

Reading material

Topics

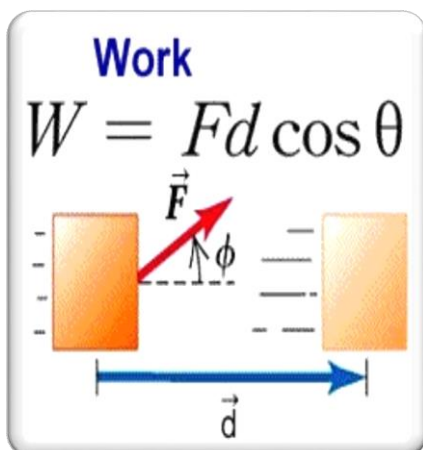
- Work
- Zero, positive and negative work
- Energy
- Forms of energy
- Kinetic energy
- Gravitational potential energy
- Work energy transformation
- Transformation of energy
- Law of conservation of energy
- Power
- Commercial unit of energy

WORK IS DIFFERENT FROM WORKING HARD

- **Work in terms of Physics needs two conditions to be satisfied-**
- **A force should act on an object & The object must be displaced.**
- **Work is defined as the product of the force and displacement in the direction of force.**

$$\text{Work} = \text{Force} \times \text{displacement}$$

$$W = F \times S$$



- SI unit
- $W = F \times S$
 $= 1\text{ N} \times 1\text{ m}$
 $= 1 \text{ Joule}$
- SI unit of work is joule.
- 1 Joule – When 1 Newton of force displaces an object through 1m in the direction of force, then the amount of work done is 1 Joule.
- $1 \text{ Joule} = 1 \text{ N} \times 1 \text{ m}$
 $= 10^5 \text{ dyne} \times 10^2 \text{ cm}$
 $= 10^7 \text{ erg}$

As force and displacement are acting along same direction i.e. angle between them is 0° Thus

$$W = F \times S$$

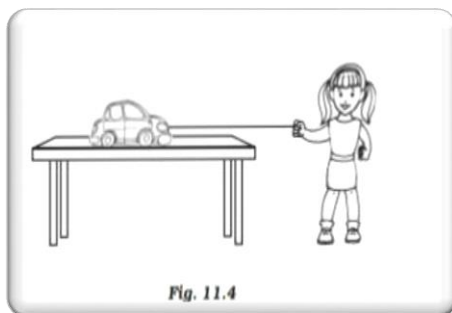
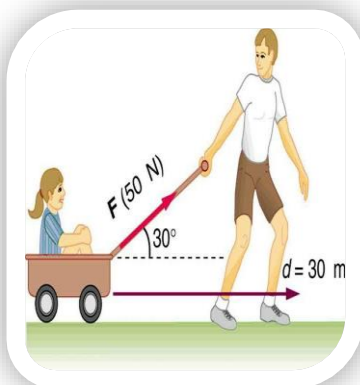


Fig. 11.4

If force and displacement are not acting along same direction, then work done is equal to the product of force, displacement and the cosine of angle between them $W = F \times S \cos \theta$



Zero Work

- As $W = F S \cos \theta$
- $W = 0$, when either
- $F = 0$
- $S = 0$ OR
- $\theta = 90^\circ$
- $F = 0$
- when no force is applied eg. Drawing diagram, organises her thoughts, collects question paper, doing meditation.



Work done is zero when, displacement is zero;

i.e. $W = 0$ when $S = 0$

eg. pushing a huge rock or wall

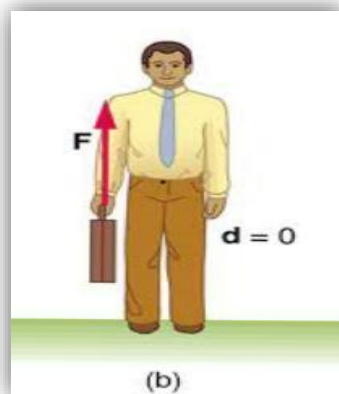


Moon when completes one revolution around the Earth then also displacement is zero.

So work done is zero

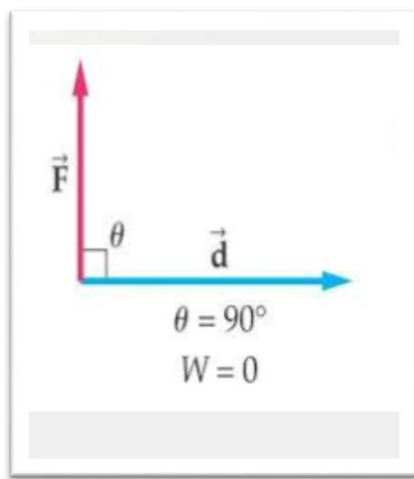


Man standing with a load on head, or holding a briefcase and waiting



for a bus

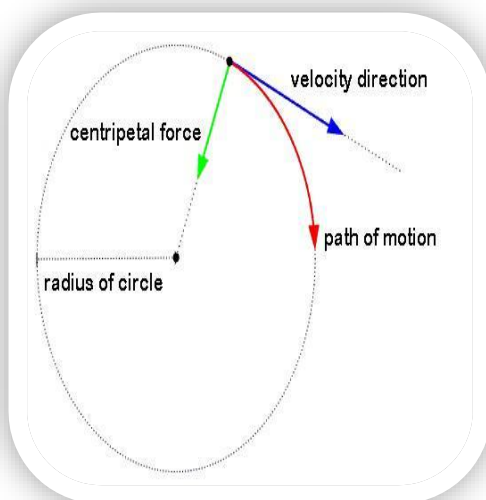
- **When $\theta = 90^\circ$ i.e. Angle between Force and displacement is 90° ; force is perpendicular to the displacement.**
- **Even when force and displacement are there but still work done is zero because they are perpendicular to each other.**



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- **A man carrying suitcase and walking Or a coolie carrying luggage and walking**

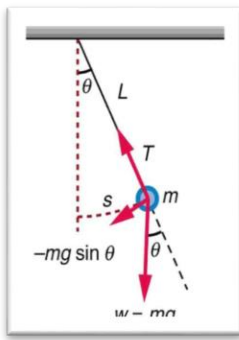


Work done by centripetal force is always zero as force and displacement are always perpendicular to each other.



During motion of simple pendulum tension in the thread(force) is always perpendicular to the displacement of the Bob.

Work done by oscillating pendulum is always zero.

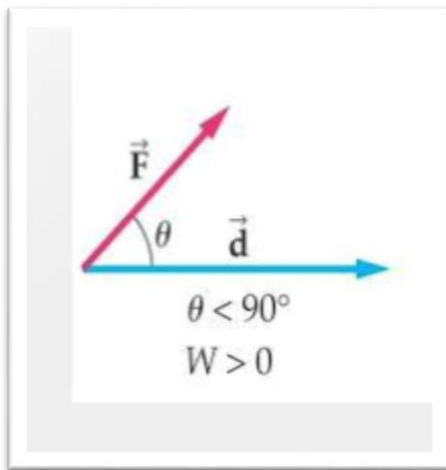


POSITIVE WORK

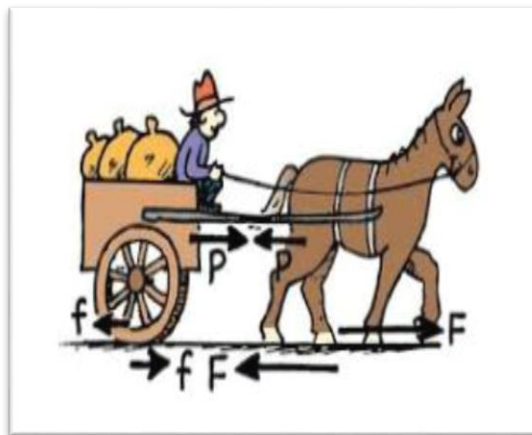
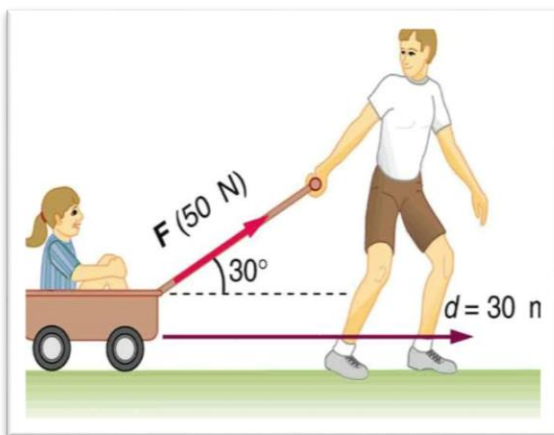
If force and displacement or Force & component of displacement are acting along same direction then the work done is positive.

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

If $0 \leq \theta < 90^\circ$, i.e. Angle between force and displacement is acute then value of $\cos \theta$ is positive therefore work done is positive.



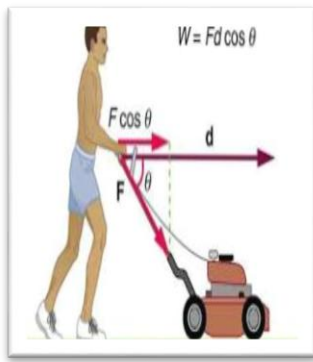
When a man pulls a cart or a horse pulls a cart, force and component of displacement are acting along same direction, thus here work is positive.



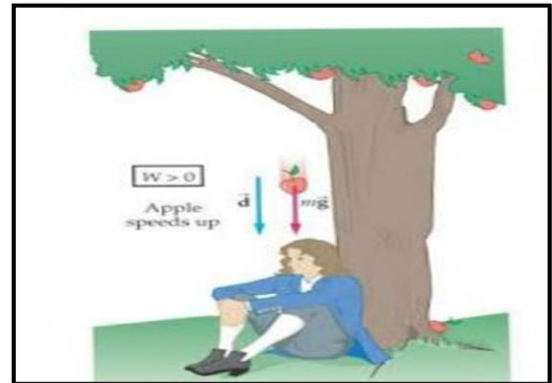
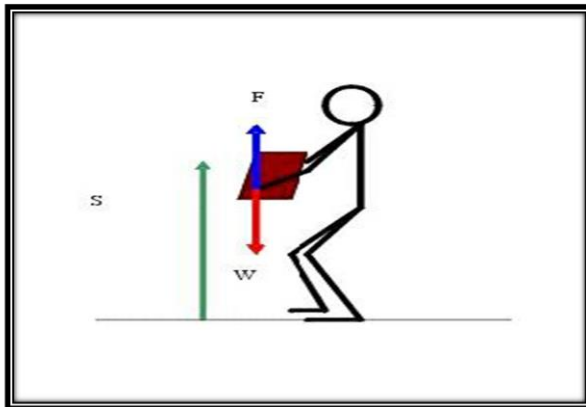
What about pushing?

Work done during pushing is negative or positive.

As displacement and component of force is along same direction
Work is again positive.



When force is applied to lift weight up, F & S are acting in the same direction.



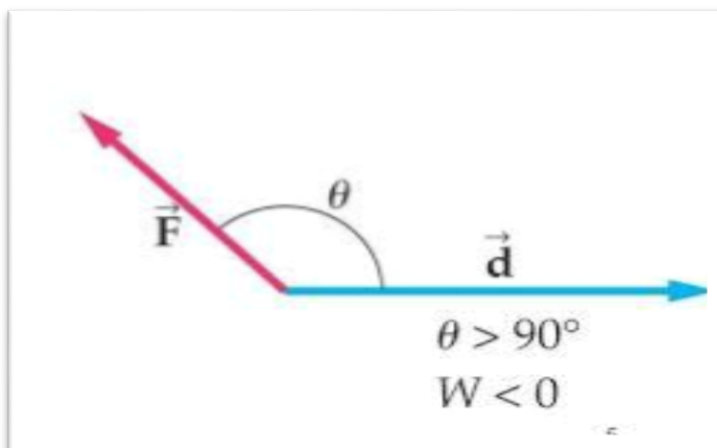
- When a body falls freely under Gravitational pull, the work done by gravity is positive.

NEGATIVE WORK

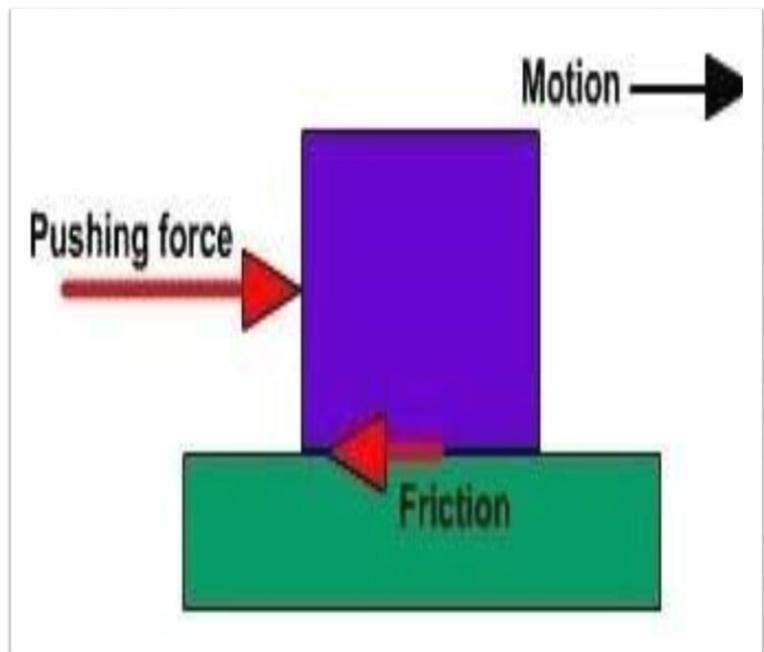
Force and displacement or component of displacement are acting along opposite directions then the work done is negative.

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

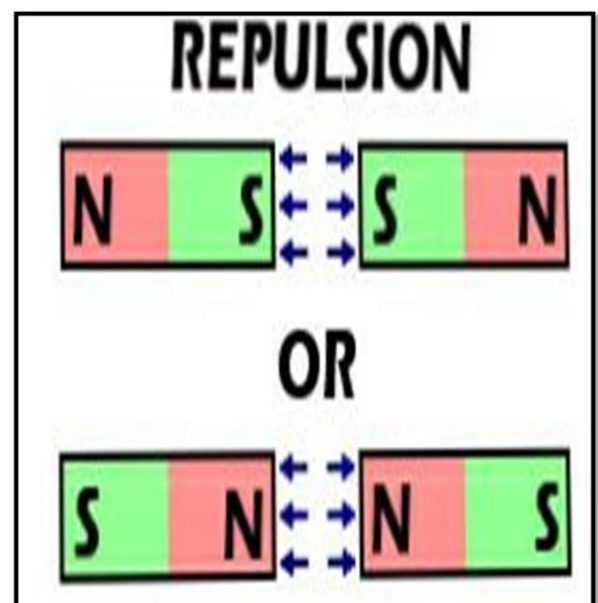
If $90^\circ < \theta \leq 180^\circ$. i.e. Angle between force and displacement is obtuse then value of $\cos \theta$ is negative therefore work done is negative.



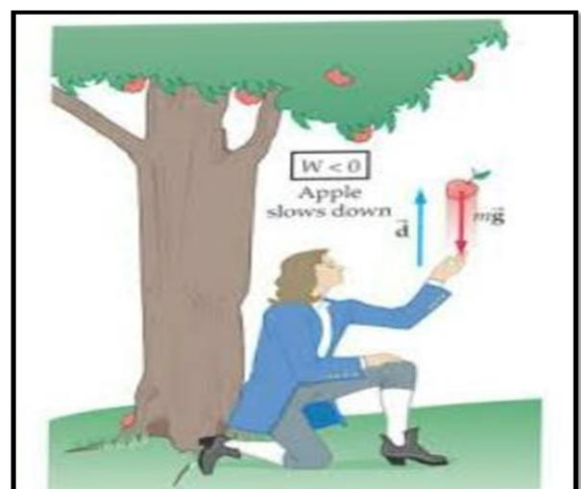
When a body is made to slide over a rough surface, the work done by frictional force (not the applied force) is negative.



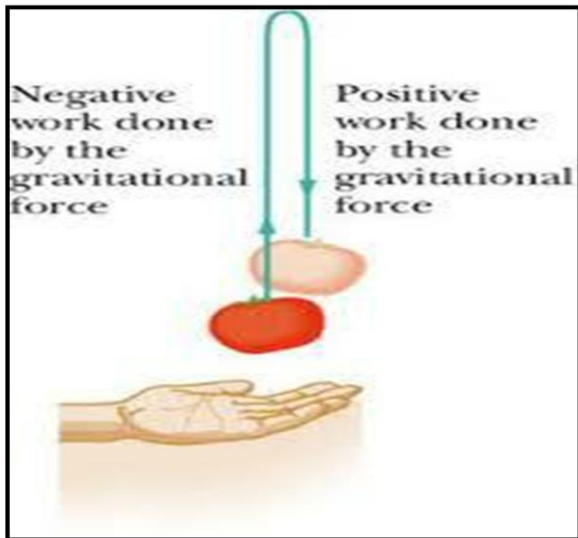
- When a S/N pole repels S/N pole of another magnet, they move away from each other. The work done by magnetic force between them is negative.



When a body is thrown up against gravitational pull, then work done by gravity is negative.

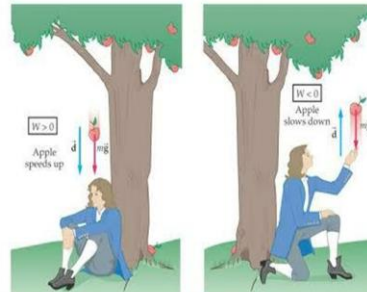


REFRESH THE CONCEPT



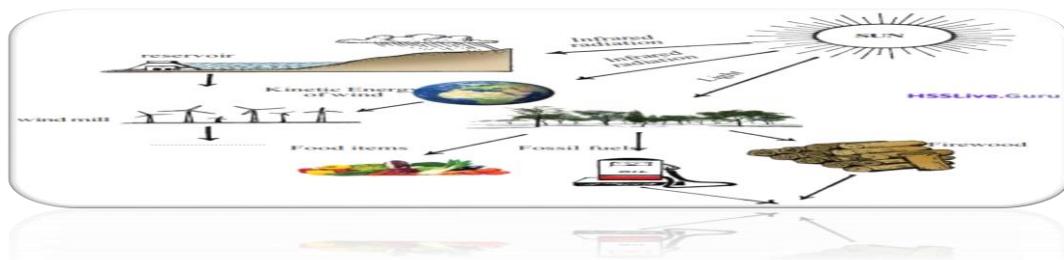
7-2 Kinetic Energy and the Work-Energy Theorem

When positive work is done on an object, its speed increases; when negative work is done, its speed decreases.



ENERGY

Energy is defined as the capability of doing work.



DIFFERENT FORMS OF ENERGY

Kinetic Energy

Potential Energy

Chemical Energy

Heat Energy

Sound Energy

Light Energy

Electrical Energy

Solar Energy

Wind Energy

Ocean wave Energy

Ocean thermal Energy

Tidal Energy

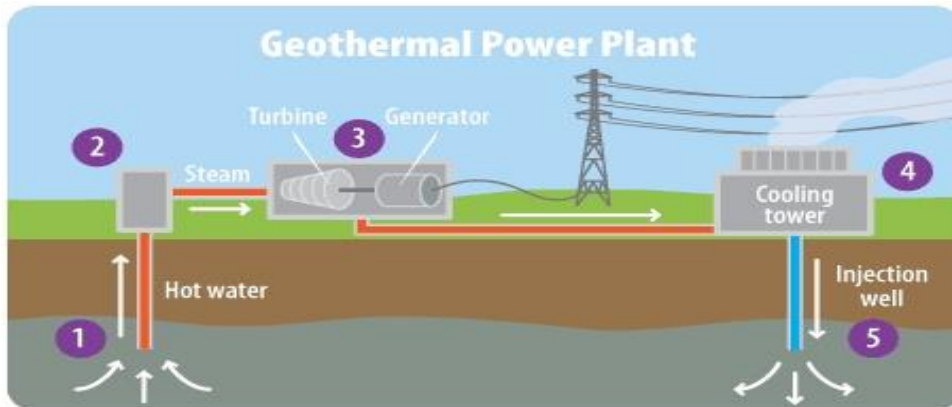
Nuclear Energy

Geothermal Energy

Geothermal energy is the only energy source which is directly or indirectly not connected to the Sun.

Geothermal energy is actually due to heat inside the Earth.

It is utilised to produce electricity.

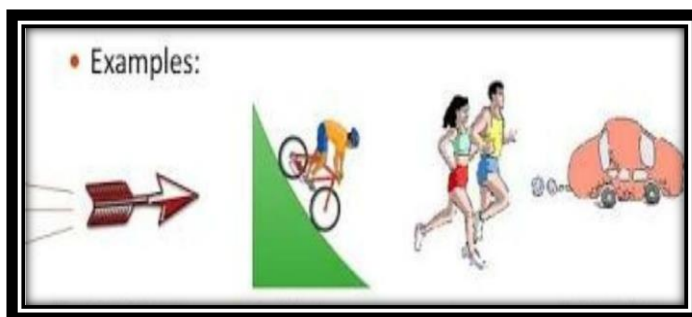


Facts related to Energy

- **The object which does the work loses energy and the object on which the work is done gains energy.**
- **An object that possesses energy can exert a force on another object.**
- **Thus any object that possesses energy can do work.**
- **SI unit of energy is same as that of work i.e. Joule**
- **1 J is the energy required to do 1 joule of work.**

Kinetic energy-

- **It is the energy possessed by the body due to virtue of its motion**
- **The Kinetic energy of an object increases with its speed.**
- **A moving car, a flying aircraft, wind, moving fan, flowing water, running athletes, a cyclist rolling down on slope**



Mathematical expression of KE

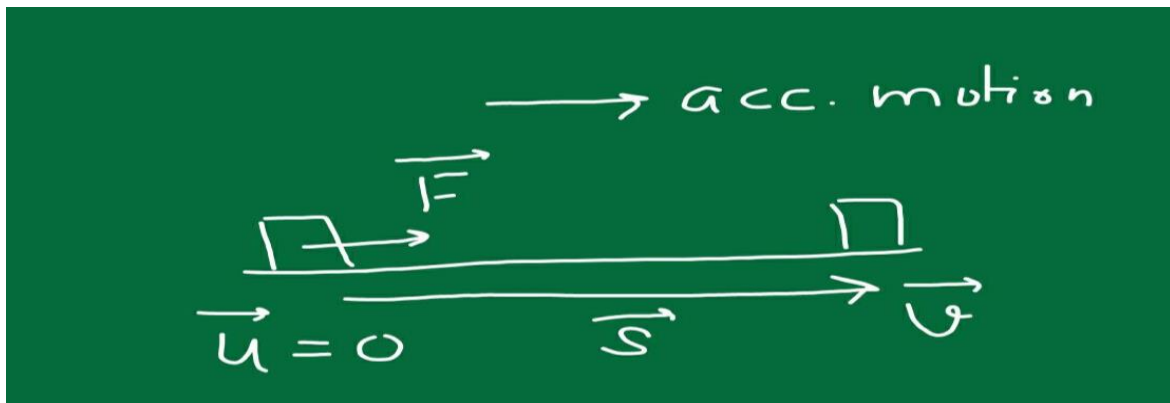
$$\begin{aligned}W &= F \times S \\&= m \times a \times S \\&= m \times a \times (v^2 - u^2) / 2a \\&= m \times (v^2 - u^2) / 2\end{aligned}$$

Work done is equal to the change in the kinetic energy of an object.

$$KE = m \times (v^2 - u^2) / 2$$

If the object is starting from rest i.e. $u = 0$, then

$$KE = m v^2 / 2$$

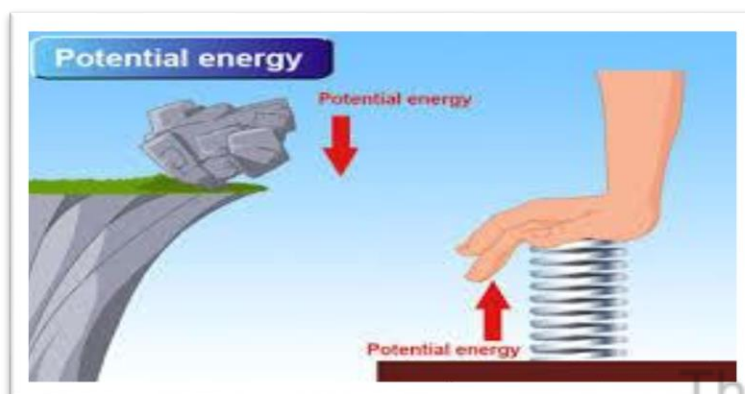


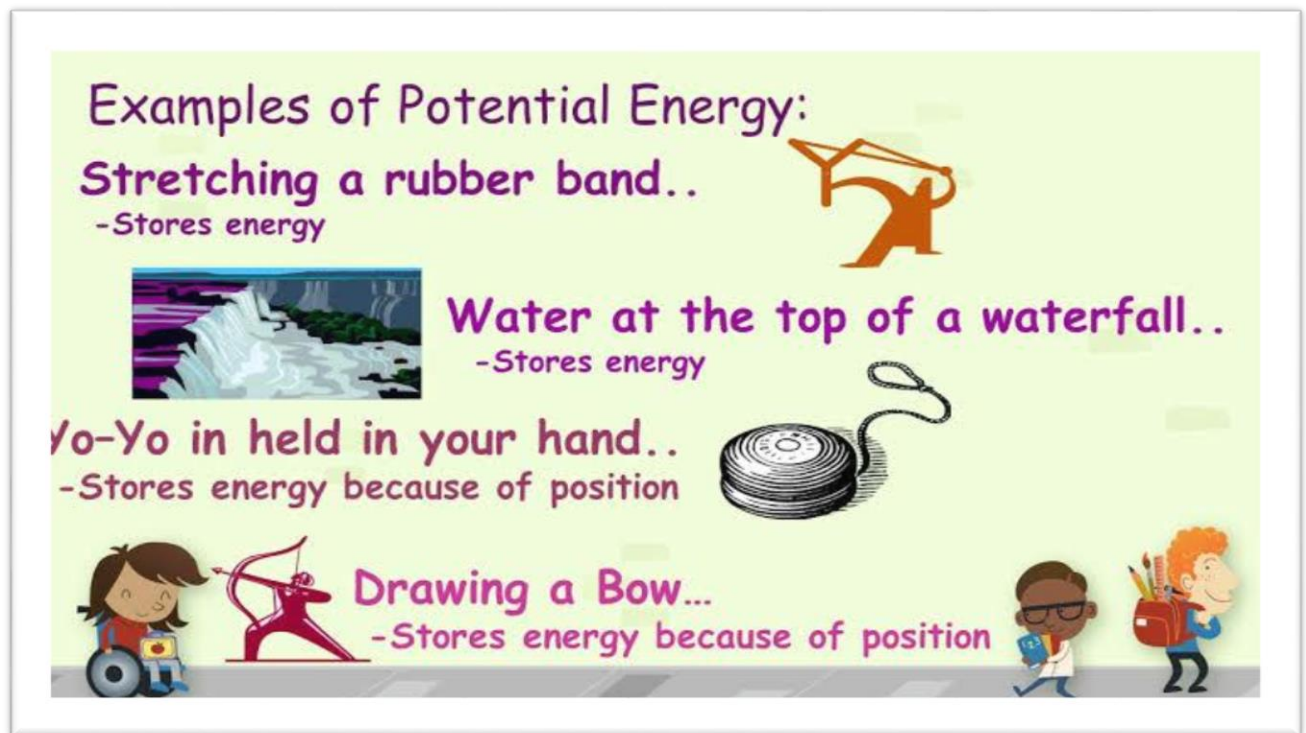
POTENTIAL ENERGY

Potential Energy is the energy possessed by the body due to virtue of its height above the earth surface, or its shape or configuration.

There are two types of potential energy

- Elastic potential energy
- Gravitational potential energy

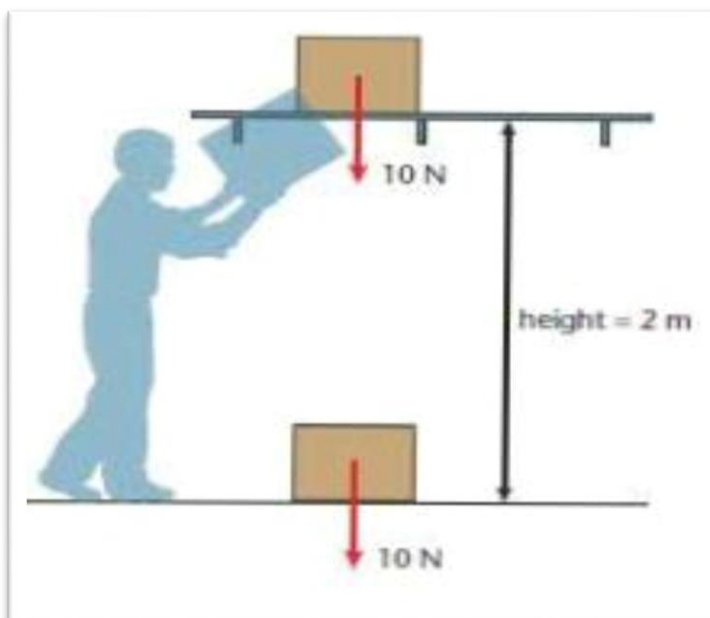




GRAVITATIONAL POTENTIAL ENERGY

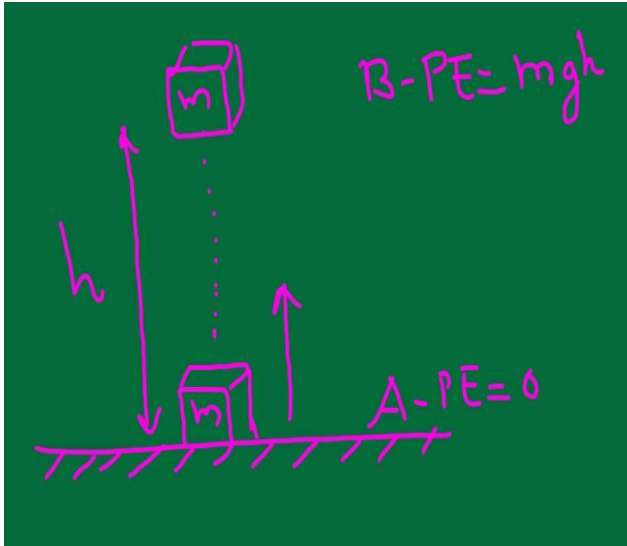
Work is done on the mass m while it is being raised against gravity, then its energy increases. This energy is the GPE.

The GPE of an object at a point above the ground is defined as the work done in raising it from the ground to that point against gravity



- $W = F \times S$
- $= mg \times h$
- $= mgh$
- Since work done is mgh , an energy equal to mgh is gained by the object in the form of gravitational potential energy.

$$PE = mgh$$



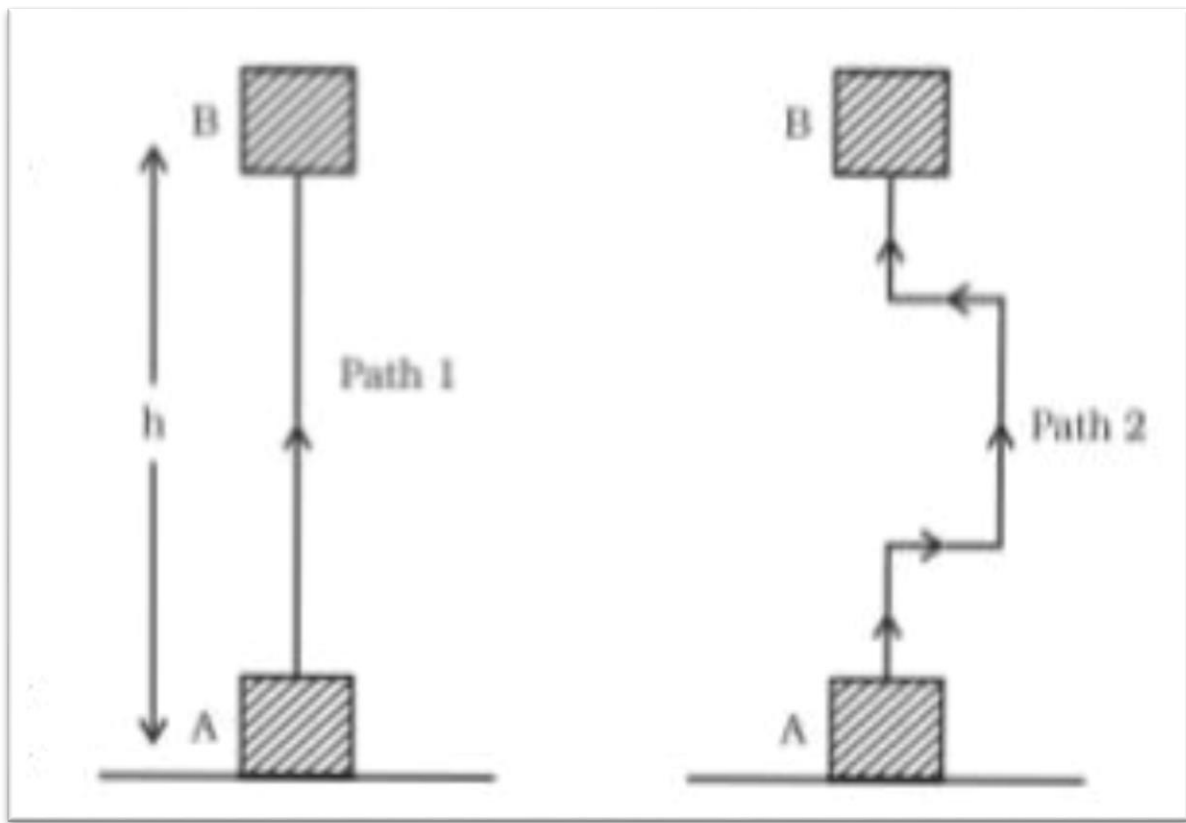
The work is done by the man against gravity, due to which the energy gets stored in the form of gravitational potential energy.

Man has to do large amount of work to raise it to a greater height, thus stored energy is also large.

Greater the height, larger will be the work, to get more GPE.



Work done by gravity depends on the difference in vertical heights of initial & final positions of the object & not on the path along which the object is moved.



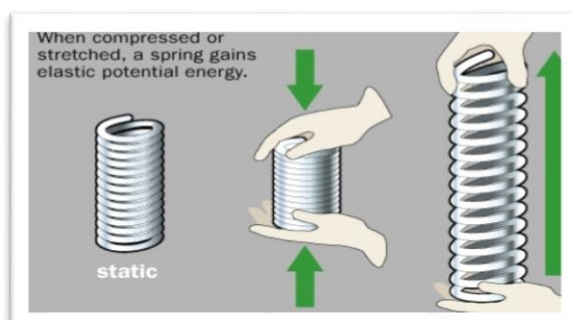
$$PE = mgh \quad PE = mgh$$

Elastic potential energy

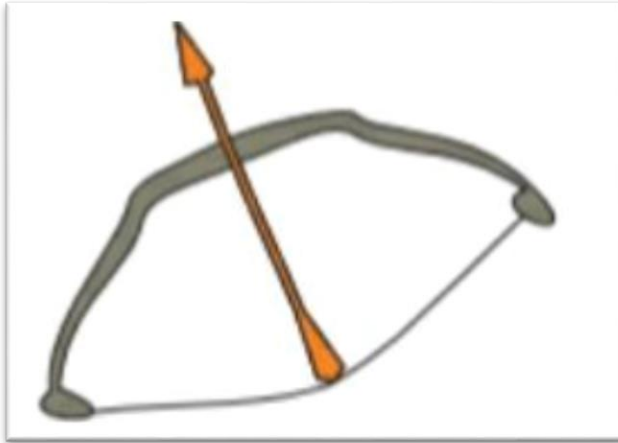
- The energy of a body due to a change in its shape and size is called elastic potential energy.
- The change in shape of a body can be brought by compressing, stretching, bending, or twisting.
- Work is done to change the shape of the body which gets stored in the deformed body in the form of elastic potential energy.

Work is being done on spring or rubber band while

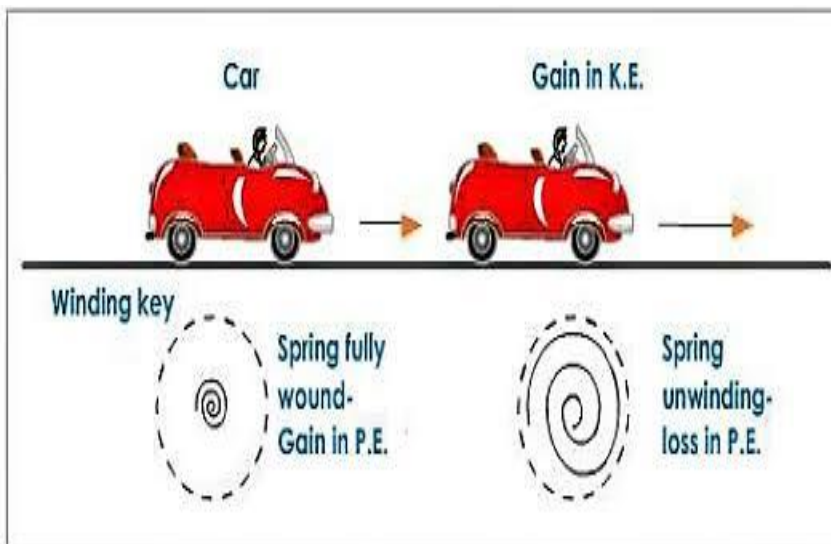
- stretching or compressing it, as it is not used to cause a
- change in velocity or speed of an object, this work thus
- gets stored in the form of elastic potential energy.



The Elastic potential energy stored in the bow due to the change of shape is thus used in the form of kinetic energy in throwing off the arrow



Work is done while winding the key of a toy car. The energy transferred to the spring inside is stored as EPE. When it unwinds itself EPE gets converted into kinetic energy.



A Toy Car Driven by a Winding Key

Law of conservation of energy

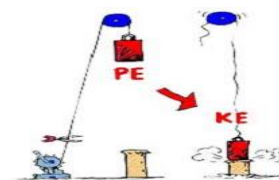
- ***Law of conservation of energy states that energy remains conserved, it can neither be created nor be destroyed.***

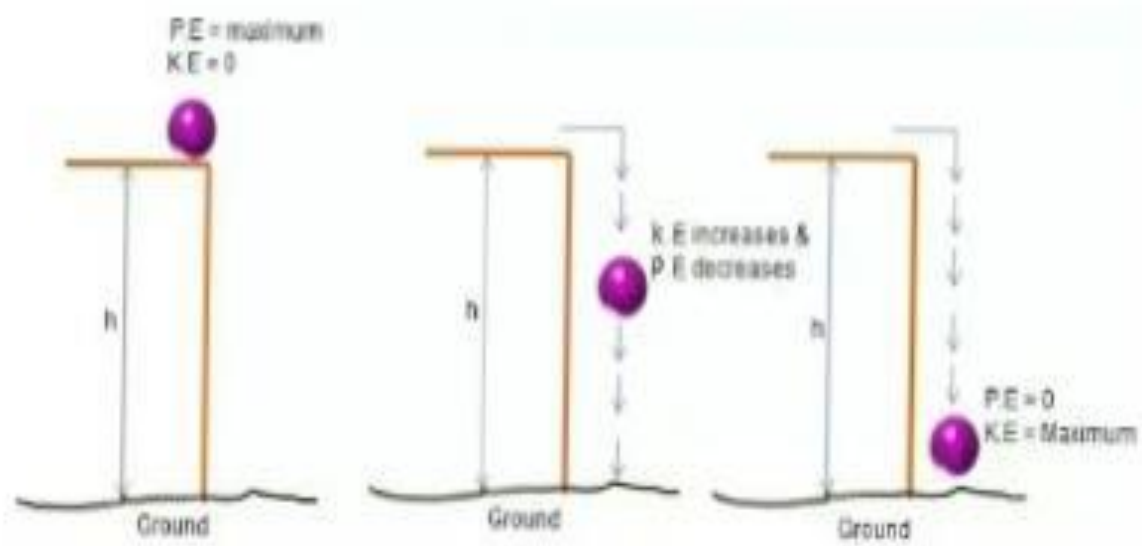


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This simply indicates that energy can be transformed from one form to another but the sum total of the energy remains constant.





Power



- Power is defined as rate of doing work OR rate of transfer of energy.
- Power measures the speed of work done, i.e. how fast or slow work is done.
- $\text{Power} = \frac{\text{work}}{\text{time}}$
- SI unit $P = \frac{W}{t}$
 $= \frac{J}{s}$
 $= \text{Watt}$
- SI unit of power is watt.

OTHER UNITS OF POWER

- $1 \text{ kW} = 1000 \text{ watt}$
- $1 \text{ MW} = 10^6 \text{ Watt}$
- $1 \text{ HP} = 746 \text{ watt}$
- 1 Watt – 1 Watt is the power of an agent, which does work at the rate of 1 joule per second.

AVERAGE POWER

- The power of an agent may be doing work at different rates at different intervals of time.
- Thus average power is used which is total energy consumed per unit total time taken.

Commercial unit of energy

- For the bigger unit ,as joule is very small unit,we use kwh
- 1 kWh is the energy used in one hour at the rate of 1000J/ s
- $1 \text{ kWh} = 1 \text{ kw} \times 1 \text{ hour}$
 $= 1000 \text{ w} \times 3600 \text{ sec}$
 $= 3600000 \text{ J}$
 $= 3.6 \times 10^6 \text{ J}$
- The energy used inhouseholds ,industries,and commercial establishments are usually expressed in kWh
 So
- $3.6 \times 10^6 \text{ J} = 1 \text{ kwh}$
 $= 1 \text{ Board of trade unit}$
 $= 1 \text{ commercial unit}$
 $= 1 \text{ unit.}$