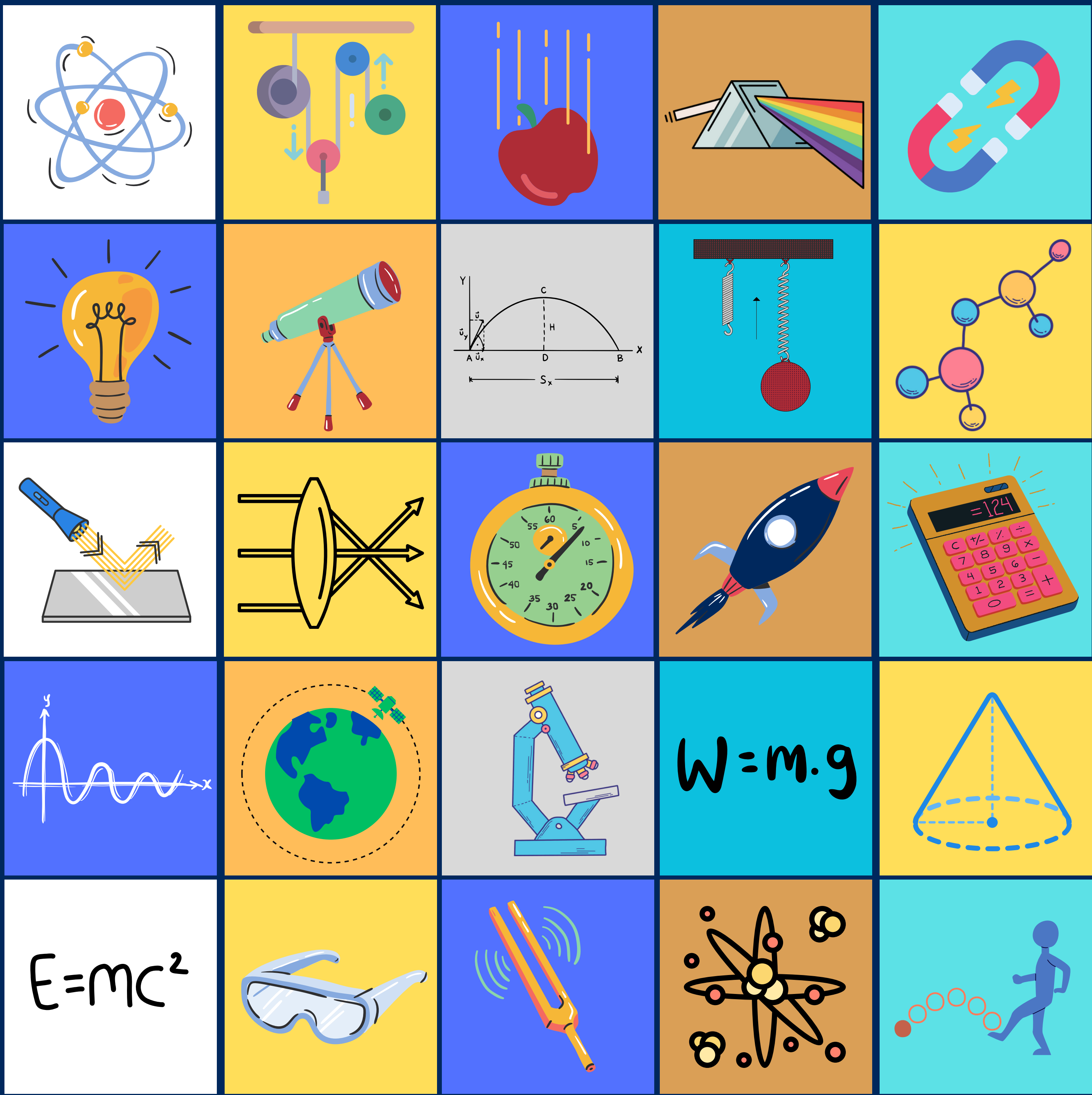

CLASS 9th NOTES

PHYSICS

WORK AND ENERGY

PRASHANT KIRAD

Work and energy

Work

For doing work, energy is required.
In animals, energy is supplied by the food they eat.
In machines, energy is supplied by fuel.

Reading, writing, drawing, thinking, and analyzing are all energy-consuming, but scientifically, no work is done in all these tasks.

- Example- A man is completely exhausted in trying to push a wall, but work done is zero as the wall is stationary.
- A man standing still with a heavy suitcase may be tired soon but he does not work in this situation as he is stationary.

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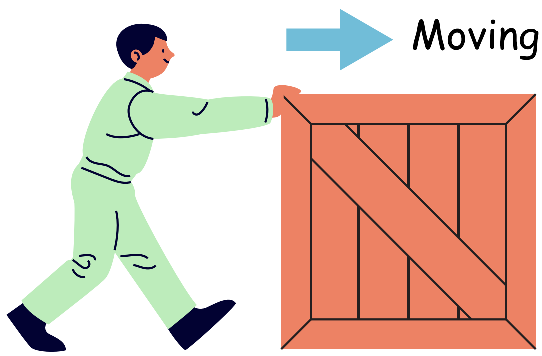
Work is said to be done when:

i. a moving object comes to rest
ii. an object at rest starts moving
iii. the velocity of an object changes
iv. the shape of an object changes

Scientific conception of work is done when force is applied on a body and when that force produces motion under its influence.

Condition of work done

i. Force should be applied on the body.
ii. Body should ne displaced.



Work is done when:

- A cyclist is pedaling the cycle.
- A man is lifting a load in an upward or downward direction

Work is not done when:

- A coolie carrying some load on his head stands stationary.
- A man is applying force on a big rock.

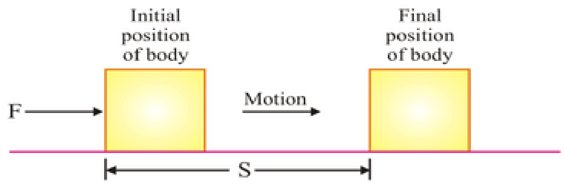
Work is done by a fixed force

Work done in the moving of a body is equal to the product of force and displacement of the body in the direction of force.

Work = Force x Displacement

W = F x S

Work is a scalar quantity.



The unit of Work is ***Newton metre or Joule.***
When a force of 1 Newton moves a body through a distance of 1 metre in its direction, then the work done is known as 1 Joule.

1 Joule = 1 newton x 1 metre

1 J = 1 Nm

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Whenever work is done against gravity, the amount of work done is equal to the product of the weight of the body and the vertical distance through which the body is lifted.

W = Weight of the body x vertical distance
W = m x g x h
where m = mass of the body
g = acceleration due to gravity
h = height through which the body is lifted

The amount of work done depends on the following factors:
i. Magnitude of force: Greater the displacement, the greater the amount of work, and vice-versa
ii. Displacement: The greater the displacement, the greater the amount of work and vice-versa.

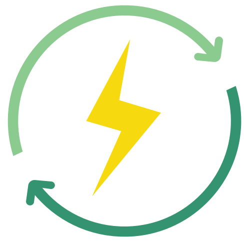
Negative, Positive, and Zero work

i. **Work done is positive** when a force acts in the direction of motion of the body. E.g., A child pulls a toy car with string horizontally on the ground.

ii. **Work done is negative** when a force acts opposite to the direction of the body. E.g., When a moving football slows due to friction acting in a direction opposite to the motion of the football.

iii. **Work done is zero** when a force acts at right angles to the direction of motion. E.g., The moon moves around the earth in a circular path, here the force of gravitation acts on the moon at right angles to the direction of the moon, so work done is zero.

Energy



The capacity to do work is known as energy.

- The sun is the biggest source of energy.
- Most of the energy sources are derived from the Sun.
- Some energy is received from the nucleus of atoms, the interior of the earth, and the tides.

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The amount of energy possessed by a body is equal to the amount of work it can do.

The working body loses energy, body on which work is done gains energy.

Forms of energy

Mechanical energy - The energy possessed by a body on account of its motion or position.

Kinetic energy - The energy of a body due to its motion is called kinetic energy. Examples-

- A moving cricket ball
- Running water
- A moving bullet
- Flowing wind
- A moving car
- A running athlete
- A rolling stone
- Flying craft

Kinetic energy formula derivation

$$W = F \times s$$

$$= ma \times \frac{v^2 - u^2}{2a}$$

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

If u = 0, (object starts at rest)

$$W = \frac{1}{2} mv^2$$

Work done = Change in kinetic energy

$$\therefore \quad E_k = \frac{1}{2} mv^2.$$

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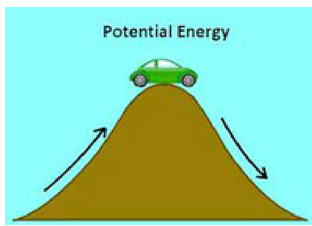
Potential energy - The energy of the body due to its position or change in shape is known as potential energy.

Examples:

i. **Water kept in damn:** It can rotate the turbine to generate electricity due to its position above the ground.

ii. **Wound-up spring of a toy car:** It possesses potential energy which is released during the unwinding of spring. So the toy car moves.

iii. **Bent string of low:** Potential energy due to change of its shape (deformation) released in the form of kinetic energy while shootigmg an arrow.



Factors affecting Potential energy

i. **Mass:** P.E. $\propto$ m

ii. **Height above the ground:** P.E. $\propto$ h

iii. **Change in shaping:** The Greater the stretching, twisting, or bending, the more the potential energy.

The potential energy of an object at a height

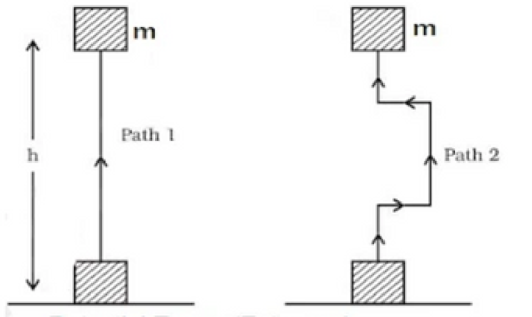
If a body of mass 'm' is raised to a height 'h' above the surface of the earth, the gravitational pull of the earth (mxg) acts in downward direction.

To lift the body, we have to work against the force of gravity.
Thus, Work done (W) = Force x displacement

$$W = m \times g \times h$$

This work is stored in the body as gravitational potential energy.

$$Ep = m \times g \times h$$



Potential Energy(Ep) = mgh

Transformation of Energy

The change of one form of energy to another form of energy is known as the transformation of energy.

Example:

- A stone at a certain height has entire energy. But when it starts moving downward, the potential energy of the stone decreases as height decreases but its kinetic energy goes on increasing as the velocity of the stone goes on increasing. At the time the stone reaches the ground, potential energy becomes zero and kinetic energy is maximum. Thus, its entire potential energy is transformed into kinetic energy.
- At a hydroelectric powerhouse, the potential energy of water is transformed into kinetic energy and then into electrical energy.
- At thermal powerhouses, the chemical energy of coal is changed into heat energy, which is further converted into kinetic energy and electrical energy.
- Plants use solar energy to make chemical energy in food by the process of photosynthesis.

Laws of Conservation of Energy

Whenever energy changes from one form to another form, the total amount of energy remains constant.

"Energy can neither be created nor be destroyed".

Although some energy may be wasted during conversion, but the total energy of the system remains the same.

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Conservation of energy during free fall of a body

A ball of mass 'm' at a height 'h' has potential energy = mgh

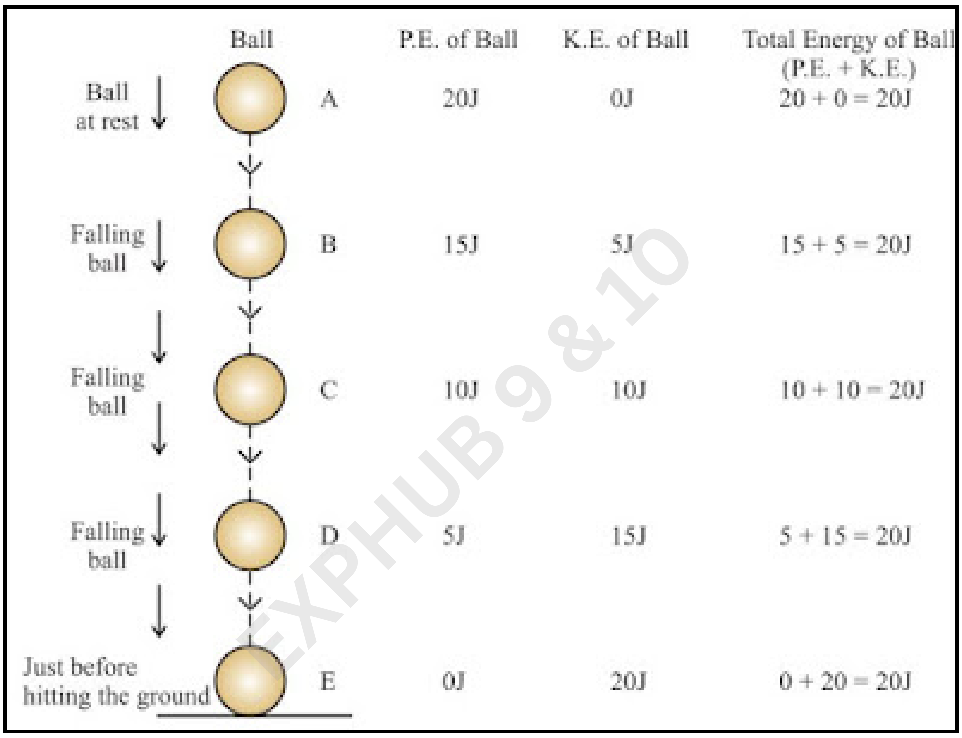
As the ball falls downwards, height 'h' decreases, so the potential energy also decreases.

Kinetic energy at 'h' is zero but it increases during the falling of the ball.

The sum of the potential energy & kinetic energy of the ball remains the same at every point during its fall.

$$\tfrac{1}{2}mv^2 + mgh = \text{Constant}$$

$$\text{Kinetic energy} + \text{Potential energy} = \text{Constant}$$



Rate of doing Work - Power

"Power is defined as the rate of energy consumption".

$$\text{Power} = \frac{\text{Work done}}{\text{Time taken}} \quad \text{Or} \quad P = \frac{W}{t}$$

where, P = Power, W = Work done, T = Time taken

Unit of Power

SI unit of Power is Watt (W) = 1 J/s

$$1\ \text{Watt} = \frac{1\ \text{Joule}}{1\ \text{second}} \quad \text{Or} \quad 1\ \text{W} = \frac{1\ \text{J}}{1\ \text{s}}$$

Average Power = $\frac{\text{Total work done}}{\text{Total time taken}}$

Power of Electrical gadget

The power of an electrical appliance tells us the rate at which electrical energy is consumed by it. Here, when work is done, an equal amount of energy is consumed.

Bigger unit of Power: Kilowatt or KW.

Commercial unit of energy: Joule is a very small unit of energy and it is inconvenient to use it where a large quantity of energy is involved.

For commercial purposes, a bigger unit of energy is Kilowatt hour (KWh).

1KWh: 1 KWh is the amount of energy consumed when an electric appliance having a power rating of 1 Kilowatt is used for 1 hour.

- $1\ kWh = 1kW \times 1\ h$
  $= 1000W \times 60 \times 60\ s$
  $= 1000\ Js^{-1} \times 3600\ s$
  $= 3600000\ J$
  $= 3.6 \times 10^6\ J$

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