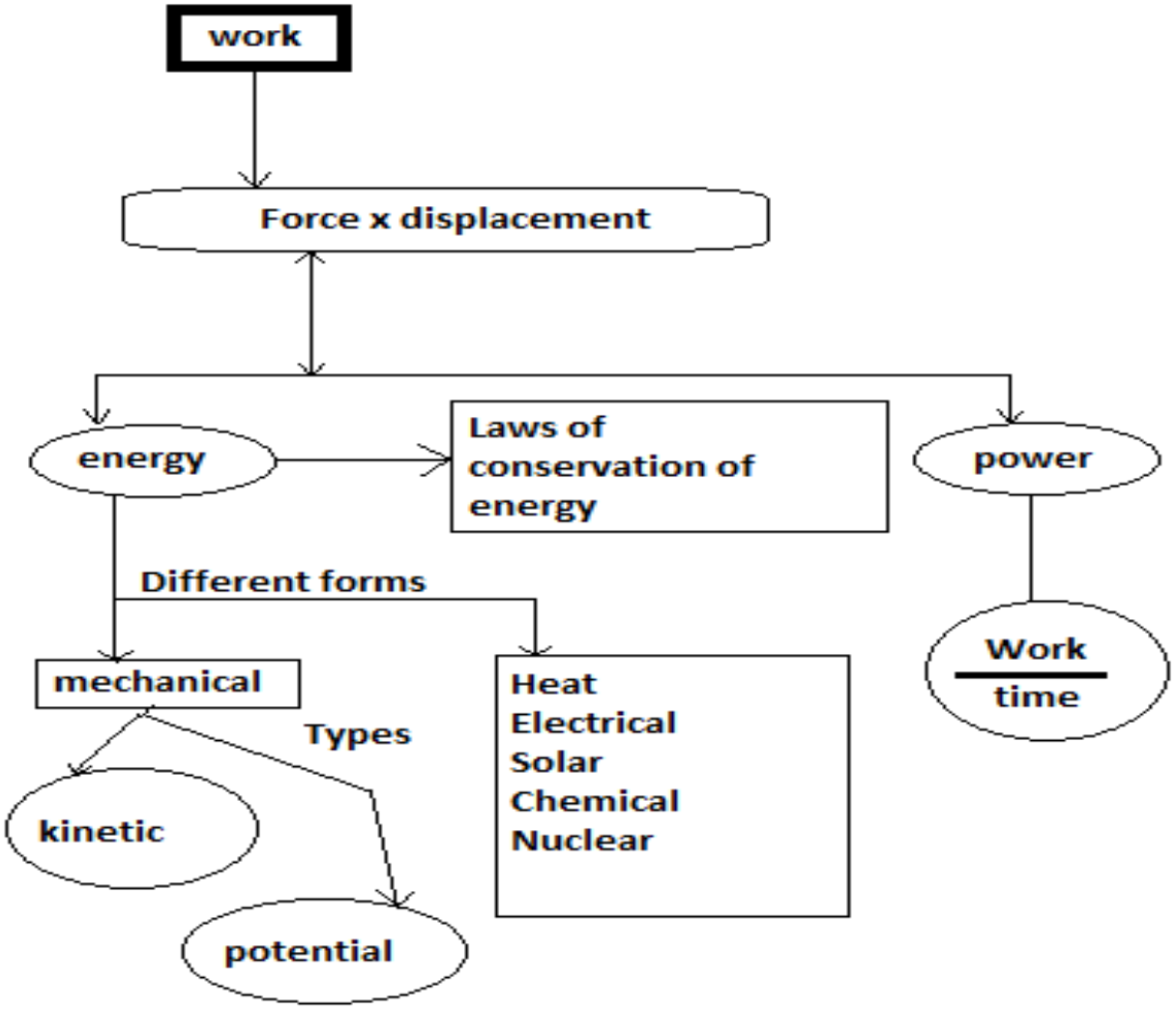
# Energy : The driving force

# Concept Map


work
Force x displacement
energy
Laws of conservation of energy
power
Different forms
mechanical
Types
kinetic
potential
Heat
Electrical
Solar
Chemical
Nuclear
Work
time

# Work

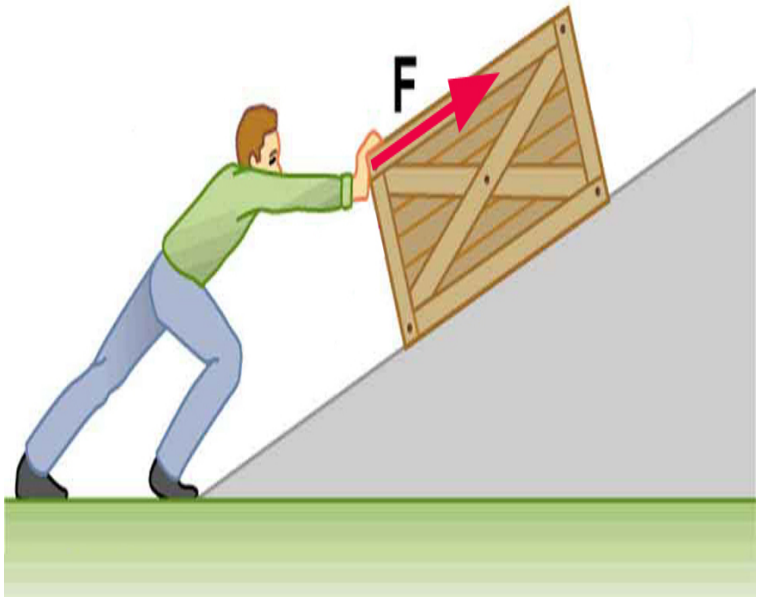
- When we stand still for few minutes with a load on our head. We get tired. We have exerted our self and have spent quite a bit of our energy.
- Are we doing work on the load?
- The way we understand the term ‘work’ in science, work is not done.
- Whereas when you climb up the steps of a staircase and reach the second floor or climb up a hill. These activities involve a lot of work

# Work

- Two conditions need to be satisfied for work to be done :

i. A force should act on an object

ii. The object should be displaced

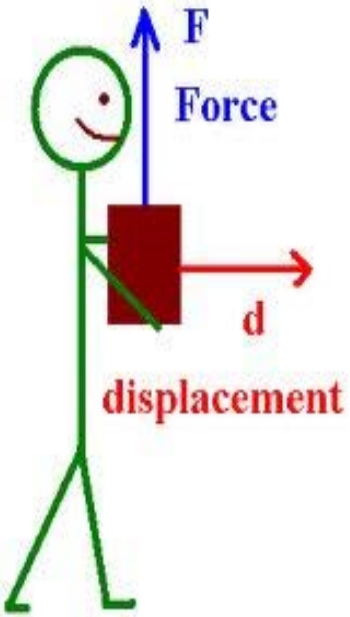


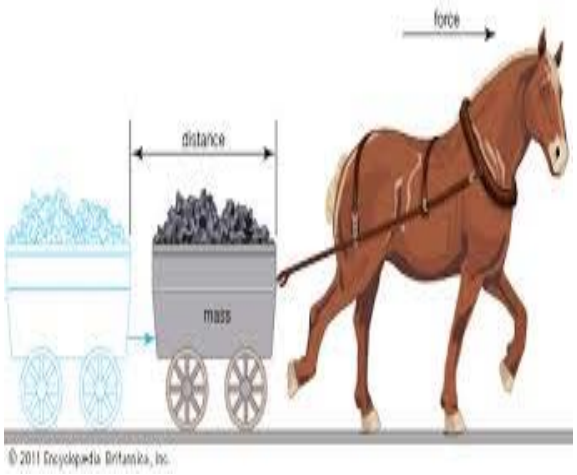
# Work

- Work is defined as the product of the force and displacement.
- If force, F acts on an object, object is displaced through a displacement, s in the direction of force. Then the work done is:

Work = force x displacement

W = F x s (scalar)




# Activity

- Watch the following video and discuss with your partner and share what you understood.

- https://www.youtube.com/watch?v=kvbOmoNXQ44

# Relation between Joule and erg.

- **One joule** is the amount of work done when a force of **one newton** acting on an object displaces it through a distance of **one metre** along its own direction.

- 1 joule = 1 newton × 1 metre

- **One erg** is the amount of work done when a force of **one dyne** acting on an object displaces it through a distance of **one centimetre** along its own direction.

- 1 erg = 1 dyne × 1 centimetre

- Relation between Joule and erg :
- 1 Newton = $10^5$ dyne and 1 metre = $10^2$ cm.
- 1 joule = 1 newton × 1 metre = $10^5$ dyne × $10^2$ cm

  1J = $10^7$ dyne.cm

  = $10^7$ erg

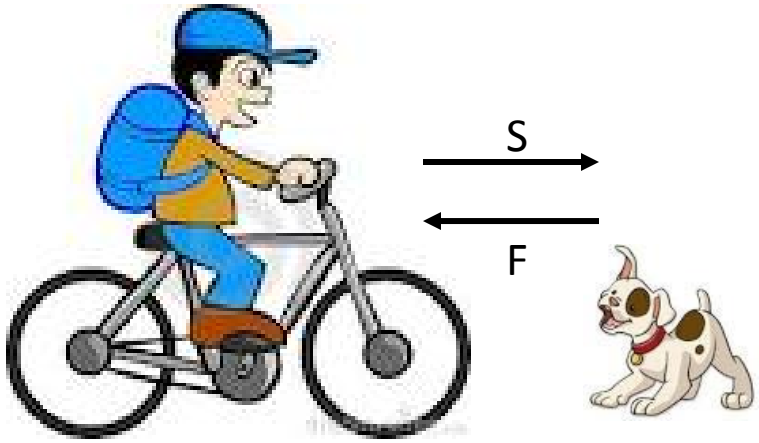
# Positive Work

- Consider one boy is playing football. When he kicks the ball, ball goes in a direction in which force is applied on it. The force required to kick the ball and the direction of displacement of a ball are in the same or one direction.

- Work done by the force is said to be positive.

# Negative work

- Amit went to meet his friend. He went on bicycle. One little puppy came in his path. So he applied brakes to stop bicycle.
- We know while cycling positive work was done but after applying brake cycle stopped suddenly. In this case which type of work was done? Think



# Zero Work

- Let’s do one activity:
- Try to push a wall.
- Does it move from its place?
- We apply force but displacement does not occur.
- In this case the applied force does not produce any displacement.
- Work done by the force is said to be zero.

# Exercise

- Priya pushes a trolley of grocery by applying force of 20N. Find the work done by this force as the trolley is displaced through 5m along the direction of the push.
- F = 20N, s = 5m
- $W = F \times s$

  $= 20 \times 5$

  $= 100$ Nm

  W = 100 Joule

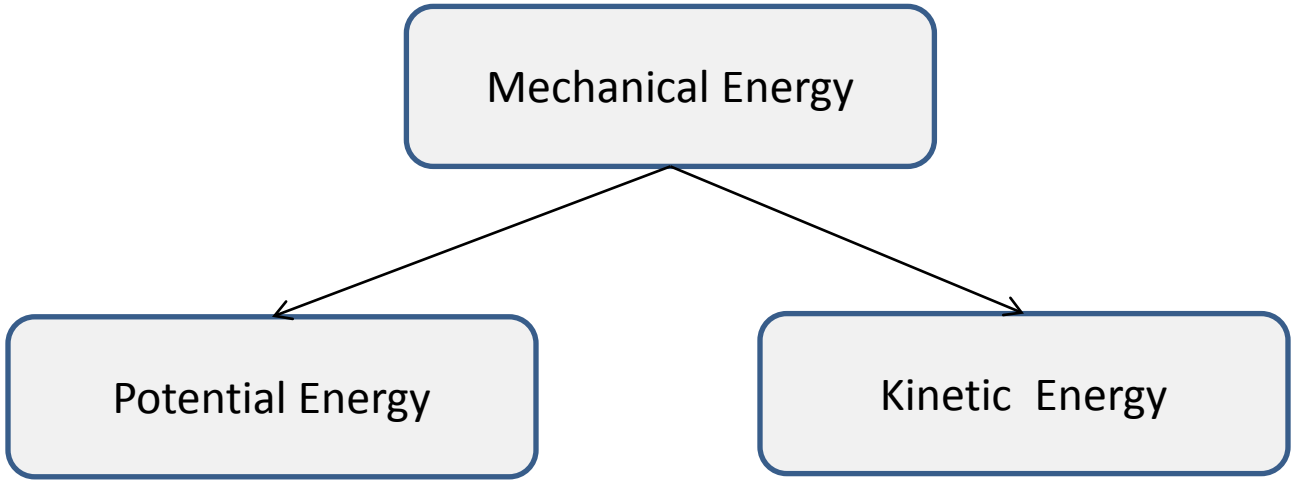
- While cycling on long route person feels drowsy.
- So he drinks glucose or eats food.
- Why does he need to drink glucose or eat food?
- Person needs to drink glucose or eat food as he lost the energy while cycling.
- After taking glucose or food person feels fresh since he regains energy by glucose or food.
- For e.g.
- To operate mixer we need electricity i.e. electric energy.
- Machines needs energy to work.

# Energy

- When a fast moving ball hits a stationary wicket, the wicket is thrown away. Similarly, an object when raised to a certain height gets the capability to do work like,
- When a hammer falls on a nail placed on a piece of wood, it drives the nail into the wood.

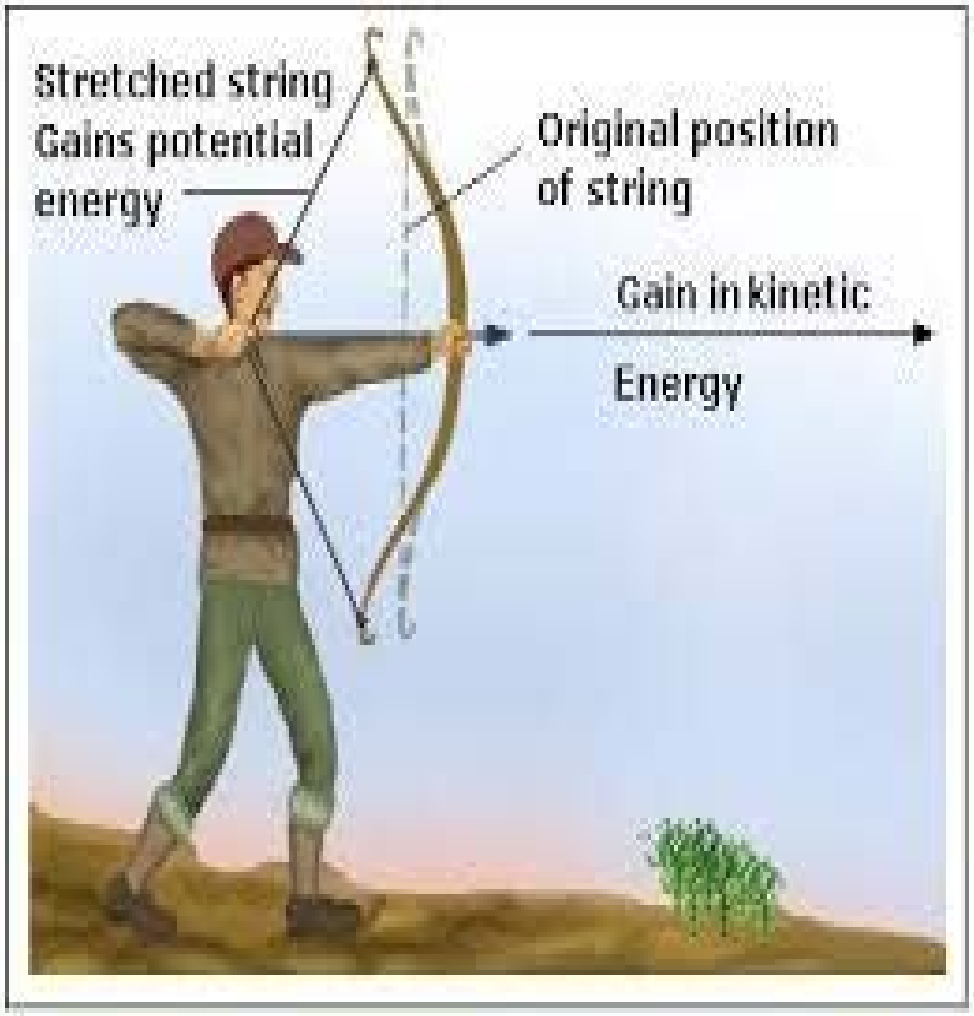
# Forms of energy

- We are surrounded with different forms of energy.
- For E.g. the Sun gives us solar energy.
- Wind energy,  heat energy, light energy, sound energy, mechanical energy, chemical energy are the different forms on energy



# Energy

- Energy is measured in terms of work and hence units of work and energy are same.
- i.e. “joules” in SI and “ergs” in CGS system.




## Explanation:

Here the archer places and aims at the target. At the moment there is no movement. The archers muscles, the bow and the arrow all contain pent-up **potential energy**. When the archer shoots, the potential energy is converted into **kinetic energy**. The archer lets go of the string and the string pushes arrow towards the target. Here the shape of a bow and the elasticity or flexibility of the string maximize the force on the arrow once the **potential energy** is converted to **kinetic energy**.

# Energy

- Kinetic energy : All moving objects have energy due to their motion.

# Energy

- Let ‘m’ be the mass of the moving object,

‘u’ be the initial velocity and ‘v’ be the final velocity and ‘a’ be the acceleration produced. Thus ,

$$v^2 = u^2 + 2as$$

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

- But we know that **F = ma** and **work = F × s**

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

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

- But initial velocity is zero.
- This statement is true for bodies at rest . so ,
- so , $W = \frac{1}{2} mv^2$
- Now work done is equal to change in kinetic energy of an object
- $KE = \frac{1}{2} mv^2$

# Energy

- Potential energy: when you stretch a rubber band the energy transferred to the band is its potential energy.
- When you wind the key of toy the energy transferred to the spring inside is stored as potential energy.
- **The potential energy possessed by the object is the energy present in it by virtue of its position or configuration.**
- Thus, A body may have energy because of its shape or position or configuration. This is known as potential energy.

# Energy

- The energy of the object is increased when raised through height. This is because work is done on it against gravity while it is being raised. The energy present in such an object is the gravitational potential energy.

- Consider an object of mass, m. Let it be raised through height, h from the ground. A force is required to do this. The minimum force required to raise the object is equal to the weight of the object, mg. The object gains energy equal to the work done on it. Let the work done on the object against gravity would be W.

- That is,
- **W = force x displacement = m x g x h = mgh (As F = m x g and s = h)**

# Activity

- Discuss on the sources of energy (shown in the image) and share with class.

# Videos

- https://www.youtube.com/watch?v=KlIbxyCqXu4
- https://www.youtube.com/watch?v=YOyrjm5zFDY

# Activity

- Make groups and discuss the various ways of energy conversion in nature.
- Discuss the following in your group;
- 1. How do green plants produce food?
- 2. How are fuels, such as coal and petroleum formed?

# Law of conservation of energy

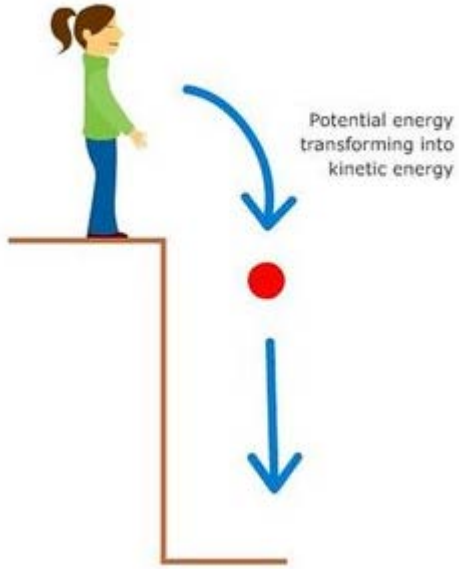
- In above activity we learned that the form of energy can be changed from one form to another.
- Whenever energy gets transformed the total energy remains unchanged in a isolated system. This is law of conservation of energy.
- According to this law, energy can neither be created nor destroyed but just converted from one form to another.
- Total energy before and after transformation remains the same.

- Eg: let an object of mass, m be made to fall freely from height, h. At the start potential energy is mgh and kinetic energy is zero as velocity is zero.


- As it falls potential energy will change into kinetic energy. If v is the velocity of the object at a given instant, the kinetic energy will be

  $\frac{1}{2} mv^2$.

- As the fall continues the potential energy will decrease while kinetic energy will increase. When object is about to reach the ground , h = 0 and v will be highest.




- Therefore kinetic energy will be largest and potential energy the least.

- However, the sum of the potential energy and kinetic energy would be the same at all points.

i.e. potential energy + kinetic energy = constant

**or** $mgh + \frac{1}{2} mv^2 = \text{constant}.$

- Eg: when you explode fire cracker chemical energy stored in it is converted into different forms of energy such as heat, light, sound, etc but the total energy remains constant.

- The sum of potential energy and kinetic energy of an object is its total mechanical energy.

# Activity

- Think and discuss in pairs:
- Consider there are two children, say A and B. They weigh the same. Both start climbing up a rope separately. Both reach a height of 8m. Let us say A takes 15 s while B takes 20 s to accomplish the task
- What is the work done by each?
- The work done is the same however A has taken less time than B to do the work.
- Who has done more work in a given time,say in 1s?

# Power

- A stronger person may do certain work in relatively less time.
- We can consider the power of machines like motorbikes and motorcars.
- The speed with which these vehicles change energy or do work is a basis for their classification.
- Power measures the speed of work done, that is, how fast or slow work is done.
- Power is defined as the rate of doing work or the rate of transfer of energy. If an agent does a work W in time t, then power is given by :
- $P = \frac{W}{t}$

# Power

- The unit of power is ‘Watt’
- 1 watt = 1 joule/sec ; 1 kW = 1000 Watt
- Power is also measured in a unit called as horse power which is used in industry.
- 1hp = 746 Watts.
- Kilowatt hour is mainly used to measure electrical consumption. 1 kWh is the energy used in one hour at the rate of 1000 J/s continuously.

- 1 kWh = 1kW x 1h

  = 1000W x 3600S

  = 3600000 J

  = $3.6 \times 10^6$ J

- The energy used in households, industries and commercial establishments are expressed in kilowatt hour.

# Activity

- Many of the human activities and the gadgets which we use involve conversion of energy from one form to another.
- Make a list of such activities and gadgets.
- Identify in each activity/gadget, the kind of energy conversion that takes place.

# Exercise

- Define : a) work  b) energy  c) power

- Look at the activities listed below. Reason out weather work is done or not.

1) Suma is swimming in a pool.
2) A donkey is carrying a load on its back.
3) Food grains are getting dried in the sun.
4) A sailboat is moving due to wind energy.
5) A green plant is carrying out photosynthesis.

6) Solve:

   1) A porter lifts a luggage of 15 kg from ground and puts it on his head 1.5m above the ground. Calculate the work done by him on the luggage.

   2) An object of mass 15kg is moving with a uniform velocity of 4 m/s. What is kinetic energy possessed by the object?

1)The unit of power is _____.

a) Wh
b) Ns
c)KW

2)Which of the following devices converts sound energy into electrical energy?

a) loudspeaker
b) television
c) microphone

3) The energy stored in the dry cell is in the form of

a) kinetic energy
b) potential energy
c)chemical energy

4) Hammer weighing 10kg when raised to a height of 10m. The potential energy acquired by it will be:

a) 9800 joules
b) 980 joules
c) 0.98 joules