**** 1. Define work.**

Work is said to be done when a force acts on an object and moves it through some distance.

***2. How is work defined in physics? When is work done and when is it zero?**

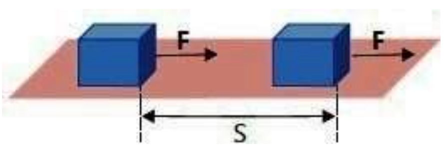
In physics, work is defined as the product of the magnitude of force and the distance covered in the direction of force.

Mathematically,

$$\boldsymbol{Work = Magnitude\ of\ force \times Distance}$$
$$\boldsymbol{W = F \times S}$$

Force and distance are two essential elements of work. When a constant force acts on a body and moves it through some distance, we say that **the force has done work**.

For example, If a force F is applied to move a block through a distance S, then work is done.



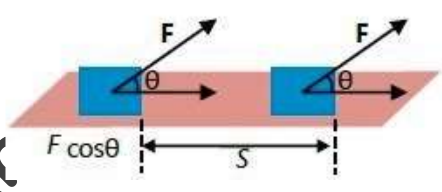
However, if force is applied but **no displacement** occurs (e.g. pushing a wall that does not move), **no work is done**.

Similarly, if a **force acting on the body is zero** and the body is moving with uniform velocity, work will be zero. As $F = 0$, so

$$W = 0 \times S$$
$$W = 0$$

3. What will be the work done when a force is acting on a body making an angle $\boldsymbol{\theta}$ with the direction of motion?

When a force **acts at an angle $\boldsymbol{\theta}$** with the direction of motion, only the horizontal component of the force in the direction of motion does the work. This component is $F\cos\theta$. Therefore,



$$W = F\cos\theta \times S$$
$$W = FS\cos\theta$$

where:

(i) F is the applied force,

(ii) S is the displacement, and

(iii) θ is the angle between force and displacement.

Special cases:

(i) If $\theta = 0^\circ$, then $\cos 0^\circ = 1$, so $W = FS$. This means force and displacement are in the **same direction**, and work is **maximum**.

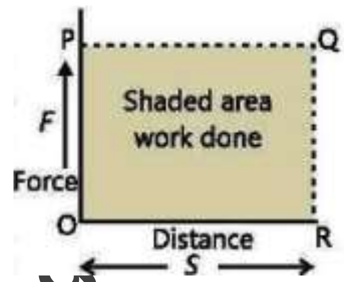
(ii) If $\theta = 90^\circ$, then $\cos 90^\circ = 0$, so $W = 0$. This means force is **perpendicular** to the displacement and **no work is done**.

For example, carrying a bag while walking horizontally involves a vertical force (holding the bag) and a horizontal displacement, so **work done is zero**.

Also, work **does not depend on direction**, and it is the same whether the object moves north, south, east, or west — as long as force and distance remain the same. Hence, **work is a scalar quantity**.

***4. How can work done be calculated using a force-distance graph?**

When a constant force F acts through a distance S, this can be shown on a force-distance graph. If the force and distance are in the same direction, the work done is:



$$Work = F \times S$$

This value is also equal to the area under the force-distance graph.

Hence, the **area under a force-distance curve represents the work done** by the force.

**** 5. What is the SI unit of work and how is it defined?**

The SI unit of work is **joule (J)**.

One joule work is done when a force of one newton acting on a body moves it through a distance of one metre in its own direction.

From equation $W = FS$:

$$1J = 1\,N \times 1\,m$$
$$1\text{J} = 1\text{N m}$$

Bigger units of work are also used like $1\,kJ = 10^3\,J$ and $1\,MJ = 10^6\,J$.

***6. What is energy? Give an example.**

Energy can be defined as the ability of a body to do work.

Our body cannot move unless we get energy from food.

A car cannot run without the energy obtained by burning fuel.

***7. What is the SI unit of energy?**

Energy, like work, is a scalar quantity. The **SI unit** of energy is the **joule (J)**.

When one joule of work is done on a body, the amount of energy spent is one joule.

***9. What is mechanical energy and what are its types?**

The combination of kinetic energy and potential energy is called mechanical energy.

There are many different forms of energy, such as electrical energy, chemical energy, nuclear energy, heat energy, and light energy.

However, there are **two basic forms of energy**:

(i) Kinetic energy

(ii) Potential energy

**** 10. What is kinetic energy and how is it calculated?**

Kinetic energy of a body is the energy that a body possesses by virtue of its motion.

Derivation: To find how much kinetic energy a moving body has, we apply a force in the **opposite direction** to bring it to rest. The **work done** by this force is **equal** to the kinetic energy of the body. So,

$$Kinetic\ energy = E_k = Work\ done\ (W)$$

Suppose a body of **mass m** is moving with **velocity v**. An opposing force F brings the body to rest over a distance S. Then,

$$E_k = F \times S \cdots (i)$$

By Newton's second law, the opposing force F is:

$$F = ma$$

where a is the deceleration.

The distance S traveled under constant deceleration can be found using the average velocity:

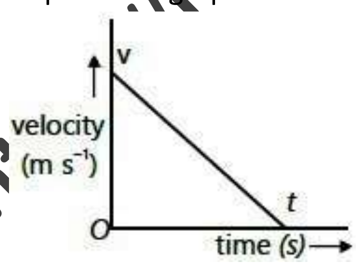
$$S = v_{av} \times t$$
$$S = \left(\frac{v+0}{2}\right) \times t$$
$$S = \frac{v}{2} \times t$$

Putting values of F and S in equation (i)

$$E_k = ma \times \frac{v}{2} \times t \cdots (ii)$$

Now using the **velocity-time graph** shown in figure, the **acceleration** a is given by the slope of the graph:

$$a = \frac{v_f - v_i}{t}$$
$$a = \frac{0 - v}{t}$$
$$a = -\frac{v}{t}$$



The negative sign indicates deceleration (force and velocity are in opposite directions). For kinetic energy, we consider the magnitude:

$$a = \frac{v}{t}$$

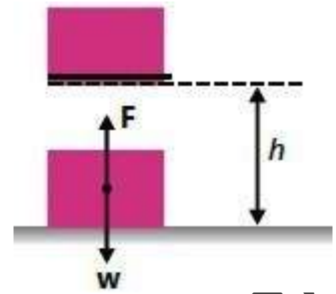
Putting value of a in equation (ii)

$$E_k = m \times \frac{v}{t} \times \frac{v}{2} \times t$$
$$E_k = \frac{1}{2} m v^2$$

***11. What is Potential Energy? How is it calculated?**

Potential energy is defined as the energy that a body possesses by virtue of its position or deformation.

Derivation: If a block shown in figure is lifted to a height h above the ground, then the block would have **potential energy** in that raised position. Therefore, it has the **ability to do work** whenever it is allowed to fall.



Because **work is done** on the block to put it into the position where it has potential energy, we can say that **this work is stored in it** as potential energy.

Thus, gravitational potential energy E_p is given by:

$$E_p = Work\ done\ to\ put\ the\ block\ in\ elevated\ position$$

The applied force necessary to lift the block with **constant velocity** is equal to the **weight (w)** of the block. Since $w = mg$, therefore:

$$E_p = wh$$
$$E_p = mgh$$

Example: The most obvious example of gravitational potential energy is a **waterfall**. Water at the top of the fall has **potential energy**. When the water falls to the bottom, it can be used to **run turbines** to produce **electricity** and thus can do **useful work**.

***12. What are the different forms of potential energy? Explain briefly.**

There are many forms of potential energy. Some of the important ones are:

(i) Gravitational Potential Energy: The energy possessed by an object due to its position relative to the Earth. For example, water stored at a height in a dam.

(ii) Elastic Potential Energy: The energy stored in a compressed or stretched spring or elastic material. This energy is due to the deformation of the object.

(iii) Chemical Potential Energy: The energy stored in chemicals, such as in batteries or fuels. It is released during chemical reactions and may be converted into electrical or thermal energy.

(iv) Thermal (Internal) Energy: This is the energy released by burning fossil fuels like coal, oil, or gas through chemical reactions.

(v) Nuclear Energy: The energy stored in the nucleus of an atom. When the nucleus splits (nuclear fission), a large amount of energy is released in the form of heat and radiation.

These different forms of potential energy can be converted into kinetic energy or other useful forms to perform work.

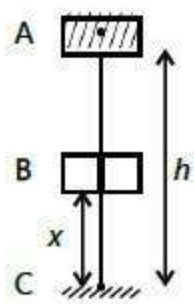
**** 13. What is meant by the conservation of energy? Explain with an example.**

Energy cannot be created or destroyed. It may be transformed from one form to another, but the total amount of energy never changes.

During the energy transfer process, some energy seems to be lost and not accounted for in calculations. This loss of energy is due to **work done against friction** of the moving parts in the process. This energy appears as **heat** and is dissipated in the environment. It does not remain available for doing useful work and is called **waste energy**.

An example of energy conversion and conservation can be described as follows:

Let a body of mass m be at rest at a **point A** above the height h from the ground as shown in figure. Its total energy is *P.E* is mgh.



$$E_p = mgh$$
$$\text{and} \quad E_k = 0$$

So, the total energy at point A is:

$$E = E_p + E_k$$
$$E = mgh + 0$$
$$\boldsymbol{E = mgh}$$

Then the body is allowed to drop to point B at a height x from the ground. The body lose potential energy and gains kinetic energy as it gets speed while falling down. Assuming air resistance negligible.

$$E_p = mg(h - x)$$

The loss of potential energy will appear as the gain in kinetic energy, hence, at **point B**

$$E_k = mgx$$

So, the total energy at point B is:

$$E = E_p + E_k$$
$$E = mg(h - x) + mgx$$
$$E = mgh - mgx + mgx$$
$$\boldsymbol{E = mgh}$$

Just before hitting the ground at **point C**, the whole of potential energy is changed into kinetic energy. Thus,

$$E_p = 0$$
$$\text{and} \quad E_k = mgh$$

So, the total energy at point A is:

$$E = E_p + E_k$$
$$E = 0 + mgh$$
$$\boldsymbol{E = mgh}$$

Thus, total energy remains the same as mgh. On hitting the ground, this energy is dissipated as heat and sound in the environment.

**** 14. Differentiate between renewable and non-renewable sources of energy with examples.**

Renewable	Non-renewable
The resources of energy which are replaced by new ones after their use are called renewable energy sources.	Non-renewable sources are those, which are depleted with the continuous use.
Sources such as hydroelectricity, solar energy, wind energy, tidal energy, wave energy and geothermal energy are renewables.	Non-renewable sources include fossil fuels (coal, oil, natural gas) and nuclear energy.
For example, snowfall and rainfall are continuous processes. Therefore, water supply to the reservoirs of dams for generation of hydroelectric power will never end up.	The remnants (باقیات) of plants and animals buried under the Earth took millions of years to change into fossil fuels.
These are not going to run out in future.	These fuels are in limited quantity. Once they are used up, it will take further millions of years to form new ones.

15. What are Sources of Energy?

Sources of energy are the origins from which energy is obtained to perform various forms of work. These sources can be **renewable** (such as solar, wind, hydro, geothermal) or **non-renewable** (such as fossil fuels and nuclear energy).

**** 16. What is Fossil Fuel Energy?**

Fossil fuel energy is the energy that is released by burning of oil, coal and natural gas.

OR

*Fossil fuel energy comes out from burning of **oil, coal and natural gas**. These materials are known as fossil fuels.*

The burning of these fuels gives out heat which is used to generate steam that runs the turbines to produce electricity.

**** 17. What is Hydroelectric Energy?**

*Hydroelectric generation is the electricity generated from the **power of falling water**.*

OR

Hydroelectric generation is the electricity generated by using the kinetic energy of the falling water.

Water stored in a high reservoir possesses gravitational potential energy. When it falls, the potential energy changes to kinetic energy which rotates a turbine. The turbine then runs an electric generator to produce electricity.

***18. What is Solar Energy and how is it used?**

*Sun is the biggest source of energy. The energy obtained from sunlight is referred to as **solar energy**.*

OR

Solar energy is the energy of the Sunlight that can be converted into electricity.

Uses of Solar Energy: Solar energy can be used in two ways.

(i) Heating System

(ii) Electricity Generation

Use in Heating Systems: In this way, solar panels absorb heat of the Sun. They consist of **large metal plates** which are painted black. Heat can be used for warming houses or running water heating system.

If solar radiation is concentrated to a small surface area by using **large reflectors or lenses**, reasonably high temperature can be achieved.

At this high temperature, water can be boiled to **produce steam** that can run the turbine of an electric generator. In this way, electricity can be produced.

Use in Electricity Generation through Solar Cells: In the second method, sunlight is directly transformed to electricity through the use of solar cells.

***Solar cells** are also known as **photo voltaic cells**. The voltage produced by a single voltaic cell is very low.*

*In order to get sufficient high voltage for practical use, a large number of such cells are connected in series to form a **solar cell panel**.*

Solar calculators are also available which work by using the electrical energy provided by solar cells.

Large solar panels are also used to **power satellites**.

***19. What is Nuclear Energy?**

The energy released by breaking the nucleus of an atom is known as nuclear energy.

OR

*Nuclear energy is the **heat energy released** when the nucleus of an atom (e.g., uranium or plutonium) splits in a process called **nuclear fission**.*

Nuclear energy is released in the form of heat when an atomic nucleus breaks. Nuclear fuels such as **uranium and plutonium** are used in nuclear power stations. The heat produced during nuclear fission is used to make steam that runs turbines to generate electricity.

Pakistan also runs nuclear power stations at Karachi and Chashma.

***20. What is Geothermal Energy?**

Geothermal energy is the heat energy of the hot rocks present deep under the surface of the Earth.

OR

*Geothermal energy is the heat derived from **hot, semi-molten rocks** deep beneath the Earth's surface. This heat is generated by the **decay of radioactive elements** and can reach temperatures of **250°C or higher**.*

To make use of the heat of the rocks, two holes are drilled up to the rocks. Cold water is pumped down through one of the holes.

It is heated up by the hot rocks and starts boiling. Steam is produced that comes out through the other hole. The steam runs the generator which produces electricity.

Where there is water already present over the hot rocks, it comes out of the surface of the Earth in the form of hot springs and geysers.

***21. What is Wind Energy and how is electricity generated from it?**

Wind energy is the electrical energy produced by using the kinetic energy of the fast- blowing wind.

For thousands of years, people have been using **windmills** to draw water from the well or to grind grains into flour.

The **modern windmill** is used to run generators that produce electricity.

Wind generators make electricity in the same way as steam generators in power stations.

For large scale power generation, a '**wind farm**' with a hundred or more windmills is needed.

***22. What is Tidal Energy and how is it used to generate electricity?**

Tidal energy is a renewable energy source that uses the movement of ocean tides (caused by the moon's gravity) to generate electricity.

The gravitational force of the Moon gives rise to **tides in the seas**.

The tide raises the water level near the sea shore **twice a day**.

The rise and fall of water can be utilized to **turn on turbine** for electricity generation.

The water at high tides can be trapped at a suitable location, a basin, by building a dam.

The water is then released in a controlled way at low tide to drive the turbines for producing electricity.

At next high tide, the **dam is filled again** and the incoming water also drives turbines.

***23. What is Wave Energy and how can it be harnessed?**

*Wave energy uses **ocean waves** (made by wind and tides) to make electricity.*

The **tides and winds** blowing over the surface of the sea produce strong water waves. Their energy can be used to generate electricity.

The method to harness wave energy is to use large floats which move up and down with the waves. One such device invented by Prof. Salter is known as **Salter's duck**. It consists of **two parts**:

(i) Duck float
(ii) Balanced float

The energy of the water waves causes duck float to move relative to the balance float. The **relative motion of the duck float** is used to drive the electricity generators.

***24. What is Biomass Energy and how is it used to generate useful energy?**

It is that energy which is obtained from the biomass. Biomass consists of organic materials such as plants, waste foods, animals dung, sewage, etc.

OR

Biofuel energy is that energy which is obtained by fermentation of organic materials in the form of biogas or ethanol.

***Sewage** is that dirt which is left over after staining dirty water.*

The material can itself be used as **fuel** or can be converted into other types of fuels.

Direct combustion is a method in which biomass, commonly known as solid waste, is burnt to boil water and produce steam. The steam can be used to generate electricity.

In another process, the rotting of biomass in a closed tank called a **'digester'** produces methane rich biogas. In this process, micro-organisms break down biomass material in the absence of oxygen.

Biogas produced in the tank is piped out and can be used for heating and cooking like natural gas.

Biofuel such as ethanol (alcohol) can also be obtained from the biomass. It is a replacement of petrol. In this case, bacteria converts it into ethanol.

25. What are the advantages and disadvantages of methods of energy production?

Advantages:

(i) The production of **hydroelectric power** is more **economical and pollution free**.

(ii) The solar power, wind, tidal and wave power need more initial cost but do not produce pollution and are also **economical** as well.

Disadvantages:

(i) **Power generation by fossil fuels** and nuclear fuel adds to the pollution of environment.

(ii) **Burning of fossil fuels** produces smoke, carbon dioxide gas and heat. They enhance direct pollution to atmosphere.

(iii) **Wind-mills** are very noisy. Some people think that wind turbines spoil the beauty of landscape.

(iv) **Nuclear power generators**: Heat is a **form of pollution**. There is always danger of leakage of radioactive radiation, which is harmful to living bodies. People living around nuclear plants are always at risk. The **disposal of nuclear waste** is another problem for nuclear power generation.

(v) Any form of waste energy ends up as **thermal energy** that goes to the environment. Thus, thermal pollution is increasing day by day, causing global warming.

**** 27. Define power. Write its formula.** *(ALP)*

Power is defined as the time rate of doing work.

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

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

It tells us how fast or slow work is done.

Power of any agency can also be defined as energy transferred per unit time.

**** 28. What is SI unit of power? Define it. Also write some bigger units of power.** *(ALP)*

SI unit of power is watt (W).

Watt: One watt is the work done at the rate of one joule per second.

$$1\,W = \frac{1\,J}{1\,s} \qquad or \qquad 1\,Js^{-1}$$

Bigger Units of Power: Bigger units of power are kilowatt (kW), megawatt (MW) etc.

$$\mathbf{1\,kilo\,watt\,(kW) = 10^3 W = 1000\,W}$$
$$\mathbf{1\,mega\,watt\,(MW) = 10^6 W = 1000\,000\,W}$$

In British engineering system, the unit of power used is **horse-power (hp)**. The horse power is defined as

$$1\,horse\,power\,(1hp) = 746\,W$$

**** 29. Define efficiency.**

The ratio of useful output energy and the total input energy is called the efficiency of a working system.

Thus

$$Efficiency = \frac{Useful\ output\ energy}{Total\ input\ energy}$$

Efficiency is often multiplied by 100 to give percentage efficiency. Thus,

$$Percentage\ Efficiency = \frac{Useful\ output\ energy}{Total\ input\ energy} \times 100$$

$$Percentage\ Efficiency = \frac{Useful\ power\ output}{Total\ power\ input} \times 100$$

**** 30. Why a system cannot have 100% efficiency?**

A system cannot have 100% efficiency because some energy is always wasted as heat due to **friction** and **air resistance** during energy conversion. This energy loss makes it impossible to convert all input energy into useful output energy.

31. Why is a perpetual machine not possible?

A perpetual machine cannot work because some energy is always lost as heat due to friction and air resistance. It would violate the principle of conservation of energy, which states that energy cannot be created or destroyed.

**** 32. What is the work done on an object that remains at rest when a force is applied on it?**

Work done on an object is zero due to rest position displacement of body is zero. i.e $S = 0$

As

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

**** 33. A slow-moving car may have more kinetic energy than a fast-moving motorcycle. How is this possible?**

As kinetic energy $\left(E_k = \frac{1}{2}mv^2\right)$ depend upon mass and square of speed.

So, a slow-moving car may induced have more kinetic energy than fast moving motorcyclist due to its **higher mass**.

Even with slower speed, if the mass is sufficiently large, the kinetic energy can be greater.

**** 34. A force F_1 does 5 J of work in 10 s. Another force F_2 does 3 J of work in 5 s. Which force delivers greater power?**

For force F_1

$$Work = W_1 = 5\,J$$
$$Time = t_1 = 10\,s$$
$$Power = P_1 = ?$$

By using formula of power

$$Power = \frac{Work}{time}$$
$$P_1 = \frac{W_1}{t_1}$$
$$P_1 = \frac{5}{10}$$
$$P_1 = 0.5\,watt$$

For force F_2

$$Time = t_2 = 5\,s$$
$$Power = P_2 = ?$$

By using formula of power

$$Power = \frac{Work}{time}$$
$$P_2 = \frac{W_2}{t_2}$$
$$P_2 = \frac{3}{5}$$
$$P_2 = 0.6\,watt$$

Hence, force F_2 delivers more power.

**** 35. A woman runs up a flight of stairs. The gain in her gravitational potential energy is $4500\,J$. If she runs up the same stairs with twice the speed, what will be her gain in potential energy?**

Gravitational potential energy depends only on height $(E_p = mgh)$, not speed. The gain in potential energy remains **4500 J** regardless of speed.

**** 36. What is the potential energy of a body of mass m when it is raised through a height h?**

The potential energy of a body of mass m raised to a height h is given by the formula:

$$E_p = wh$$
$$E_p = mgh$$

where g is the acceleration due to gravity.