A hammer is raised up to some height has the ability to do work
- A stretched bow has potential energy due to its stretched

Q.5 Define Gravitational Potential Energy and give at least one example.

Ans: The energy present in a body due to its height is called gravitational potential energy.

Example

- Stored water in dam
- Energy of a stone lying on the roof

Q.6 Define Efficiency.

Ans: Efficiency of a system is the ratio of required form of energy obtained from a system as output to the total energy given to it as input.

Q.7 What do you know about Ideal machine?

Ans: An ideal machine is that which gives an output equal to the total energy used by it. In other words, its efficiency is 100 %. People have tried to design a working system that would be 100% efficient. But practically such system does not exist.

Q.8 Can we say that practical systems can be 100% efficient?

Ans: Every system meets energy losses due to friction that causes heat, noise etc. these are not the useful forms of energy and go waste. This means we cannot utilize all the energy given to working system. The energy in the required form obtained from working system always less than the energy given to it as input.

Q.9 Define Power. Write down its unit and define it.

Ans: "Rate of doing work with respect to time is called the power."

Unit of power

In System International, the unit of power is watt (W).

Watt

"If a body does a work of one joule in one second then its power will be one watt".

Q.10 Do we do any work when we lift a load from the Earth to some height?

Ans: Yes, we do work when we lift a load from the earth to some height because we have to do work against the gravitational pull of the earth. Mathematically, it can be expressed as,

As we know that $W = FS$

As $F = mg$ and $S = h$

So the work done is $W = mgh$

Q.11 How much power is used by a 40 kg athlete by climbing 10m high ladder in 10s?

Ans:

We have
Mass = m = 40 kg
Time = t = 10 s
Height = h = S = 10 m

As we know that Force = weight = w = mg = 40 x 10 = 400N
Work = W = FS = 400 x 10 = 4000 J

As we know that Power = P = W/t

So, Power = P = 4000/10 = 400 W

Q.12 Give some examples of energies used in our body?

Ans: There are many kinds of energies are used in our body. Some of them are given below:

Mechanical Energy

For the moving of our body.

Chemical Energy

For making body molecules.

Electrical Energy

For the propagation of electrical signals in the body.

Heat Energy

For maintaining the body temperature.

Q.13 How much work is done when a body moves with uniform velocity?

Ans: When a body moves with uniform velocity means moving with zero acceleration then work done will be zero because according to Newton's second law of motion if $a = 0$ then the net resultant force acting on the body is zero.

As we know that $W = FS$

If $F = 0$ then $W = 0 \times S = 0$

LONG QUESTIONS

6.1 WORK

Q.No.1 Define work. Derive its mathematical formula.

Ans: Definition

Work is done when force acting on a body displaces it in the direction of a force.

OR

The product of force and distance covered in the direction of force is equal to the work done.

Explanation

Suppose a force 'F' is acting on a body. It makes the body to move from point 'A' to 'B'. If the distance between these two points is 'S' then we say that force has done some work.

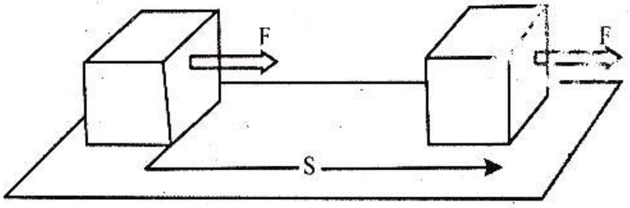


Figure 6.1: Work done in displacing a body in the direction of force.

Conditions

For work, the following two conditions must be fulfilled:

- A force should act on a body.
- The body should cover some distance under the action of this force.

Mathematical Form

If 'W' stands for work, 'F' for force and 'S' for distance.

then

Work = Force x Displacement

$W = FS$

Components of Force

Sometimes force and displacement do not have same direction. Here the force **F** is making an angle θ with the surface on which the body is moved. Resolving **F** into its perpendicular components 'F_x' and 'F_y'.

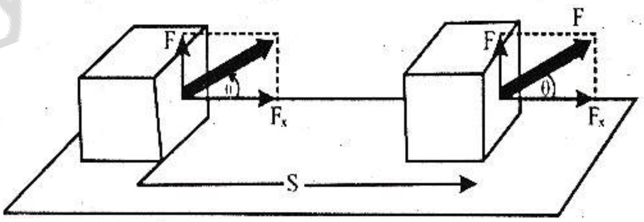


Figure 6.2: Work done by a force inclined with the displacement.

$F_x = F \cos\theta$

$F_y = F \sin\theta$

In case when force and displacement are not parallel then x-component F_x parallel to the surface causes the body to move on the surface and not y-component F_y.

Hence $W = F_x S$

$W = (F\cos\theta)\, S$

$W = FS\cos\theta$

Work is a scalar quantity. It depends on the force acting on a body, displacement of the body and the angle between them

Unit of work

In System International, its unit is joule (J).

Joule

"The amount of Work done will be one joule if a force of one Newton displaces a body through a distance of one meter in the direction of the force."

Bigger Units

Joule is a smaller unit of work. Commonly bigger units of work are also in use.

$1\ kJ = 10^3 J$

$1\ MJ = 10^6 J$

6.3 KINETIC ENERGY

Q.No.2 Define kinetic energy and derive its mathematical formula.

Ans: "The energy possessed by a body due to its motion is called kinetic energy"

Example

- Moving air is called wind. We can use wind energy for doing various things. It drives windmills and pushes sailing boats.
- Moving water in a river can carry wooden logs through large distances and can also be used to drive turbines for generating electricity.

Mathematical Derivation

Let a body of mass m is moving with velocity v. An opposing force F acting through a distance S brings it to rest. The body possesses kinetic energy and is capable to do work against opposing force F until add of its kinetic energy used up.

K.E of the body = Work done by it due to motion

$K.E = FS$

$vi = v$

$vf = 0$

As $F = ma$

$a = - F/m$

Since motion is opposed, hence, a is negative.

Using 3rd equation of motion:

$2\,a\,S = vf^2 - vi^2$

$2\,(-F/m) = (0)^2 - (v)^2$

$FS = \frac{1}{2}\,m\,v^2$

As we know that K.E is equal to the work done,

So $K.E. = \frac{1}{2}\,m\,v^2$

The above equation gives the K.E. possessed by a body of mass m moving with velocity v.

6.4 POTENTIAL ENERGY

Q.No.3 Define Gravitational Potential Energy and derive its mathematical formula.

Ans: The energy present in a body due to its height is called gravitational potential energy.

Mathematical Derivation

Suppose a ball of mass 'm' is lifted from the surface of the Earth to a height 'h' as shown in Figure. The body will acquire potential energy equal to the work done in lifting it to height h.

Thus Potential Energy $= F \times h$

$= w \times h$

As we know that weigh of the body $= w = mg$

So P.E. $= w\,h = m\,g\,h$

Thus, the potential energy possessed by the body with respect to the ground is m g h and is equal to the work done in lifting it to a height h.

6.5 FORMS OF ENERGY

Q.No.4 Explain different Forms of Energy.

Ans: Energy exists in various forms. Some of the main forms of energy are explained below:

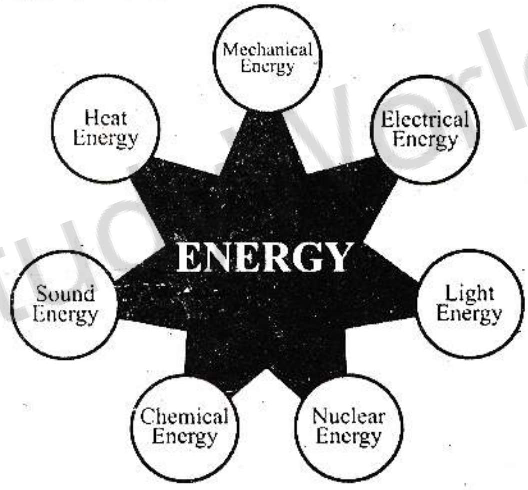


Figure 6.6: Some of the main forms of energy

1) Mechanical Energy

The energy possessed by a body due to its motion or position is called mechanical energy.

Examples

- Water running down a stream
- A moving car
- A lifted hammer
- A stretched bow
- A catapult or a compressed spring

2) **Heat Energy**

Heat is a form of energy given out by hot bodies. Large amount of heat is obtained by burning fuel. Heat is also produced when motion is opposed by frictional forces. The foods we take provide us heat energy. The Sun is the main source of heat energy.

3) **Electrical Energy**

Electricity is one of the widely used forms of energy. Electrical energy can be supplied easily to any desired place through wires.

Sources

We get electrical energy from batteries and electrical generators. These electric generators are run by hydro power, thermal or nuclear power.

4) **Sound Energy**

Sound is a form of energy. It is produced when a body vibrates.

Examples

Sound is produced by:

- By knocking at the door
- By vibrating diaphragm of a drum
- By vibrating strings of a sitar
- By vibrating air column of wind instruments as flute pipe

5) **Light Energy**

Light is an important form of energy. Plants produce food in the presence of light. We also need light to see things.

Sources

We get light from candles, electric bulbs, and fluorescent tubes and also by burning fuel. However, most of the light comes from the Sun.

6) **Chemical Energy**

Chemical energy is present in food, fuels and in other substances. We get other forms energy these substances during chemical reactions.

Examples

- The burning of food, coal or natural gas in air is a chemical reaction which releases energy as heat and light.
- Electric energy is obtained from electric cells and batteries as a result of chemical substances present in them.
- Animals get heat and muscular energy from the food they eat.

7) **Nuclear Energy**

Nuclear energy is the energy released in the form of nuclear radiations in addition to heat and light during nuclear reactions such as fission and fusion reactions. Heat energy released in nuclear reactors is converted into electrical energy.

Biggest source

The energy coming from the Sun for the last billions of years is the result of nuclear reactions taking place on the Sun.

6.6 INTERCONVERSION OF ENERGY

Q.No.5 Explain Inter Conversion of Energy.

Ans: Energy cannot be destroyed however it can be converted into some other forms.

Example

Rub your hands together quickly. You will feel them warm. You have used your muscular energy in rubbing hands as a result heat is produced. In the process of rubbing hands, mechanical energy is converted into heat energy.

Interconversion of energy in Nature

Processes in nature are the results of energy changes. For example, some of the heat energy form the Sun is taken up by water in the oceans. This increases the thermal energy. Thermal energy causes water to evaporate from the surface to form water vapors. These vapors rise and form clouds. As they cool down, they form water drops and fall down as rain. Potential energy changes to kinetic energy as the rain falls. This rain water may reach a lake or a dam. As the rain water flows down, its kinetic energy changes into thermal energy while parts of the kinetic energy flowing water is used to wash away soil particles of rocks known as soil erosion.

Total Energy

During the inter conversion of energy from one form to other forms, the total energy at any time remains constant.

6.7 MAJOR SOURCES OF ENERGY

Q.No.6 Explain Major Sources of Energy.

Ans: The energy we use comes from the Sun, wind and water power etc. Actually, all of the energy we get comes directly or indirectly from the Sun.

1) Fossil Fuels

We use fossil fuels such as coal, oil and gas to heat our houses and run industry and transport. They are usually hydrocarbons (compounds of carbon and hydrogen).

Chemical Reaction

When they are burnt, they combine with oxygen from air. The carbon becomes carbon dioxide; hydrogen becomes hydrogen oxide called water; while energy is released as heat. In case of coal;

Carbon + Oxygen $\longrightarrow$ carbon dioxide + heat energy

Hydrocarbon + Oxygen $\longrightarrow$ carbon dioxide + water + heat energy

Future of Hydrocarbons

The fossil fuels took millions of years for their formation. They are known as non-renewable resources. We are using fossil fuels at a very fast rate. Their use is increasing day by day to meet them at present rate, they will soon be exhausted. Once their supply is exhausted, the world would face serious energy crises.

Future Crises of Energy

Thus, fossil fuels would not be able to meet our future energy needs. This would cause serious social and economical problems for countries like us. Therefore, we must use them wisely and at the same time, develop new energy sources for our future survival.

Harmful effects produced by burning Hydrocarbons

Moreover, fossil fuels release harmful waste products. These wastes include carbon mono-oxide and other harmful gases, which pollute environment. This causes serious health problems such as headache, tension, nausea, allergic reactions, and 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 organs of our body.

2) Nuclear Fuels

In nuclear power plants, we get energy as a result of fission reactions. During fission reaction, heavy atoms, such as uranium atoms, split up into smaller parts releasing a large amount of energy. 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 lot of heat goes waste into the environment.

Renewable Energy Sources

Q.No.7 Explain Renewable Energy Sources.

Ans: Sources of energy which will not be run out in future are called Renewable sources. Sunlight and water power are the renewable sources of energy.

1) Energy Form Water

Energy from water power is very cheap. Dams are being constructed at suitable locations in different parts of the world. Dams serve many purposes. They help to control floods by storing water. The water stored in dams is used for irrigation and also to generate electric energy without creating much environmental problems.

2) Energy from Sun

Solar energy is the energy coming from the sun and is used directly and indirectly. 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 fuels. If we find a suitable method on use a fraction of the solar energy reaching the Earth, then it would be enough to fulfill our energy requirements.

Q.No.8 Explain Solar House Heating.

Ans: The use of solar energy is not new. However, it's use in houses and offices as well as for commercial industrial purposes is quite recent. Complete solar house heating system are successfully used in area with a minimum amount of sunshine in winter. A house heating *system consists of:*

- A collector
- A storage device
- A distribution system

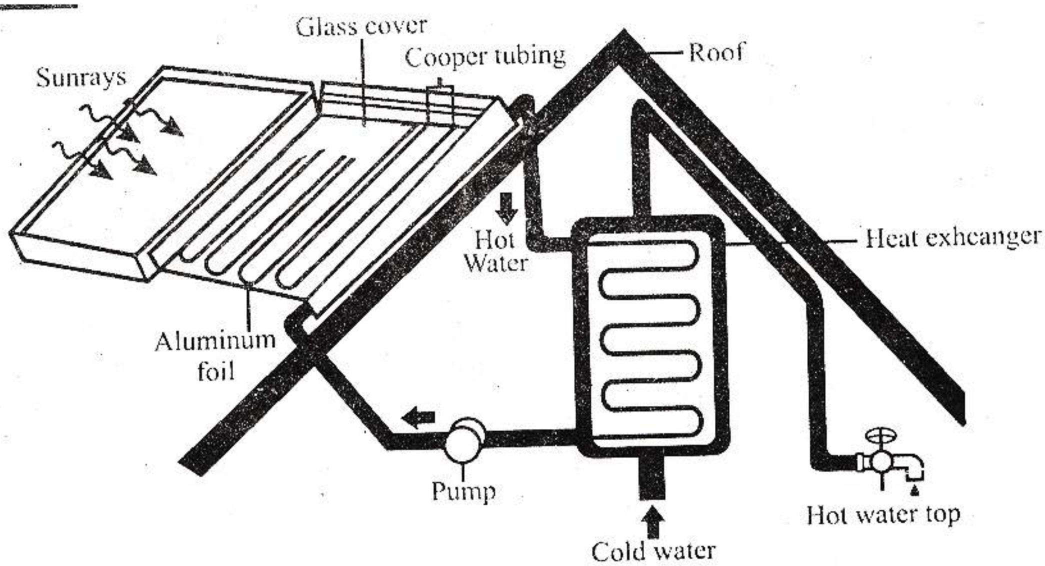


Figure 6.21: A Solar house heating system.

The above figure shows a solar collector made of glass panels over blank metal plates. The plates absorb the sun energy which heats a liquid flowing in the pipes at the back of the collector. The hot water can be used for cooking, washing and heating the buildings. Solar energy is used in solar cookers, solar distillation plants, solar power plants.

Solar cells

Solar energy can also be converted directly into electricity by solar cells. A solar cell also called photo cell is made from silicon wafer. When sunlight falls on the solar cell, it converts the light directly into electrical energy.

Solar panels

Solar cells are used in calculators, watches and toys. Large number of solar cells are wired together to form a solar panel. Solar panels can provide power to telephone booths, light houses and scientific research centers. Solar panels are also used to power satellites.

Q.No.9 What are the future hopes of the world about energy?

Ans: Solar Energy

Several other methods to trap sunrays are under way. If scientist could find an efficient and in-expansive method to use solar energy, then the people could get clean, limitless energy as long as the Sun continues to shine.

Wind Energy

Wind has been used as a source of energy for centuries. It has powered sailing ships across the oceans. It has been used by wind mills to grind grain and pump water.

Wind Turbines

More recently, wind power is used to turn wind turbines. When many wind machines are grouped together on wind farms, they can generate enough power to operate a power plant. In the United States, some wind farms generate more than 1300 MW of electricity a day. In Europe, many wind farms routinely generate hundred megawatts or more electricity a day.

Geothermal Energy

In some parts of the world, the earth provides us hot water from geysers and hot springs. There is hot molten part, deep in the Earth called magma. Water reaching close to the magma changes to steam due to high temperature of magma. This energy is called geothermal energy.

Geothermal well

Geothermal well can be built by drilling deep near hot rocks at places, where magma is not very deep. Water is then pushed 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 pipes directly into houses and offices for heating purposes or it can be used to generate electricity.

Energy from Biomass

Biomass is plant or wastes that can be burnt as fuel. Other forms of biomass are garbage, farm wastes, sugarcane and other plants. These wastes are used to run power plants. Many industries that use of forest products get half of their electricity by burning bark and other wood wastes. Biomass can serve as another energy source, but problems are there in its use.

Source of biomass

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

Mass Energy Equation

Q.No.10 Explain Mass – Energy Equation.

Ans: Einstein predicted the Interconversion of matter and energy. According to him, a loss in the mass of a body provides us a lot of energy. This happens in nuclear reactions.

Equation

The relation between mass m and energy E is given by Einstein mass – energy equation.

$$E = m c^2$$

Here c is the speed of light ($3 \times 108\ ms^{-1}$). The above equation shows that tremendous amount of energy can be obtained from small quantity of matter. It appears that matter is highly concentrated form of energy.

Energy on Sun and Stars

This process of getting energy from our nuclear power plants is taking place on the sun and stars for the last millions of years. Only a very small fraction of the sun energy reaches the earth. This very small fraction of the sun energy is responsible for life on the earth.

Electricity from Fossil Fuels

Q.No.11 Explain the electricity from fossil fuels with block diagram.

Ans: We are using electricity in houses, offices, schools, business centers, factories and in farms. We have different ways of generating electricity. Most of the electricity is obtained using fossil fuels such as oil, gas and coal. Fossil fuels are burnt in thermal power stations to produce electricity. Various energy conversion process involved in producing electricity from coal are described in block diagram.

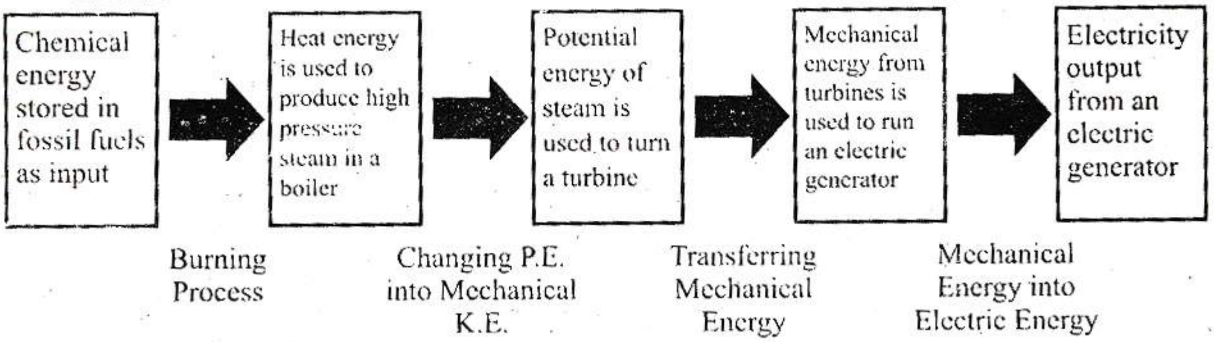


Figure 6.27: Several energy conversion processes are involved in producing electricity.

Energy and Environment

Q.No.12 Explain the effect of consumption of Energy on Environment.

Ans: Environmental problems such as pollution that consists of noise, air pollution and water pollution may arise by using different sources of energy such as fossil fuels and nuclear energy.

Pollution

Pollution is the change in the quality of environment. Pollution is the changes unpleasant for living things.

Thermal pollution

A temperature rise in the environment that disturbs life is called thermal pollution. Thermal pollution upsets the balance of life and endangers the survival of many species.

Air pollution

Air pollutions are unwanted and harmful. Natural processes such as volcanic eruptions, forest fires and dust storms add pollutant to the air. These pollutant, rarely build up to harmful levels. On the other hand, the burning of fuel and solid wastes in homes automobiles, and factories releases harmful amount of air pollutants.

Nuclear pollution

All power plants produce waste heat, but fission plants produce the most. The heat released into a lake, a river or an ocean upsets the balance of life in them. Unlike other power plants, nuclear power plants do not produce carbon dioxide. But they produce dangerous radioactive waste.

Government Laws

In many countries, governments have passes laws to control air pollution. Some of these laws limit the amount of pollution level that, power plants, factories and automobiles are allowed to give off. To meet these conditions for automobiles, new cars have catalytic gases. The use of lead free petrol has greatly reduced the amount of lead in air. Engineers are working to improve new kinds of cars that use electricity or energy sources other than petrol and diesel.

Individual Efforts

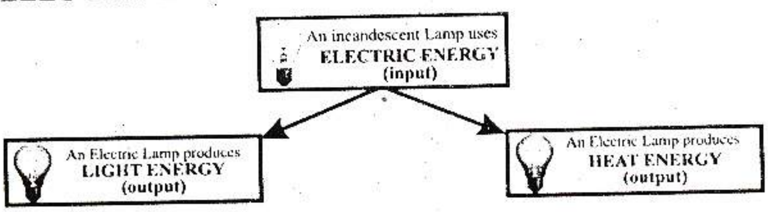
Many individual communities have laws which protect their areas from pollution. Individuals can help to control air pollutions simply by reducing the use of cars and other machines that burnt fuel. Sharing rides and using public transportation are the ways to reduce the number of automobiles in use.

Flow Diagram of an Energy Converter

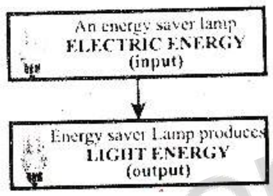
Q.No.13 Draw the Flow Diagram Of An Energy Converter.

Ans: In an energy converter, a part of energy taken (used up) by the system is converted into useful work. Remaining part of the energy is dissipated as heat energy, sound energy (noise) into the environment. Energy flow diagram given below shows the energy taken up by an energy converter to transform it into other forms of energy.

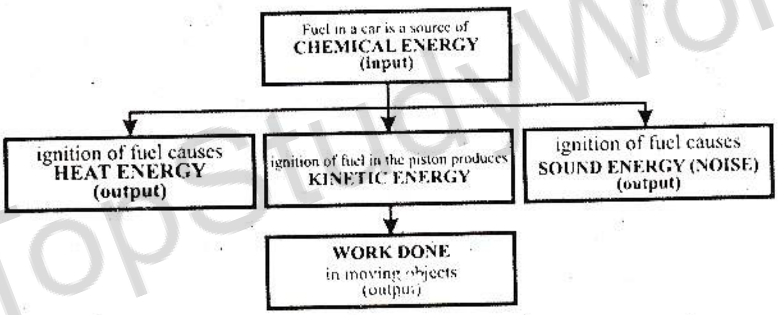
ELECTRIC LAMP



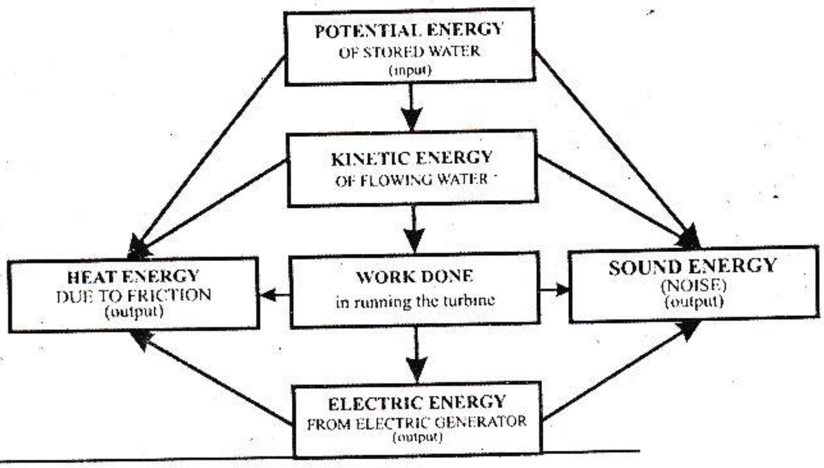
ENERGY SAVER LAMP



VEHICLE RUNNING WITH CONSTANT SPEED ON A LEVEL ROAD



POWER STATION



6.8 EFFICIENCY

Q.No.14 What is Efficiency? Explain the ideal machine and practical systems.

Ans: Efficiency of a system is the ratio of required form of energy obtained from a system as output to the total energy given to it as input.

Example

Electric motors may be used to pump water, to blow air, to wash clothes, to drill holes, etc. for that they use electric energy. How good a machine is, depends how much output we obtain from it by giving certain input. The ratio of useful output to input energy is very important to judge the working of machine.

Mathematical Form

$$\text{Efficiency} = \frac{\text{Required form of output}}{\text{Total input energy}}$$

Or $$\%\ \text{Efficiency} = \frac{\text{Required form of output}}{\text{Total input energy}} \times 100$$

Ideal Machine

An ideal machine is that which gives an output equal to the total energy used by it. In other words, its efficiency is 100 %. People have tried to design a working system that would be 100 % efficient. But practically such system does not exist.

Practical Systems

Every system meets energy losses due to friction that causes heat, noise etc. these are not the useful forms of energy and go waste. This means we cannot utilize all the energy given to working system. The energy in the required form obtained from working system always less than the energy given to it as input.

6.9 POWER

Q.No.15 What is Power? Write down its unit and define it.

Ans: "Rate of doing work with respect to time is called the power."

Thus $$\text{Power} = \frac{\text{Work}}{\text{time}}$$

If we represent power by 'P', work by 'W' and time by 't', then

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

Quantity

Since work is scalar quantity so power is also a scalar quantity.

Unit of power

In System International, the unit of power is watt (W).

Watt

"If a body does a work of one joule in one second then its power will be one watt".

Bigger Units

$1\ KW = 10^3\ W$
$1\ MW = 10^6\ W$
$1\ \text{horsepower} = 746\ W$

MINI EXERCISE

A crate is moved by pulling the rope attached to it. It moves 10m on a straight horizontal road by a force of 100 N. How much work will be done if

(1) The rope is parallel to the road.

Ans. As we know that $W = FS\cos\theta$.

If the rope is parallel to the road then $\theta = 0$.

So

$$W = 100 \times 10 \times \cos 0$$
$$= 100 \times 10 \times 1 \quad \text{(as } \cos 0 = 1\text{)}$$
$$= 1000\ J$$

(2) The rope is making angle of 30° with road.

Ans. As we know that $W = FS\cos\theta$.

If the rope is parallel to the road then $\theta = 30^\circ$.

So

$$W = 100 \times 10 \times \cos 30^\circ$$
$$= 100 \times 10 \times 0.866 \quad \text{(as } \cos 0 = 0.866\text{)}$$
$$= 866\ J$$

TEXTBOOK EXERCISE

QUESTIONS

6.1 Encircle the correct answer from the given choices.

i. The work done will be zero when the angle between force and distance is:

a) 45° b) 60° **c) 90°** d) 180°

ii. If the direction of motion of the force is perpendicular to the direction of motion of the body, then work done will be:

a) Maximum b) minimum **c) zero** d) none of above

iii. If the velocity of a body becomes double, then its kinetic energy will:

a) Remains the same b) becomes double **c) becomes four times** d) become half

iv. The work done in lifting a brick of mass 2 kg through a height of 5 m above the ground will be:

a) 2.5 J b) 10 J c) 50 J **d) 100 J**

v. The kinetic energy of a body of mass 2 kg is 25 J. Its speed is:

a) 5 ms^{-1} b) 1.5 ms^{-1} c) 12.5 ms^{-1} d) 50 ms^{-1}

vi. Which one of the following converts light energy into electrical energy?

a) Electric bulb b) electrical generator **c) photocell** d) electric cell

vii. When a body is lifted through a height 'h', the work done on it appears in the form of its:

a) kinetic energy **b) potential energy** c) elastic potential energy d) geothermal energy

viii. **The energy stored in coal is:**

a) heat energy b) kinetic energy **c) chemical energy** d) nuclear energy

ix. **The energy stored in a dam is:**

a) electrical energy **b) potential energy** c) kinetic energy d) thermal energy

x. **In Einstein's mass-energy equation, c is the**

a) speed of sound **b) speed of light** c) speed of electron d) speed of Earth

xi. **Rate of doing work is called**

a) energy b) torque **c) power** d)momentum

6.2 Define work. What is its SI unit?

Ans: Work is done when force acting on a body displaces it in the direction of a force.

Unit of work

In System International, its unit is joule (J).

Joule

The amount of Work done will be one joule if a force of one Newton displaces a body through a distance of one meter in the direction of the force.

6.3 When does a force do work? Explain.

Ans: When force acts on the body and body covers some distance in the direction of force then we said work is done. And this work can be calculated by the formula.

$W = F \times S$

6.4 Why do we need energy?

Ans: We need energy to do different types of work in our daily life. When we say that body has energy, we mean that it has the ability to do work.

Examples

- Energy is required to move.
- Energy is required to stop the moving objects.

6.5 Define energy; give two types of mechanical energy.

Ans: A body possesses energy if it is capable to do work.

OR

Ability of a body to do work is known as energy.

Types of Mechanical Energy

Mechanical energy possessed by a body is of two types:

i) Kinetic Energy

ii) Potential Energy

6.6 Define K.E. and derive its relation.

Ans: See Q. no.2 Long Question

6.7 Define potential energy and drive its relation.

Ans: See Q. no.3 Long Question

6.8 Why fossils fuels are called non - renewable form energy?

Ans: Fossils fuels after giving energy are consumed completely. So they are called non – renewable form of energy.

6.9 Which form of energy is most preferred and why?

Ans: Solar energy is most preferred because it is the ultimate source of energy for life and sunrays do not pollute the environment. It is huge source of energy and if we find a suitable method to use a fraction of the solar energy reaching the Earth, then it would be enough to fulfill our energy requirements.

6.10 How is energy converted from one form to another? Explain.

Ans: See Q. no.5 Long Question

6.11 Name the five devices that convert electrical energy into mechanical energy.

Ans:

(i) Electric Motor
(ii) Electric Fan
(iii) Elevator
(iv) Drill machine
(v) Grinder
(vi) Sewing machine

6.12 Name a device that converts mechanical energy into electrical energy.

Ans: Electric Generator is device which is used to convert the mechanical energy into electrical energy.

6.13 What is meant by efficiency of a system?

Ans: Efficiency of a system is the ratio of required form of energy obtained from a system as output to the total energy given to it as input.

Example

Electric motors may be used to pump water, to blow air, to wash clothes, to drill holes, etc. for that they use electric energy. How good a machine is, depends how much output we obtain from it by giving certain input. The ratio of useful output to input energy is very important to judge the working of machine.

6.14 How can you find the efficiency of a system?

Ans: Efficiency of a system is the ratio of required form of energy obtained from a system as output to the total energy given to it as input.

Mathematically, it can be calculated as:

$$\text{Efficiency} = \frac{\text{Required form of output}}{\text{Total input energy}}$$

Or

$$\%\ \text{Efficiency} = \frac{\text{Required form of output}}{\text{Total input energy}} \times 100$$

6.15 What is meant by the term power?

Ans: "Rate of doing work with respect to time is called the power."

Thus

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

If we represent power by 'P', work by 'W' and time by 't', then

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

6.16 Define watt.

Ans: In System International, the unit of power is watt (W).

Watt

If a body does a work of one joule in one second then its power will be one watt.

$1\ W = 1\ Js^{-1}$

Bigger Units

$1\ KW = 10^3\ W$

$1\ MW = 10^6\ W$

PROBLEMS

6.1 A man has pulled a cart through 35 m applying a force of 300 N. Find the work done by the man.

Given Data

Force applied = F = 300 N

Distance moved by cart = S = 35 m

Required

Work done by the man = W =?

Solution

As we know that

$W = F \times S$

By putting the values, we have

$W = 300 \times 35$

$W = 10500\ J$

Result

Work done by the man = W = 10500 J

6.2 A block weighing 20 N is lifted 6 m vertically upward. Calculate the potential energy stored in it.

Given Data

Weight of the block = W = 20 N

Distance moved vertically upward = h = 6 m

Required

Potential energy of the block = P.E = ?

Solution

As we know that

$W = F \times S$

By putting the values, we have

$W = 20 \times 6$

$W = 120\ J$

Result

Potential energy of the block = P.E = 120 J

6.3 A car weighing 12 kN has speed of 20 ms-1. Find its kinetic energy stored in it.

Given Data

Weight of car = w = 12 kN

Speed of car = v = 20 ms-1

Required

Kinetic energy stored in car = K.E = ?

Solution

As we know that

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

By putting the values, we have

$K.E. = \frac{1}{2} \times 1200 \times (20)^2$

$K.E. = \frac{1}{2} \times 1200 \times 400$

$K.E. = 240000\ J$

$K.E. = 240\ kJ$

Result

Kinetic energy stored in car = K.E = 240 kJ

6.4 A 500 g stone is thrown up with a velocity of 15 ms^{-1}. Find its

i) P.E. at its maximum height

ii) K.E. when it hits the ground

Given Data

Mass of the stone = m = 500 g = 0.5 kg

Velocity of the stone = v = 15 ms^{-1}

Required

P.E. at its maximum height = P.E. = ?

K.E. when it hits the ground = K.E. = ?

Solution

As we know that

Potential energy at maximum height = kinetic energy while throwing

Potential energy at maximum height = ½ mv^2

By putting the values, we have

Potential energy at maximum height = ½ x 0.5 x $(15)^2$

Potential energy at maximum height = ½ x 0.5 x 225

Potential energy at maximum height = 56.25 J

Also we know that

Kinetic energy while hitting the ground = Potential energy at maximum height

As Potential energy at maximum height = 56.25 J

So Kinetic energy while hitting the ground = 56.25 J

Result

P.E. at its maximum height = P.E. = 56.56 J

K.E. when it hits the ground = K.E. = 56.56 J

6.5 On reaching the top of a slope 6 m high from its bottom, a cyclist has a speed of 1.5 ms^{-1}. Find the kinetic energy and the potential energy of the cyclist. The mass of the cyclist and his bicycle is 40 kg.

Given Data

Speed of the cyclist = v = 1.5 m^{s-1}

Height of slope = h = 6 m

Mass of cyclist and bicycle = m = 40 kg

Required

Kinetic energy of the cyclist = K.E. = ?

Potential energy of the cyclist = P.E = ?

Solution

As we know that

P.E. = mgh

By putting the values, we have

P.E. = 40 x 10 x 6

P.E. = 2400 J

Also we know that

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

By putting the values, we have

$$K.E. = \frac{1}{2} \times 40 \times (1.5)^2$$
$$K.E = \frac{1}{2} \times 40 \times 2.25$$
$$K.E. = 45 \text{ J}$$

Result

Kinetic energy of the cyclist = K.E. = 45 J
Potential energy of the cyclist = P.E = 2400 J

6.6 A motor boat moves at a steady speed of 4 ms^{-1}. Water resistance acting on it is 4000 N. Calculate the power of its engine.

Given Data

Speed of the motor boat = v = 4 ms^{-1}
Water resistance acting on boat = 4000 N

Required

Power of the engine of motor boat = P = ?

Solution

As we know that

$$P = F \times v$$

By putting the values, we have

$$P = 4000 \times 4$$
$$P = 16000 \text{ W}$$
$$P = 16 \text{ kW}$$

Result

Power of the engine of motor boat = P = 16 kW

6.7 A man pulls a block with a force of 300 N through 50 m in 60 s. Find the power used by him to pull the block.

Given Data

Force applied on block = F = 300 N
Distance covered by the block = S = 50 m
Time taken = t = 60 s

Required

Power used to pull the block = P = ?

Solution

As we know that

$$P = \frac{W}{t} = \frac{F \times S}{t}$$

By putting the values, we have

$$P = \frac{3000 \times 50}{60}$$
$$P = \frac{150000}{60}$$
$$P = 250 \text{ W}$$

Result

Power used to pull the block = P = 250 W

6.8 A 50 kg man moved 25 steps up in 20 seconds. Find his power, if each step is 16 cm high.

Given Data

Mass of man = m = 50 kg

Height of each step = h = 16 cm = 0.16 m

Number of steps = n = 25

Time taken = t = 20 s

Required

Power of the man = P = ?

Solution

As we know that

$$P = \frac{W}{t} = \frac{F \times S}{t}$$

By putting the values, we have

$$P = \frac{500 \times 4}{20}$$

$$P = \frac{2000}{20}$$

$$P = 100\ W$$

Result

Power of the man = P = 100 W

6.9 Calculate the power of a pump which can lift 200 kg of water through a height of 6 m in 10 seconds.

Given Data

Mass of the water = m = 200 kg

Height attained = h = 6 m

Time taken = t = 10 s

Required

Power of the pump = P = ?

Solution

As we know that

$$P = \frac{W}{t} = \frac{F \times S}{t}$$

By putting the values, we have

$$P = \frac{2000 \times 6}{10}$$

$$P = \frac{12000}{10}$$

$$P = 1200\ W$$

Result

Power of the pump = P = 1200 W

6.10 An electric motor of 1 hp is used to run water pump. The water pump takes 10 minutes to fill an overhead tank. The tank has a capacity of 800 liters and height of 15 m. find the actual work done by the electric motor to fill the tank. Also find the efficiency of the system.

Given Data

Power of the motor = P = 1 hp

Time taken by pump = t = 10 mins = 600 s

Capacity of the tank = v = 800 liters

Height of the tank = h = 15 m

Required

Work done by the motor = W = ?

Efficiency of the system = ?

Solution

As we know that

$$P = \frac{W}{t} \qquad \text{So} \qquad W = P \times t$$

By putting the values, we have

$W = 1 \text{ hp} \times 600\text{s}$

Or $W = 746 \text{ w} \times 600\text{s} = 447600 \text{ J}$

Now Output = W = mgh

By putting the values, we have

Output = 800 x 10 x 15

Output = 120000 J

We also know that

$$\% \text{ Efficiency} = \frac{\text{Required form of output}}{\text{Total input energy}} \times 100$$

By putting the values, we have

$$\% \text{ Efficiency} = \frac{120000 \text{ J}}{447600 \text{ J}} \times 100$$

% Efficiency = 0.268 x 100

So, % Efficiency = 26.8%

Result

Work done by the motor = W = 447600 J

Efficiency of the system = 26.8%