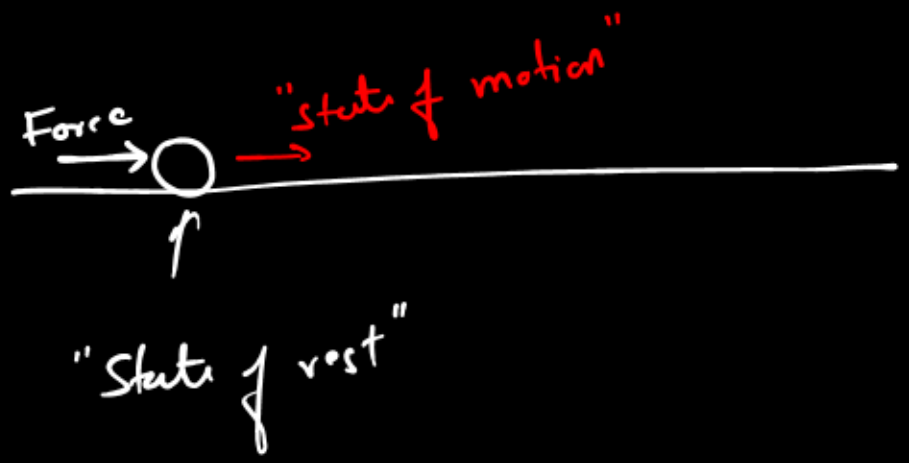
Force, Work, Energy and Simple Machines

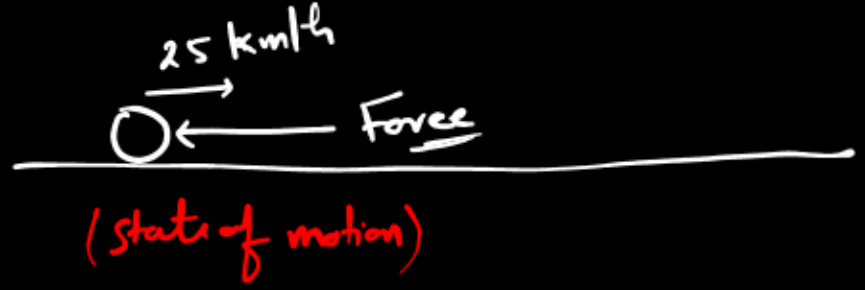
Force :

Object can be in the "state of rest" (object is not moving)
↳ tree, mountain,

or

it can be in the "state of motion" (object is moving)
↳ moving car, train





→ Force is a push or pull that changes the state of rest or motion, direction of motion & shape of the object.

→ Force is directional.

(Applied force)

⇒ force applied by a person / object on another object

→ Amount of force required to move an object (or to stop a moving object) depends on the mass of object.

⇒ Absolute rest is not possible.

⇒ Because earth is moving

⇒ Sun is moving about centre of Milkyway galaxy.

Types of force

Contact Forces

⇒ It requires actual contact between objects.

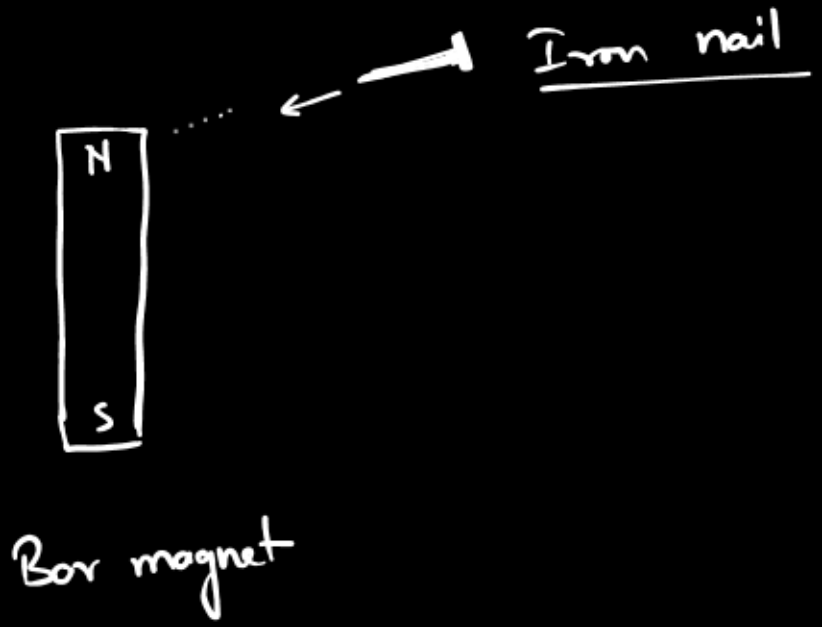
⇒ eg: pushing a book by making contact with it.

- mechanical force (muscular force)
- Frictional force

Non-contact forces

⇒ actual contact between the objects is not necessary to apply/feel/exert the force.

eg.: gravitational force
- magnetic force.
- electro-static force



Contact force

↳ Mechanical force

When a force exerted by an object make another object (in contact) move is called **mechanical force**.

eg: ① Fixing a nail into a wall using a hammer. (muscular force)

② Movement of sailboat due to force exerted by wind.

Mon → Math.

Tue → Sc.

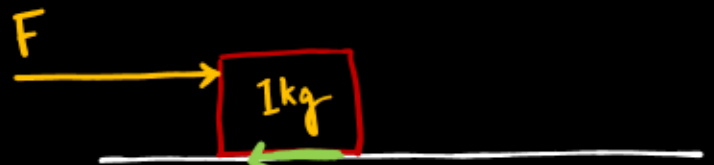
Wed → Math

Thur → Sc

Fri → Math.

⑪ Frictional force

→ The force opposes or slows down the motion of a moving object when trying to move over the other surface



Frictional force between box and road surface.

eg: . A rolling ball gradually slows down and finally stops.

. Sliding a book on the table's surface.

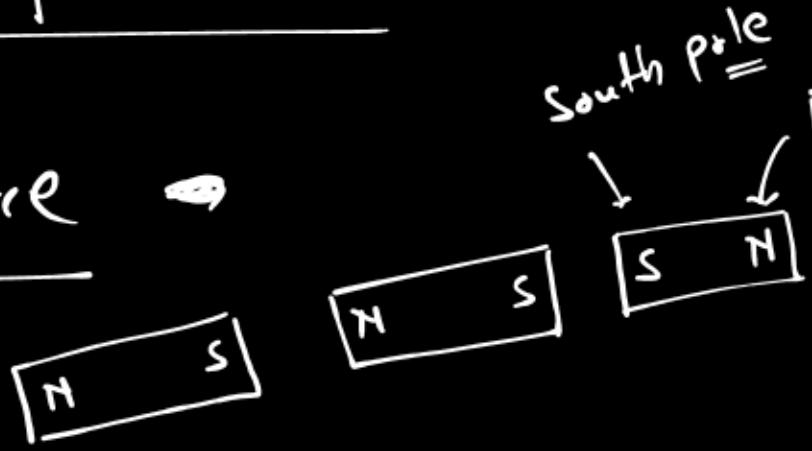
⇒ Frictional force is due to the roughness of the surfaces in contact.

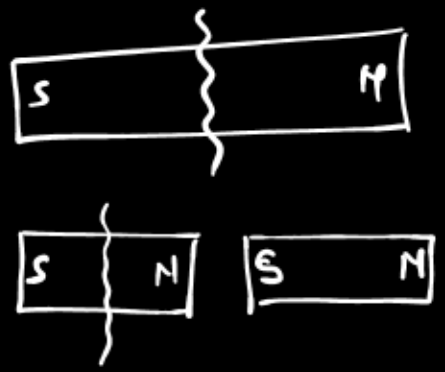
Roughness ↑ , frictional force ↑

⇒ Frictional force is always opposite to the applied force or direction of motion

Non-Contact forces

→ Magnetic force





→ Exerted by magnets / electrical charges.

→ Like pole repel each other. S↔S N↔N Magnetic Repulsion

→ Unlike poles attract each. S→←N Magnetic attraction

→ Magnets also exerts force on metals like iron, nickel, cobalt. steel.

→ Earth is also a giant magnet.

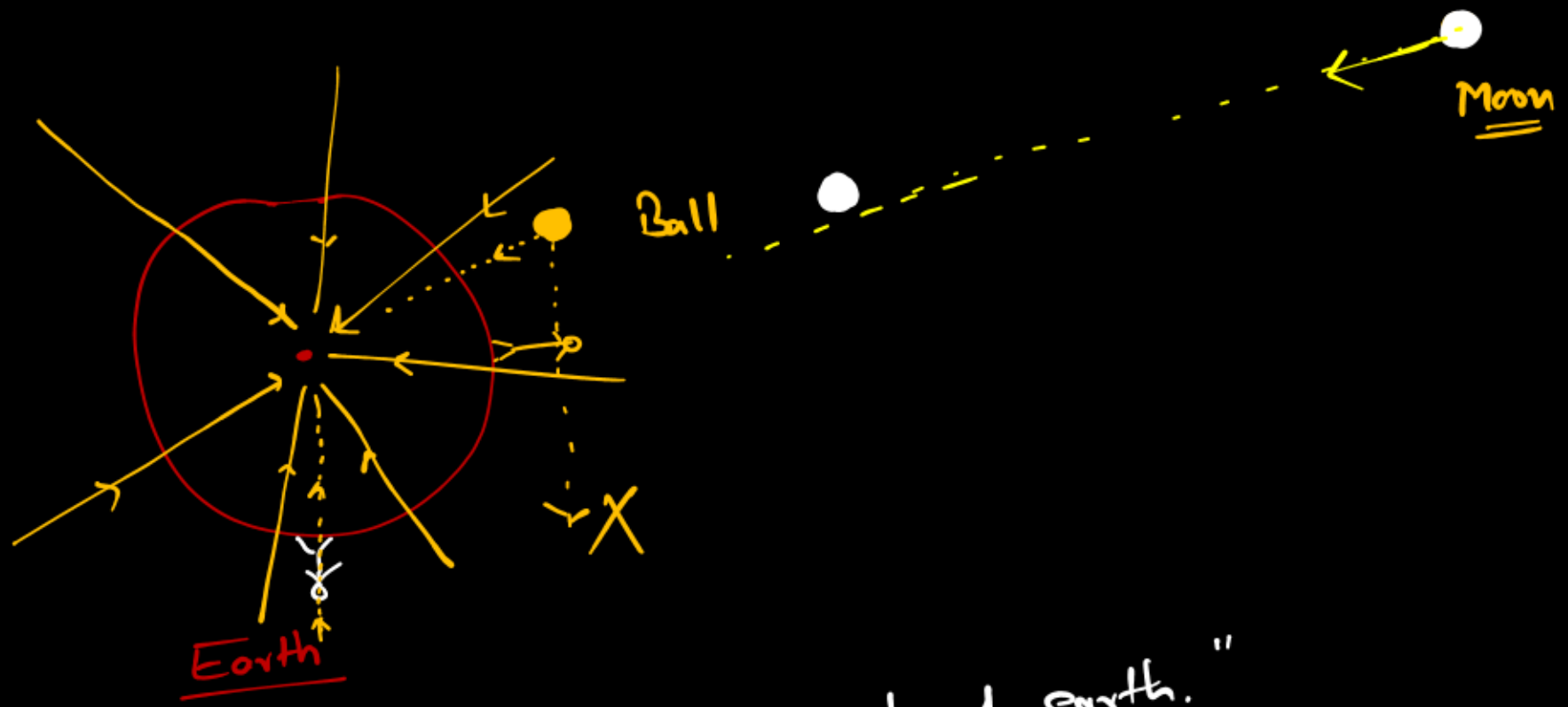
Gravitational force

↳ It is the force between any two object in this universe

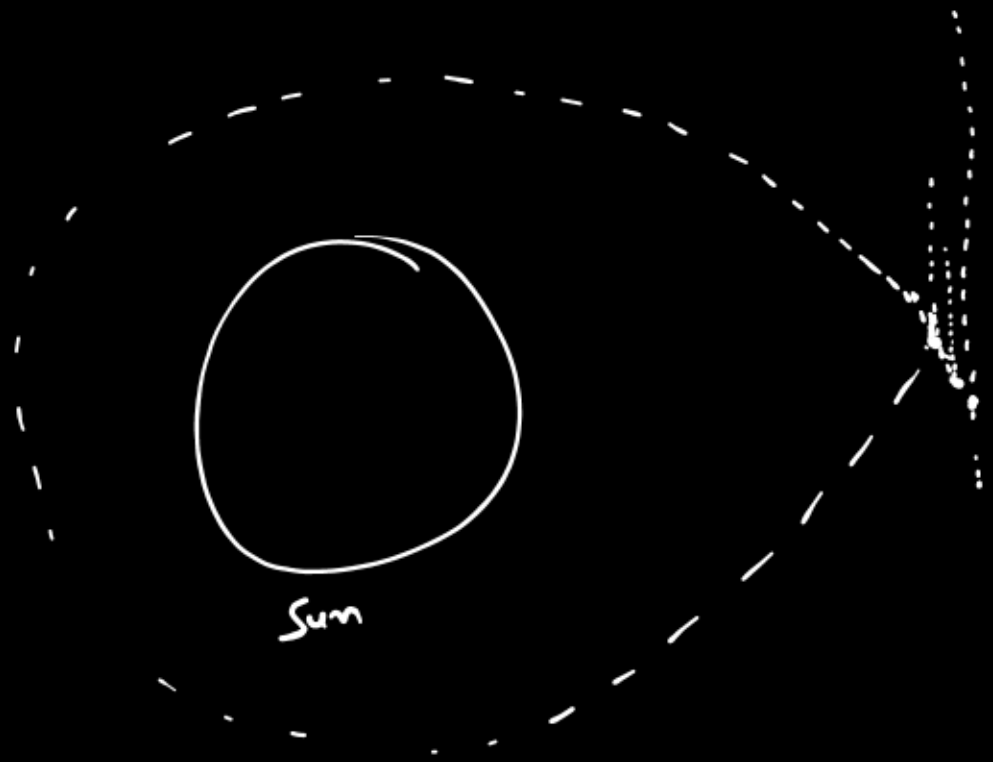
→ This force is because of mass of the object.

→ It is always attractive in nature.

→ Gravitational force of earth is also known as gravity.



" gravity is towards the centre of earth. "

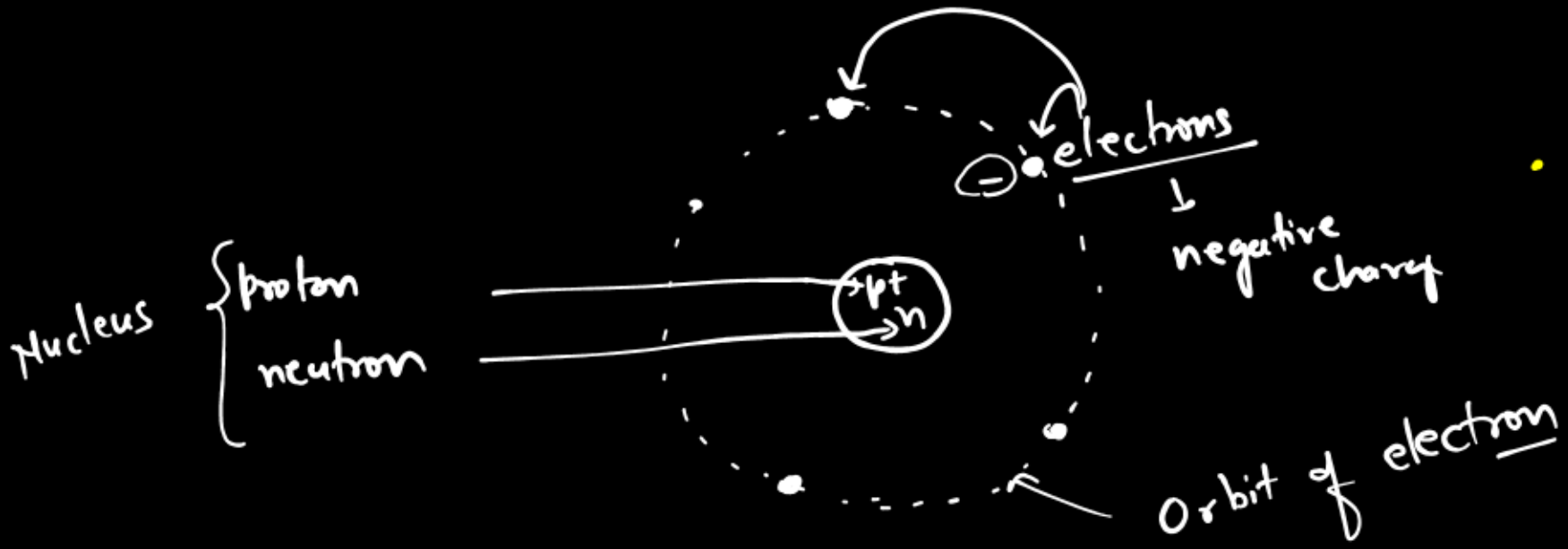


Electrostatic Force :

→ It is force between charges

→ Electrostatic repulsion : between like charges

→ Electrostatic attraction : between unlike charges.



Charges or **Electrical charge**

Two types of charges

positive charge

negative charge.

- Like charges repel each other

- Unlike charges attract each other.

Buoyant force ||

→ It is upward force on an object produced by the surrounding liquid or gas in which it is fully or partially immersed.

→ Responsible for floatation of objects in water (or fluid)

Buoyant force (Buoyancy)

→ {Boat, Ship, Submarine, can move / float due to buoyant force provided by water.

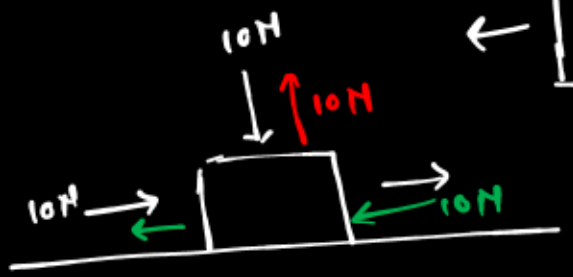
⇒ Contact force

How to measure force :

(International Standard) S.I. unit to measure force is newton (N)

Force (it has two parameters)

- Magnitude of the force
  eg. 10 newton = 10 N
  (How much force is applied)
- Direction of application of the force: (in which direction force is applied)



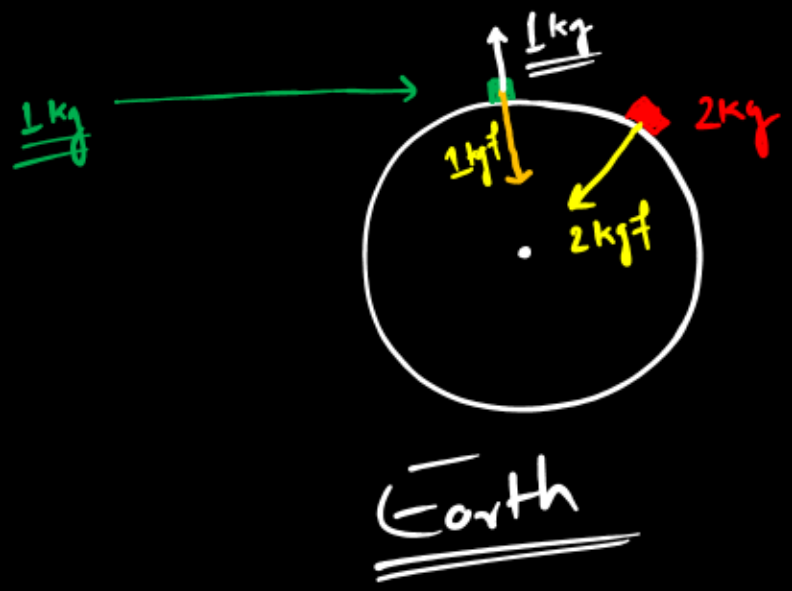
⇒ Gravitational unit of force

↳ defined using mass

unit of mass is kg (kilogram)

↳ gravitational unit of force is kilogram force (kgf)

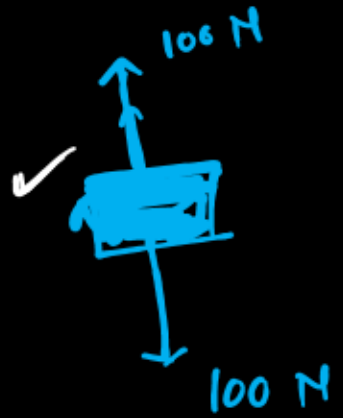
⇒ Relation between kgf and newton (N)

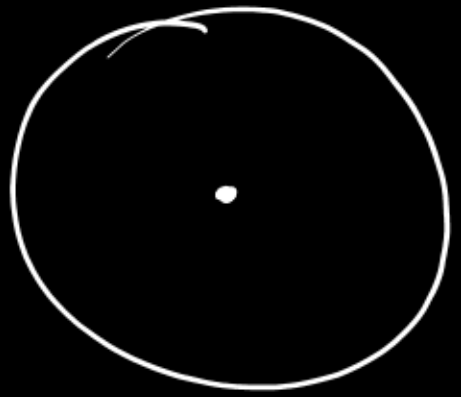


Amount force with which earth attracts an object of mass 1 kg (mass) is 1 kgf. (force)

a.k.a

1 (weight)





Earth

Gravity

"It has some value."

"gravitational factor"

$\sim 9.8\ m/s^2$

$1\ kgf = 1\ kg \times 9.8\ m/s^2$

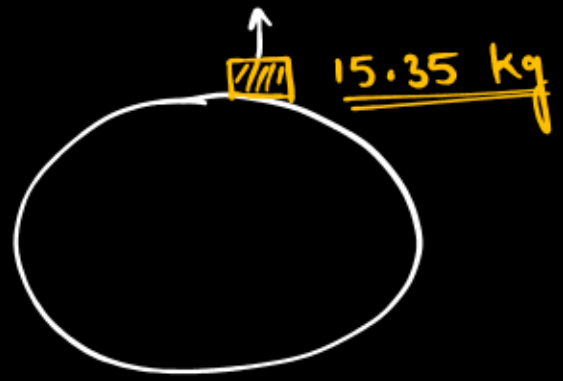
$\approx 9.8\ kg\ m/s^2$

$\approx 9.8\ N \approx 10\ N$

$1\ kgf \approx 10\ N$

= equal

$\approx$ → approx.



How much force in newtons is required to lift this object.

In kgf ⇒ 15.35 kgf

In newton ⇒ 15.35 × 10 = 153.5 N

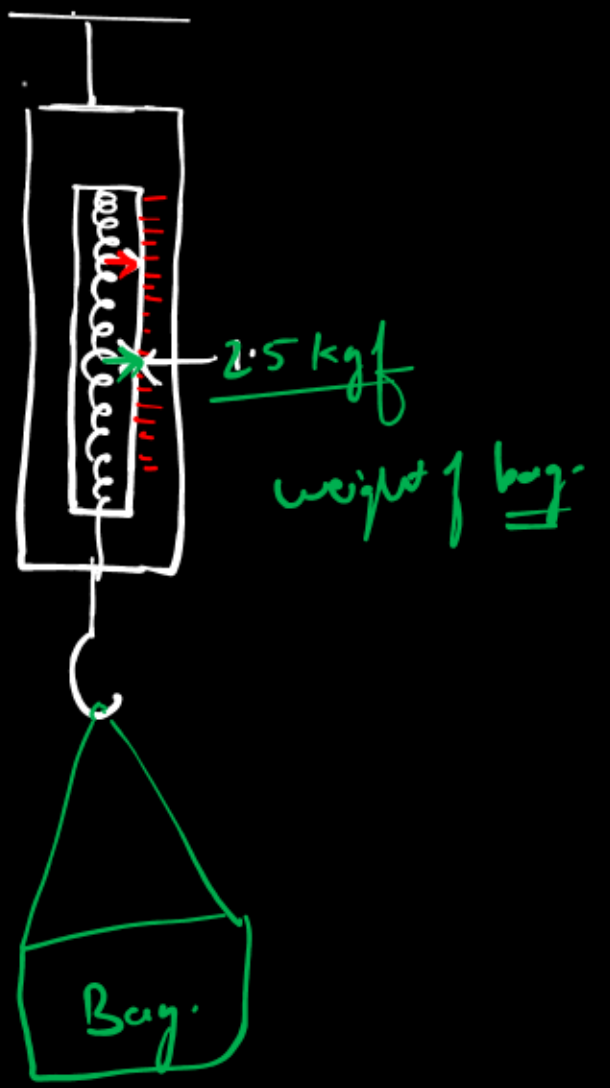
⇒ 15.35 × 9.8 ≈ 150.43 M

15.35
× 10

$$
\begin{array}{r}
^{2}\,{}^{4} \\
15.35 \\
9.8 \\
\hline
80
\end{array}
$$

→ **Spring balance**

↳ is used to measure force exerted by earth on object.



Net force / Resultant force

Net force = 60 N − 50 N

or = 10 N

Resultant force

If two forces are in opposite direction then the amount of net force is difference of the two forces, in the direction of bigger force.

Net force on object = $F_1 + F_2$ = 20 N + 30 N = 50 N.

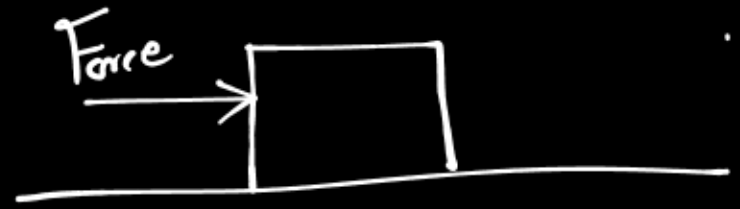
If two or more forces are in the same direction, then

net force or Resultant force } = sum of all the forces.

- List 4 Advantages and 4 disadvantages of Friction. H.W.

Work

When we apply force on an object, and object moves from its position we say that work has been done on the object.

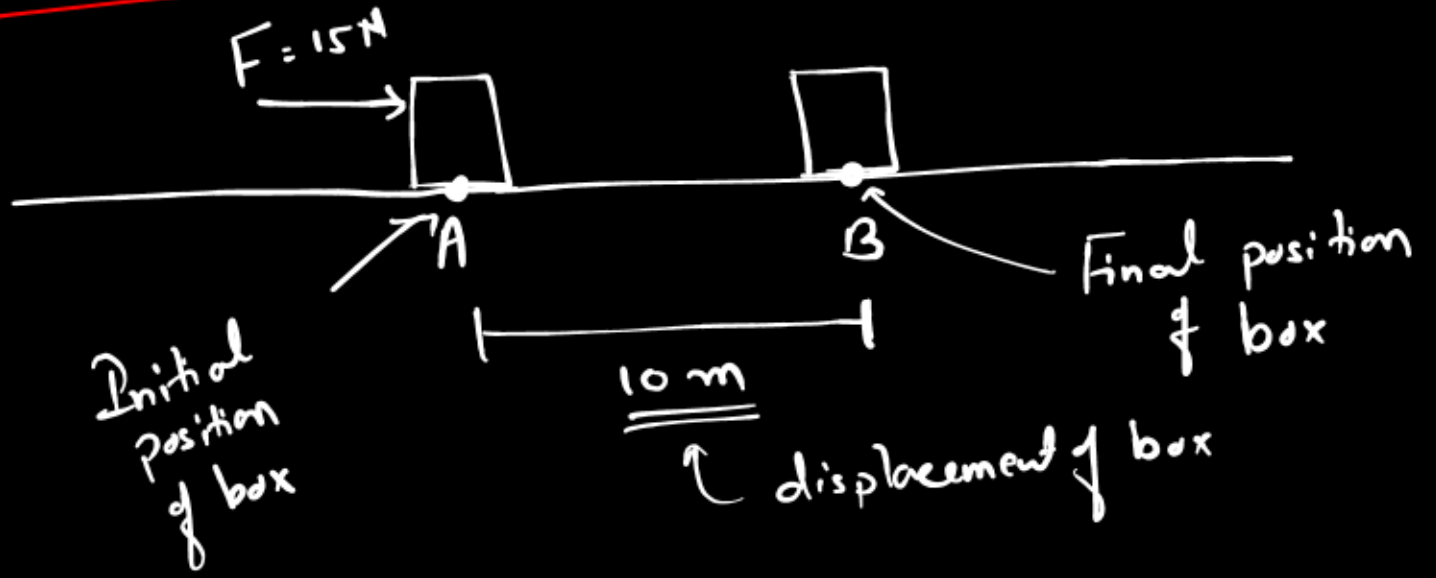


If on applying force, object does not move, then we say that no work has been done.

Calculation of amount of work done :

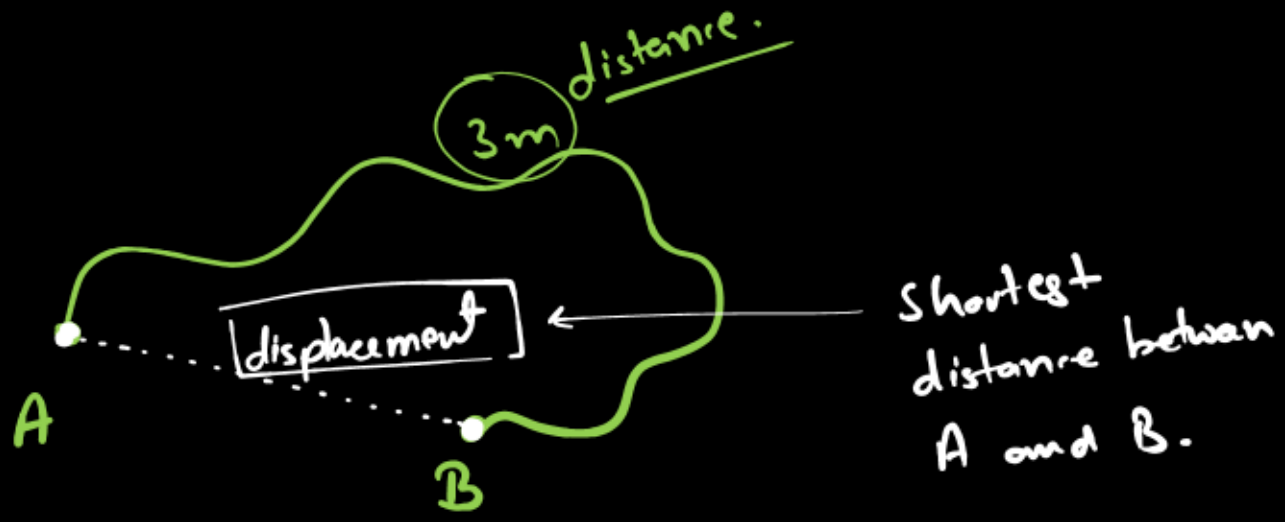
Work done depends on → Force (or applied force)
→ Displacement of the object

Work done (W) = Force x Displacement



$W = F \times D = 15\ N \times 10\ m$

Work = 150 Nm = 150 J



1 Nm = 1 joule (J)

1 newton meter

1 Nm = 1 J

joule is preffered SI unit of work

Q. Calculate the amount of work done when an object moves 350 cm from its initial position on applying 20 N of force.

Sol:

Given

Force = 20 N

Displacement = 350 cm = 3.5 m

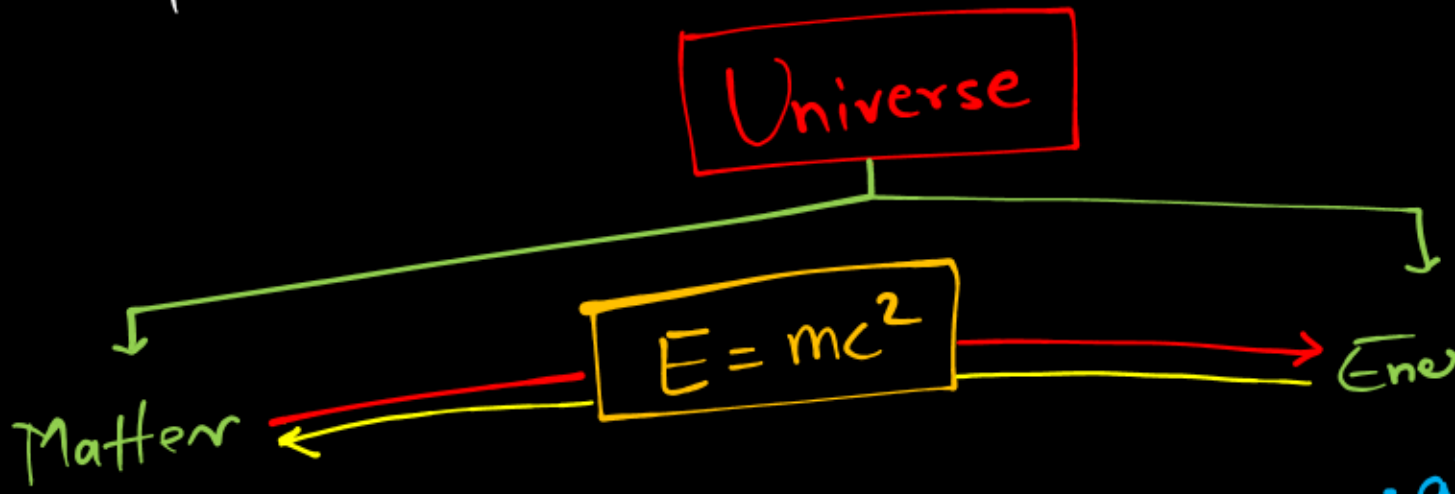
Work done = F x d

= 20 N x 3.5 m

= 70 Nm or 70 J

Energy :

- "Energy is the ability/capacity to do work"
- Energy is everywhere in the universe



- Any physical substance that exist in nature is matter.
- Matter has mass and volume. eg: pen, human, sun, earth, etc. water, air,

- ability to do the work.

eg: sunlight, wind, water, electricity, sound, flame energy

⇒ We cannot see energy, we can only see/feel its effects.

⇒ Unit of energy is same as the unit of work done. i.e. joules (J).

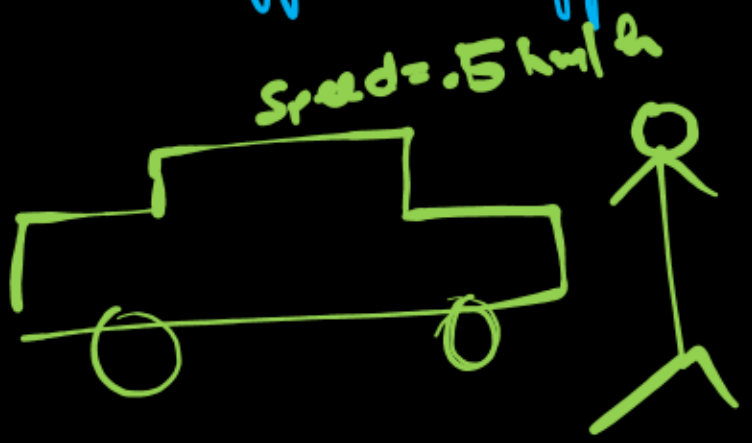
Different forms of energy

Energy in action

- Heat energy
- Sound energy
- Electricity
- Light energy

Stored Energy

- Chemical energy
- Magnetic energy
- Nuclear energy



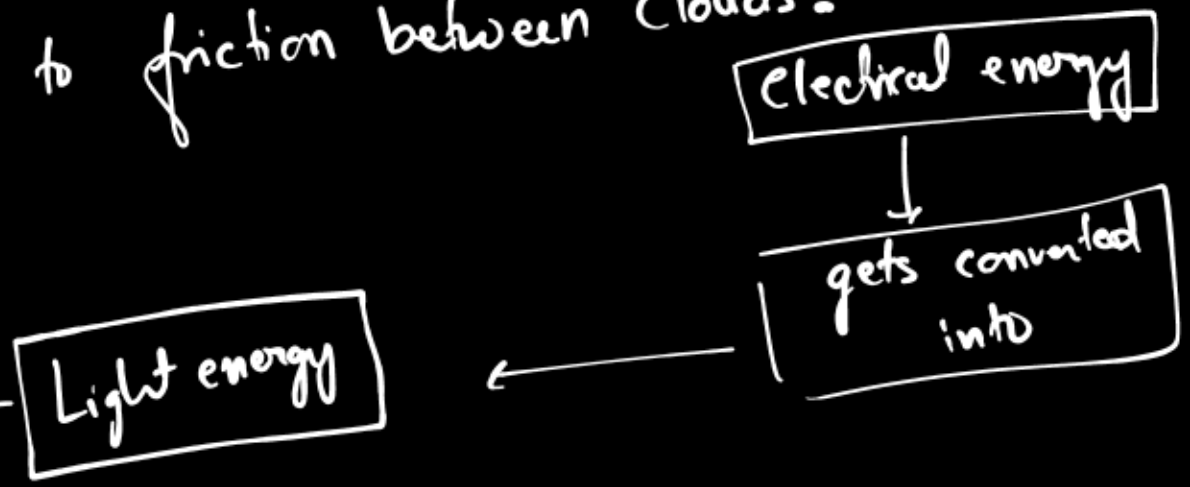
Mechanical energy

- Kinetic energy
- Potential energy
  - Gravitational Potential energy
  - Elastic Potential Energy

Electrical energy :

→ Produced by rubbing two dry objects together.

→ Lightening due to friction between clouds.



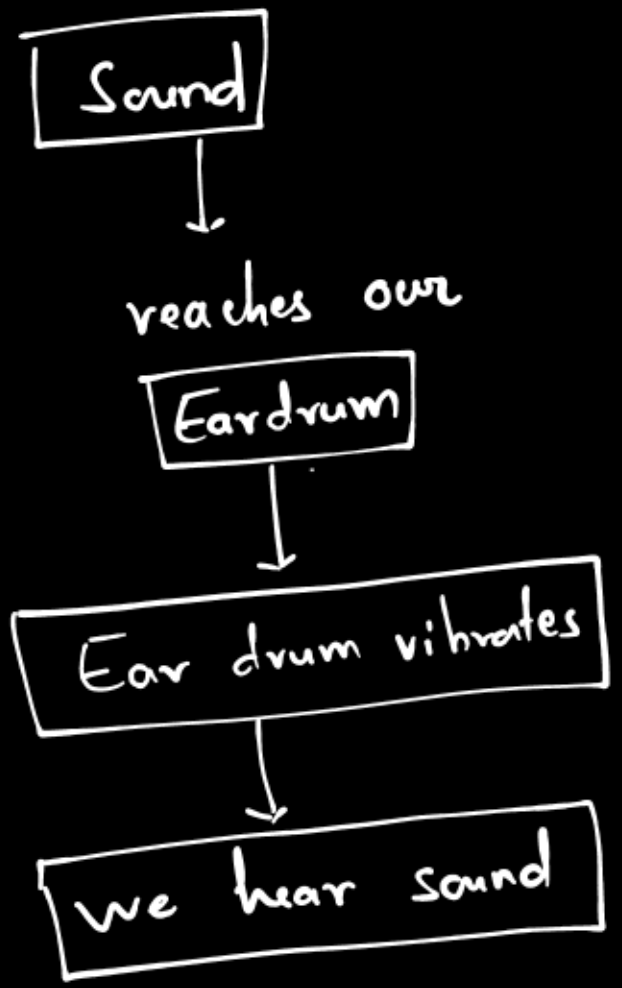
Heat energy :

- It is also k.a. thermal energy.
- It is produced by friction, burning.

Sound energy:

→ Produced by vibration of an object.

Vibrating object generates Sound



Sound Energy (Important)

→ Sound energy / sound can travel through solids, liquids and gas.

→ It cannot travel in vacuum.

Speed of sound: solid > liquid > Gas

- Sound travel in the form of wave

Lost content

Lost content

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Stored form of Energy

① Chemical energy

⇒

② Magnetic Energy :

- Magnets can move other objects from its position by applying magnetic force.

eg: It can move iron from its position.

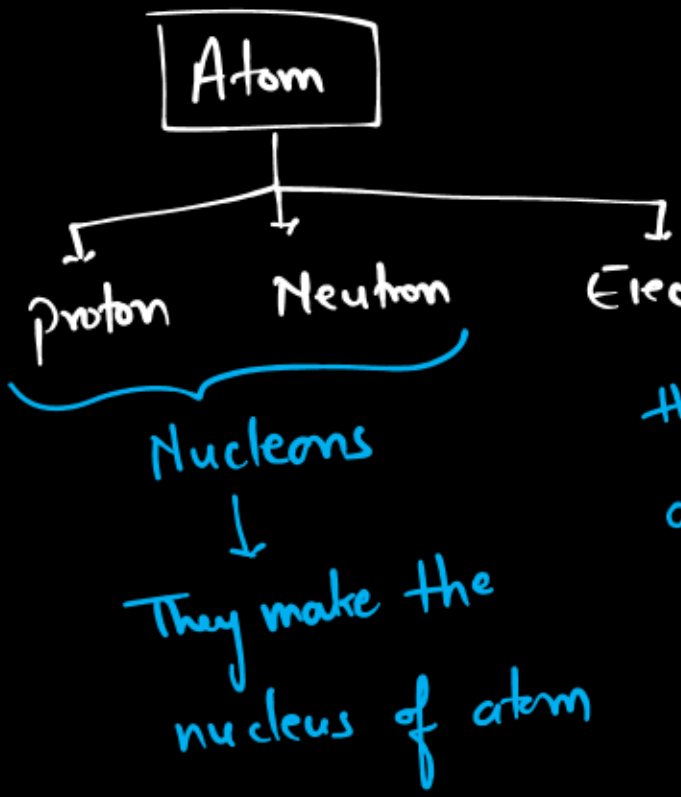
→ It means magnets are capable of doing work.

→ This work done is possible only because of energy stored in magnets.

↳ (magnetic energy)

③ Nuclear Energy

→ Energy stored in the nucleus of atom.



We can utilize nuclear energy in two different ways:

(i) By splitting the nucleus of a heavy atom (like Uranium)

↓

(Nuclear Fission)

↓

splitting

it releases large amount + New elements of energy.

→ This energy can be used in nuclear power plant to generate electricity

→ This also powers nuclear bombs/atomic bombs

(ii) By fusion (joining) of two or more nucleus of lighter atoms (like Hydrogen).

Nuclear Fusion

- huge amount of energy is released. + new element

* This process powers stars (sun)

Light Energy:

- Light travels in the form of wave.
- It can travel through, transparent solids, transparent liquids, gas and vacuum.

Geothermal Energy

=> Geo => earth

therm => heat

=> Heat energy trapped inside earth.

=> Geothermal energy → converted into → Electrical energy

Hydro energy

→ Energy of moving water.

→ This energy is used to generate electrical energy.
(Current electricity)

↓

hydro-electricity

Power station that use hydro energy to generate electricity → Hydro power station

Wind energy

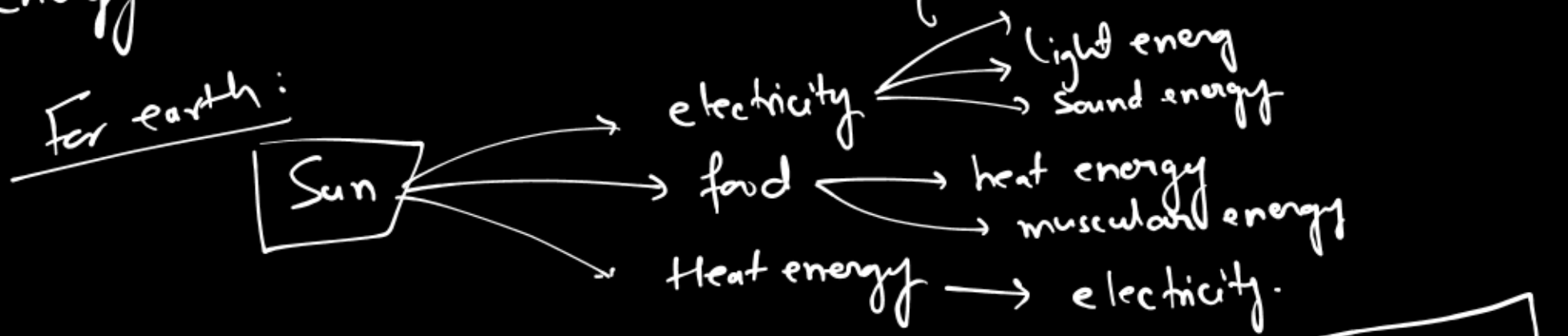
→ Moving air is called wind.

→ Wind energy can be used to generate electricity using wind turbine.

Important :

+ Energy is converted from one form to another.

For earth :



- "Energy can neither be created nor be destroyed. It can only be converted from one form to another."

↳ Law of conservation of energy

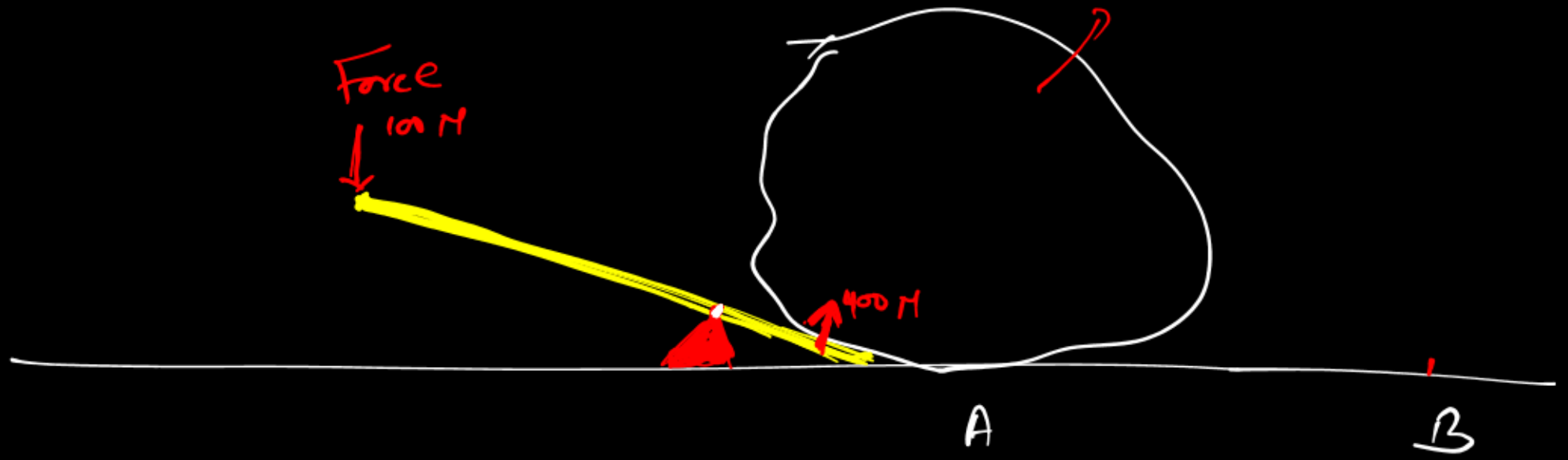
⇒ It means energy of our universe is constant or conserved.

Simple Machines

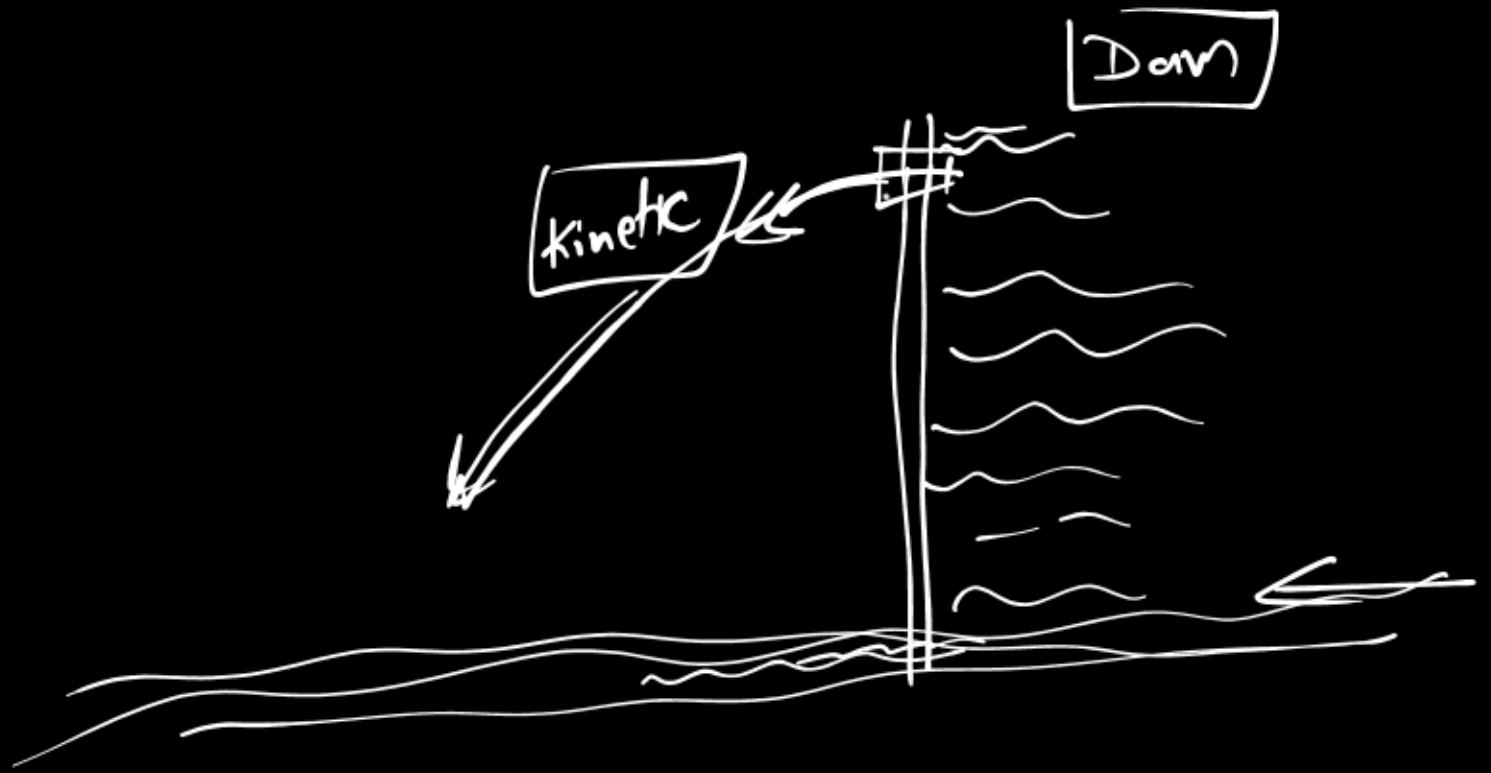
→ Very basic machines.

→ Machines helps us to do work easily and efficiently.

→



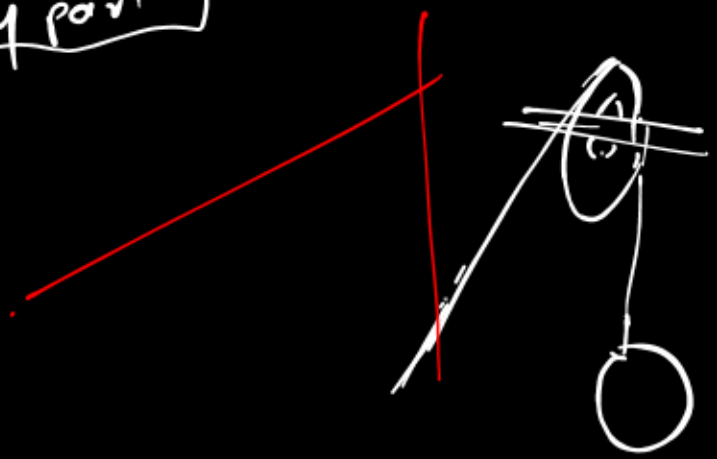
→ Simple machines are made up of only few parts.



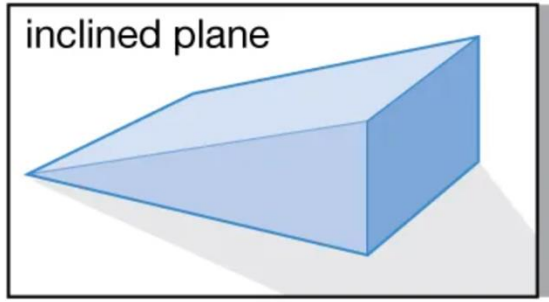
$E = V_s$

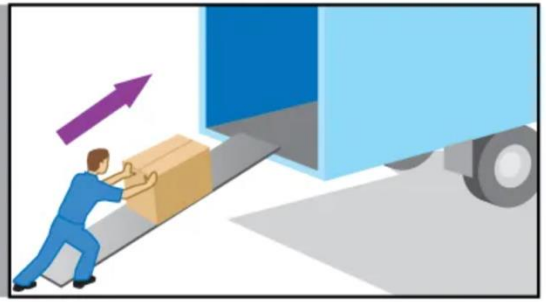
Examples of Simple machines:

1. Lever ✓ — Liver — Body part
2. Inclined plane ✓
3. Wheel and axle
4. Pulley.
5. Wedge
6. Screw

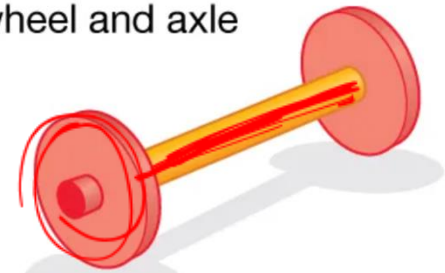


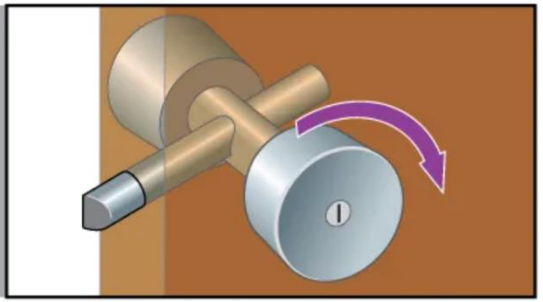
inclined plane



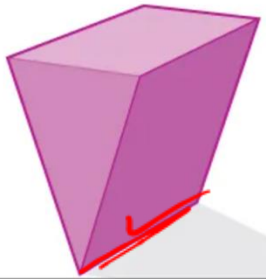


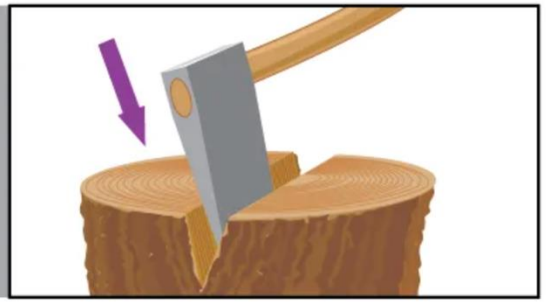
wheel and axle



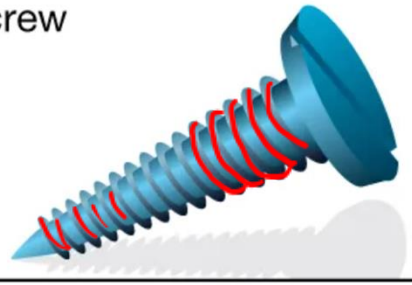


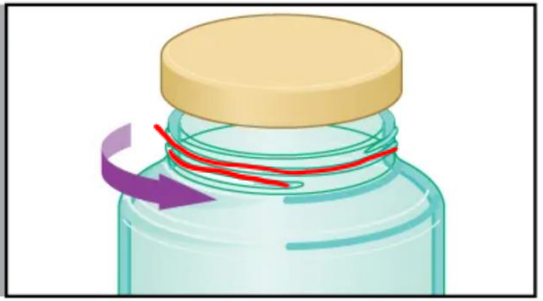
wedge



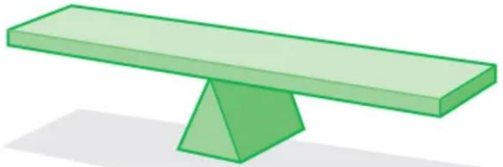


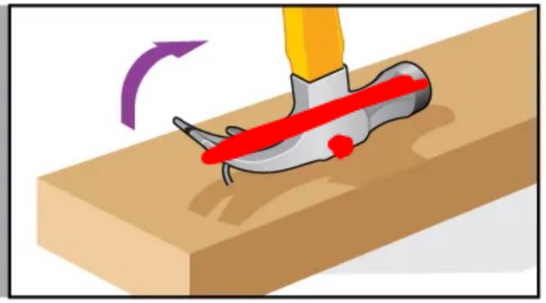
screw



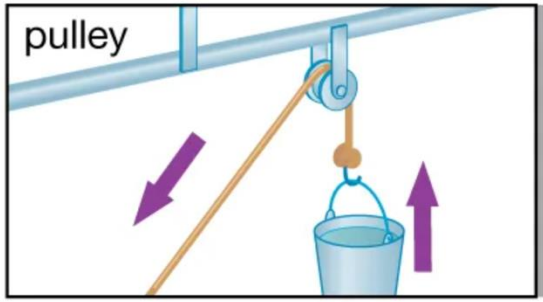


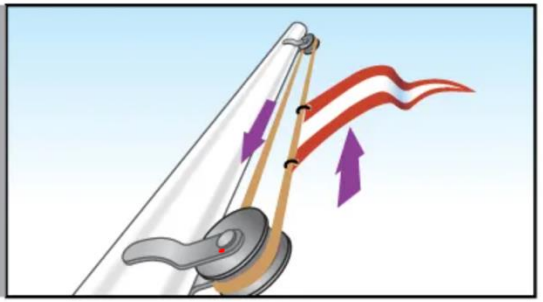
lever





pulley



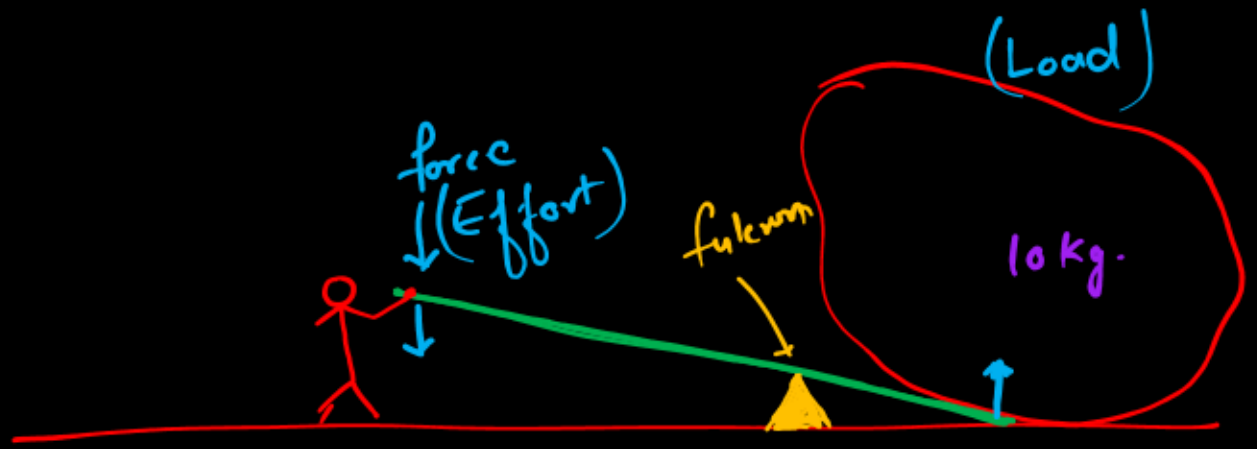


Lever

- Simple machine
- Consists of
  - beam or a rigid rod,
  - fixed hinge / pivot.

Fulcrum

- Rod is free to rotate on fulcrum.
- Used to lift or move heavy objects.



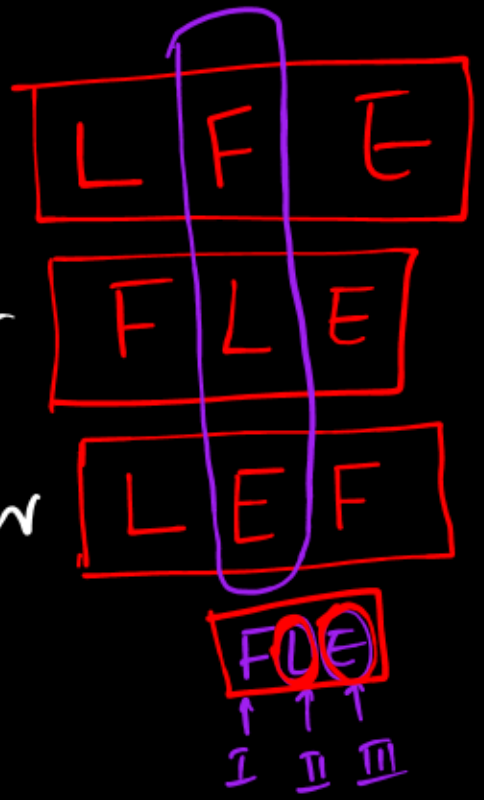
Lever

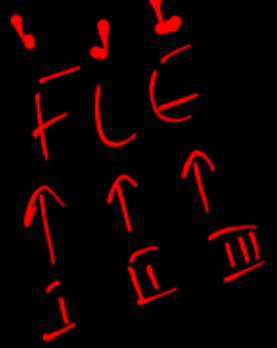
- Effort (E)
- fulcrum (F)
- Load (L)

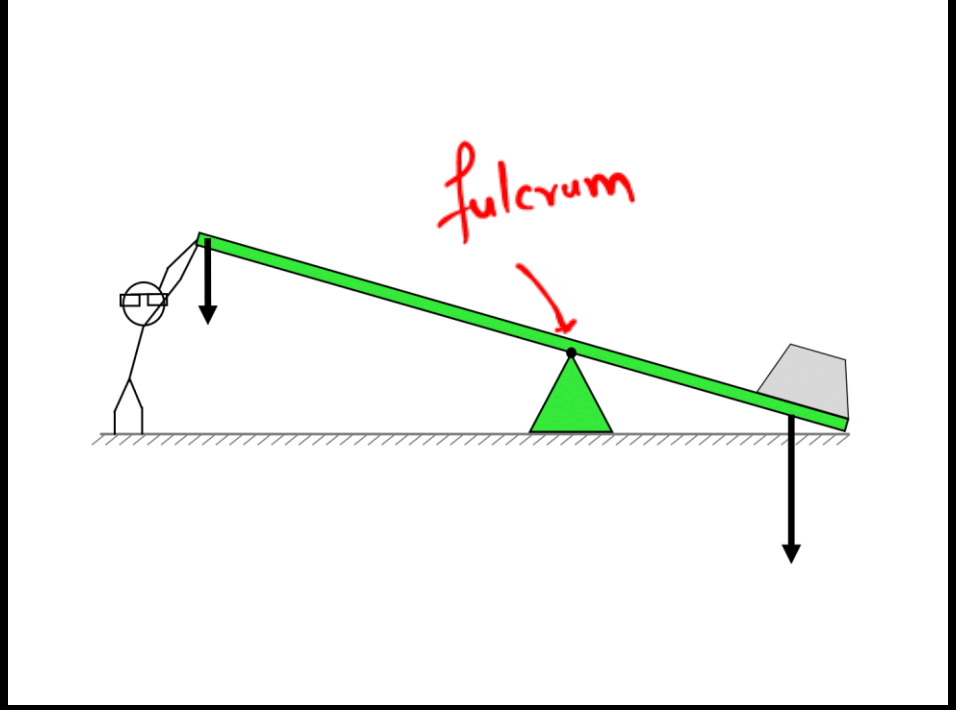
[Examples : Hammer, Bottle opener, Scissors]

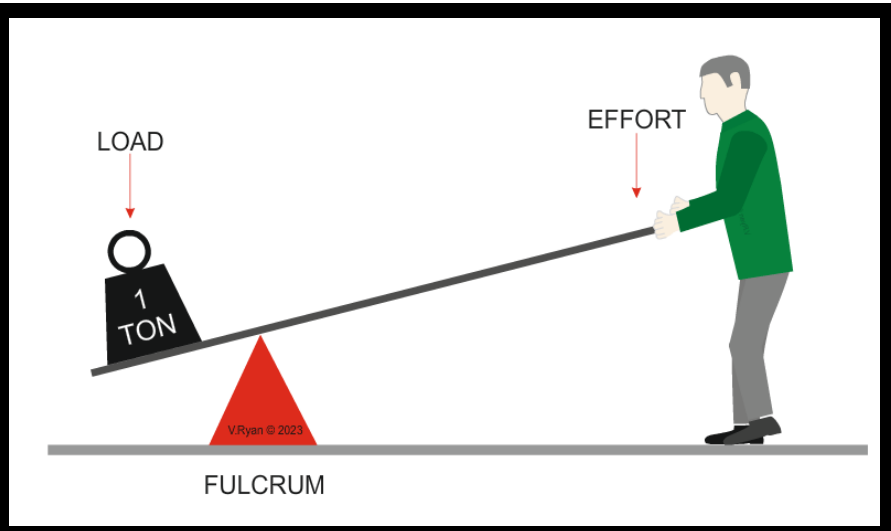
Based on position of E, F, and L; lever can be classified into three Class.

- Class I lever
- Class II lever
- Class III lever





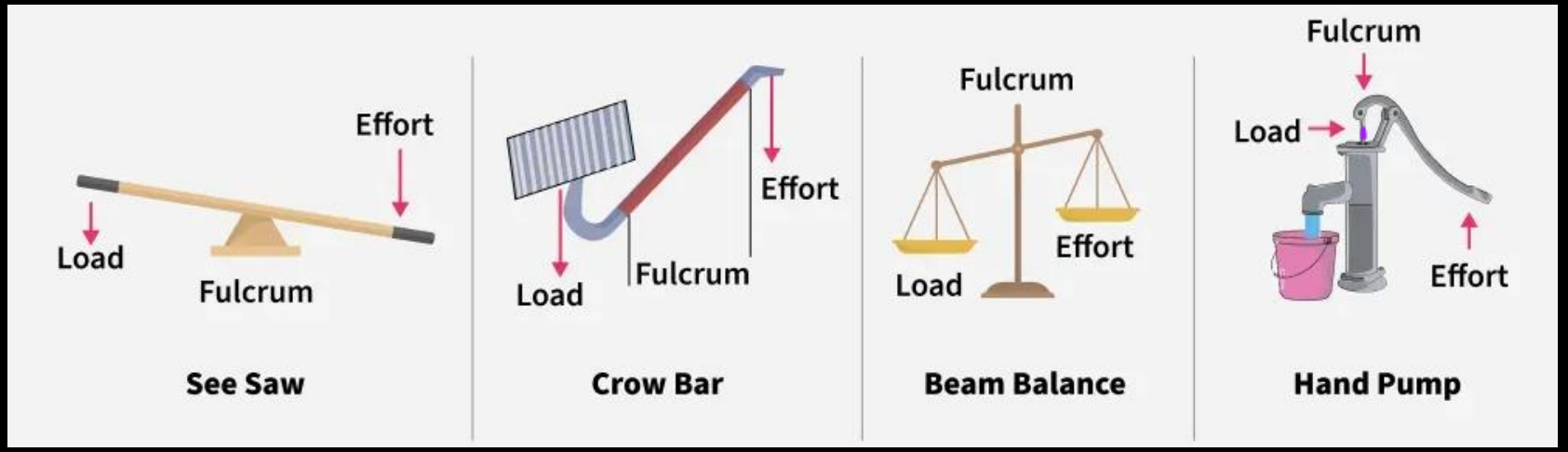


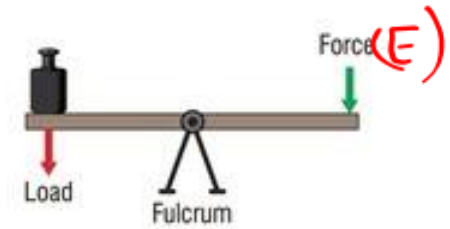


Class I Lever

L F E

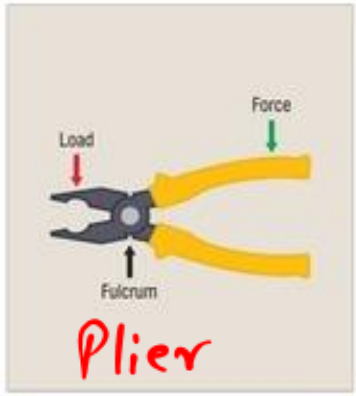
E F L

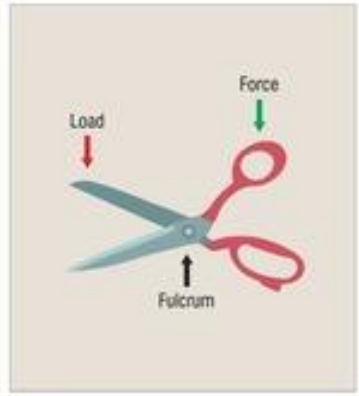


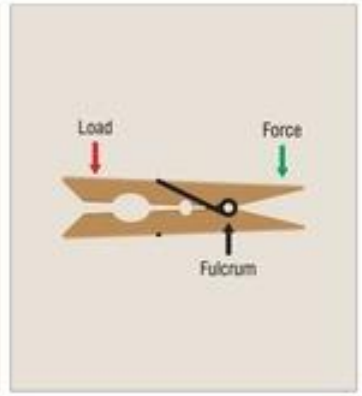


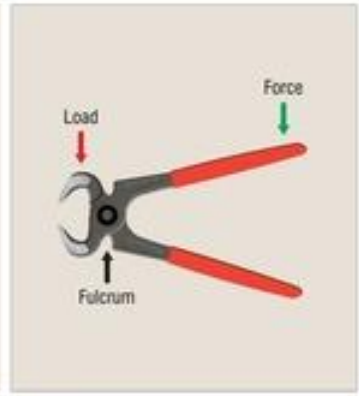
THREE CLASSES OF LEVERS

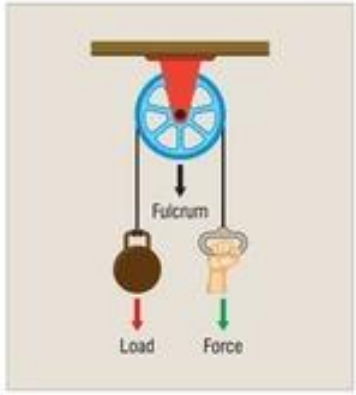
First class lever

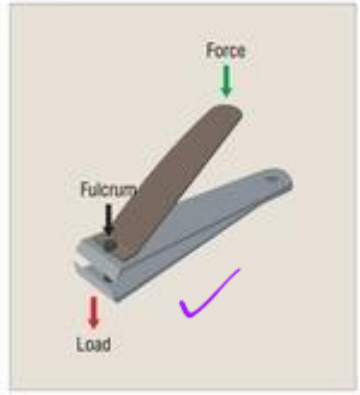


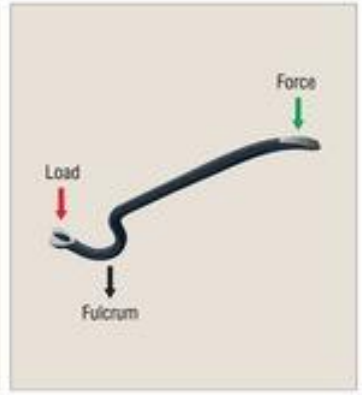


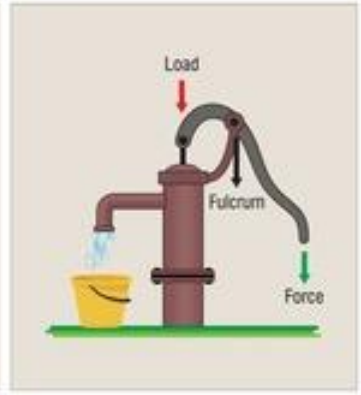


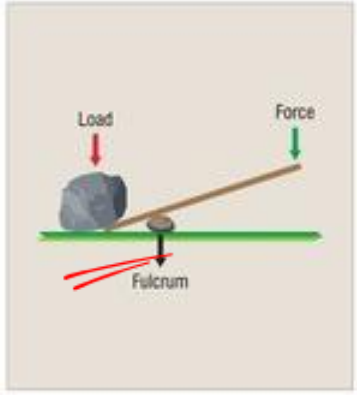


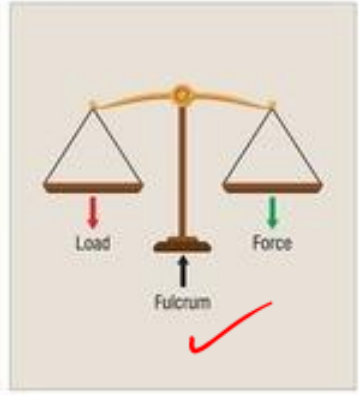


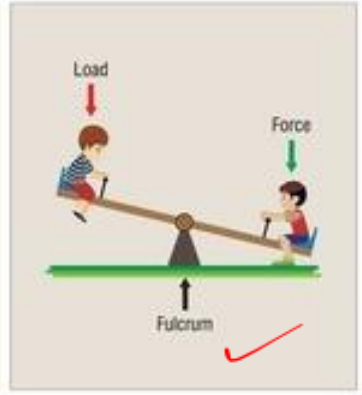


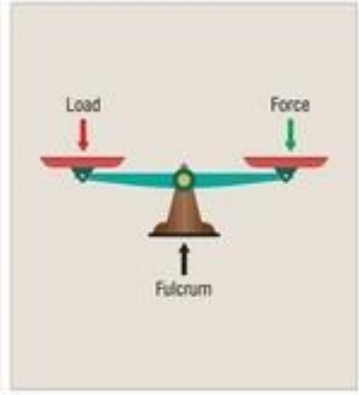








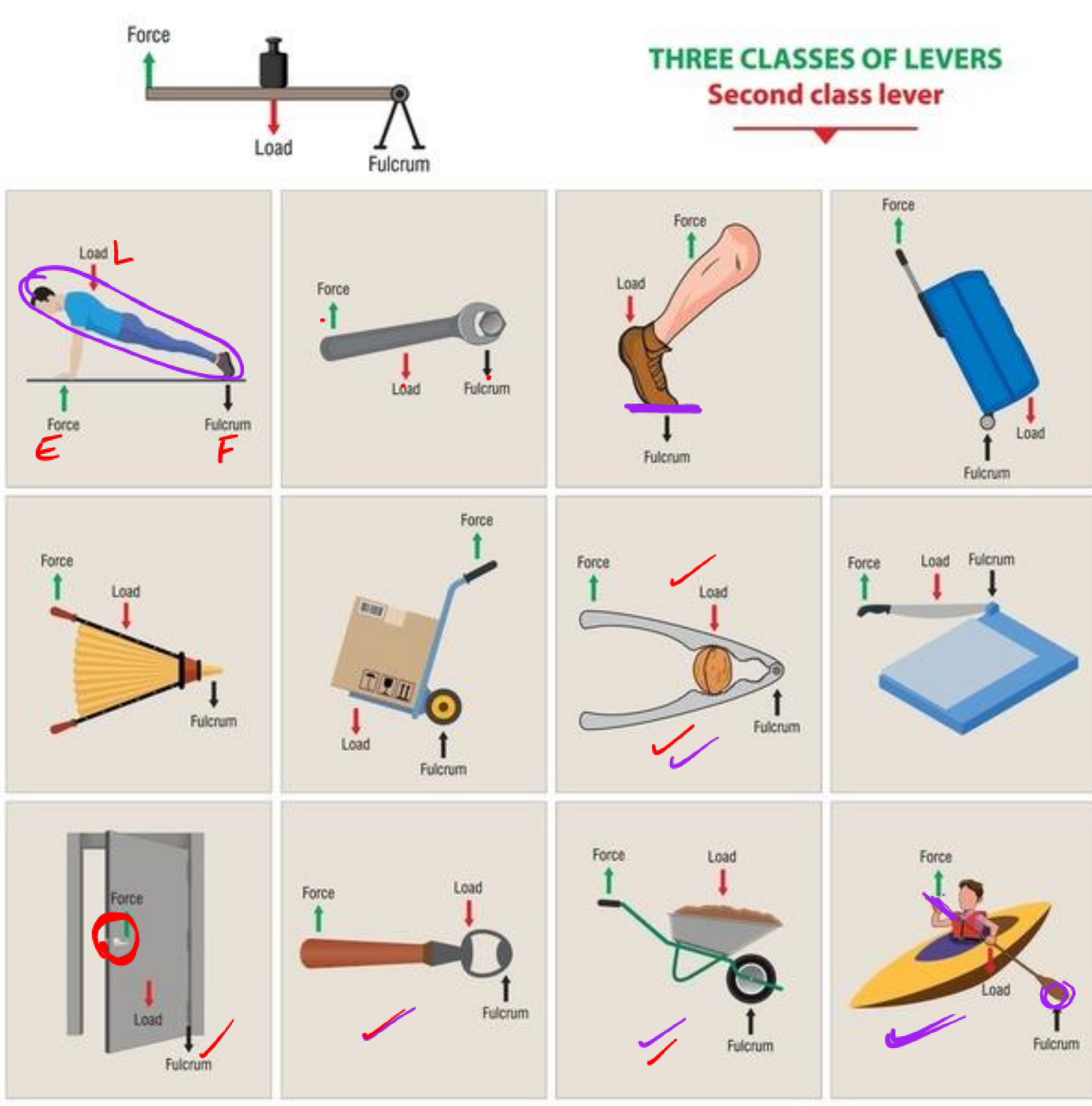




Class II Lever

E L F

F L E

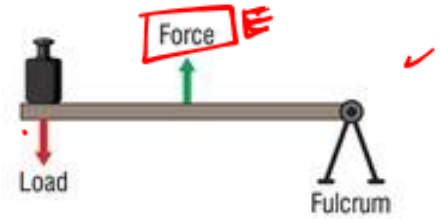


Class III Lever

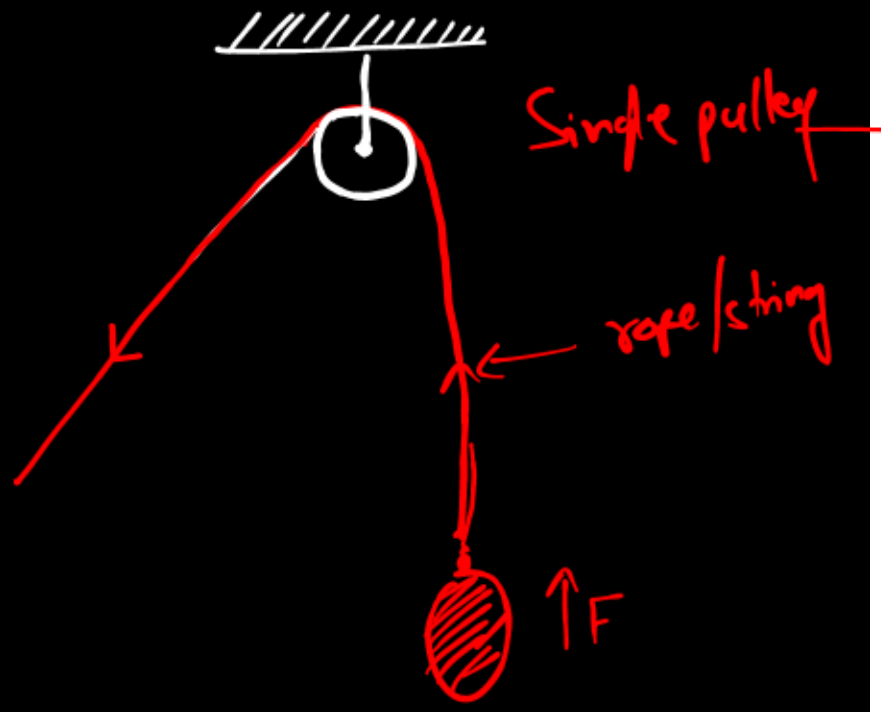
F E L

L E F

Mechanical Advantage



② Pulley :



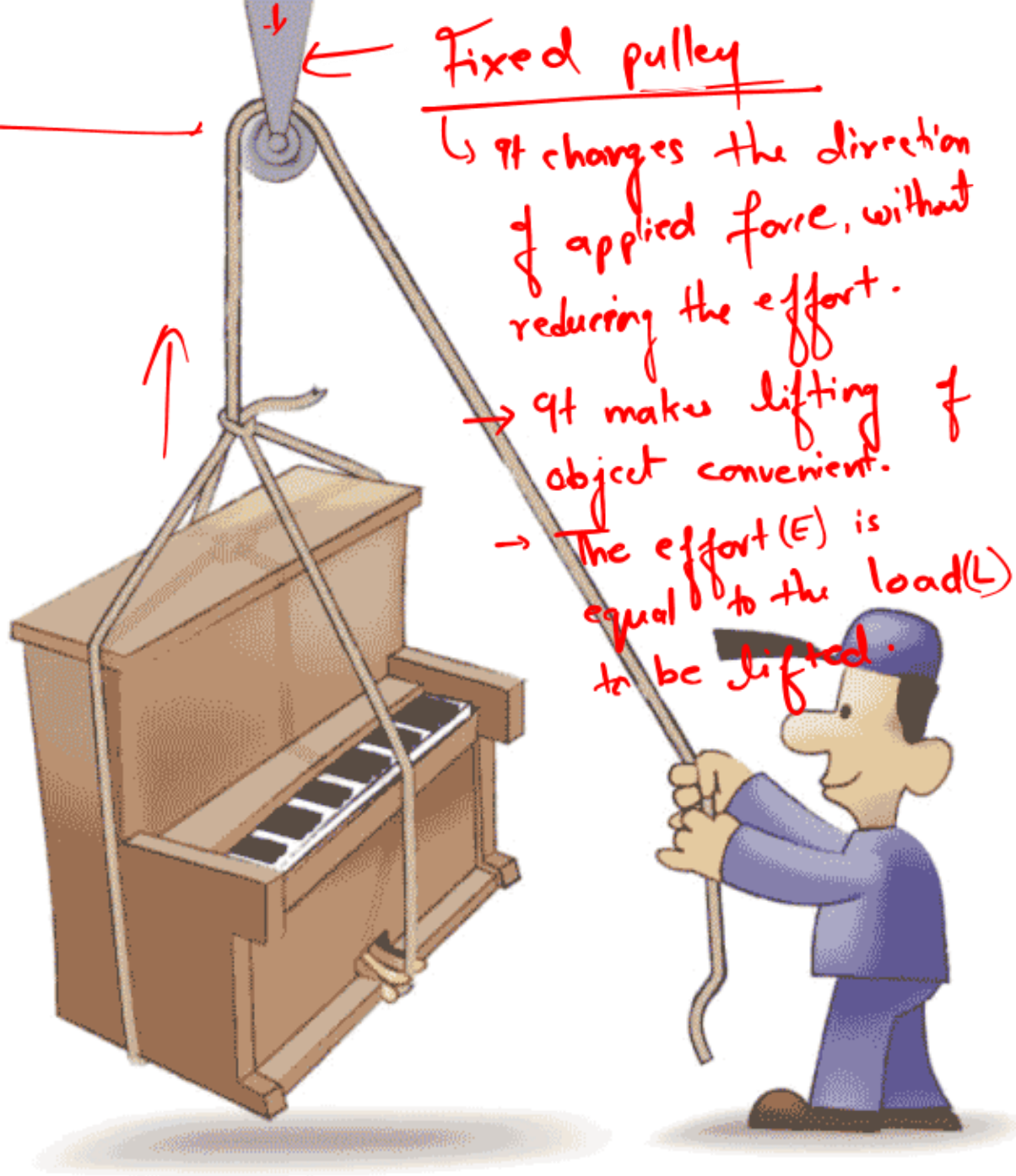
- A Small wheel with a groove around its outer edge.
- Groove can hold a rope/string in position
- Two types of pulleys are
  - Fixed pulley.
  - Movable pulley.

Fixed pulley

↳ It changes the direction of applied force, without reducing the effort.

→ It make lifting of object convenient.

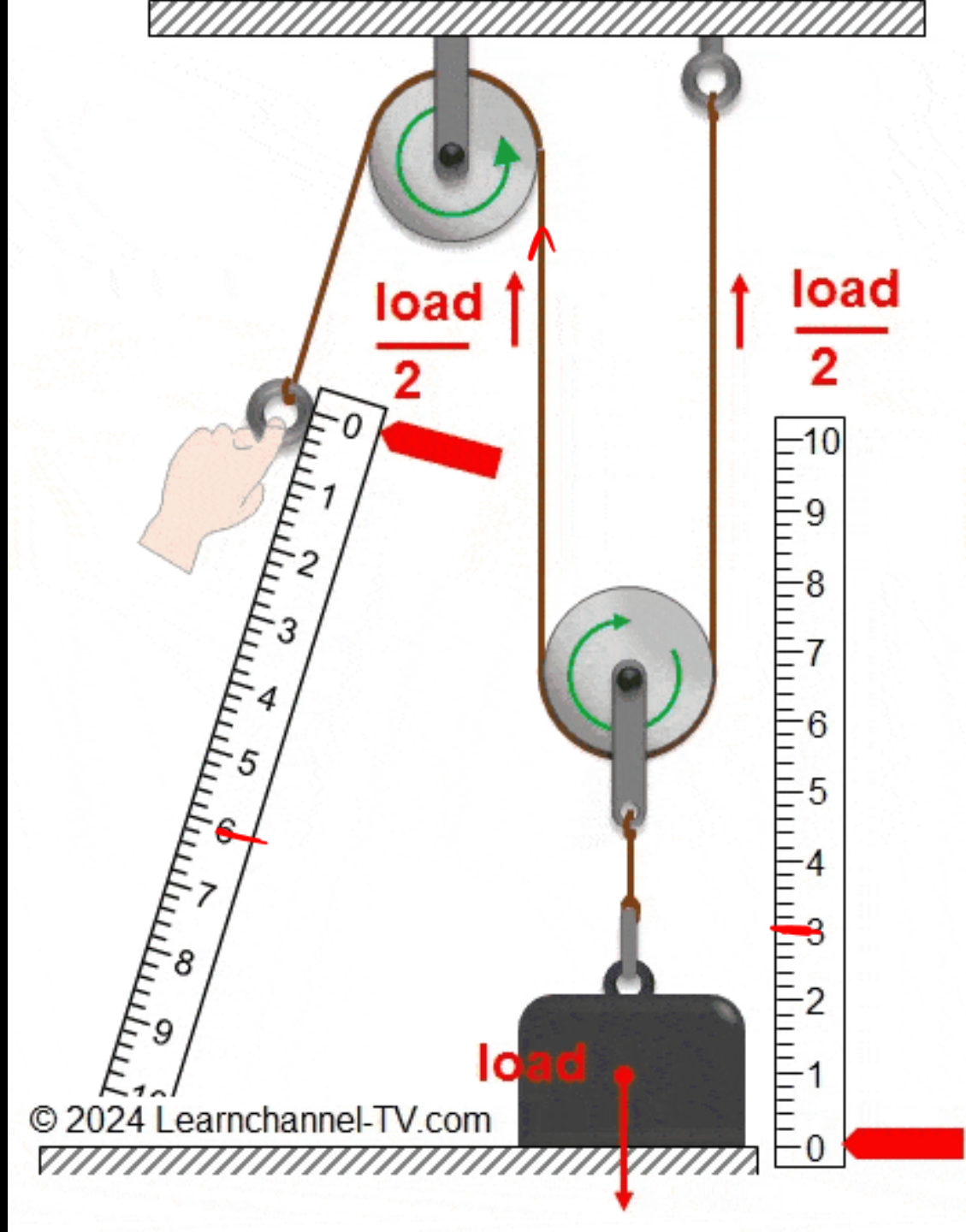
→ The effort (E) is equal to the load (L) to be lifted.



Movable Pulley

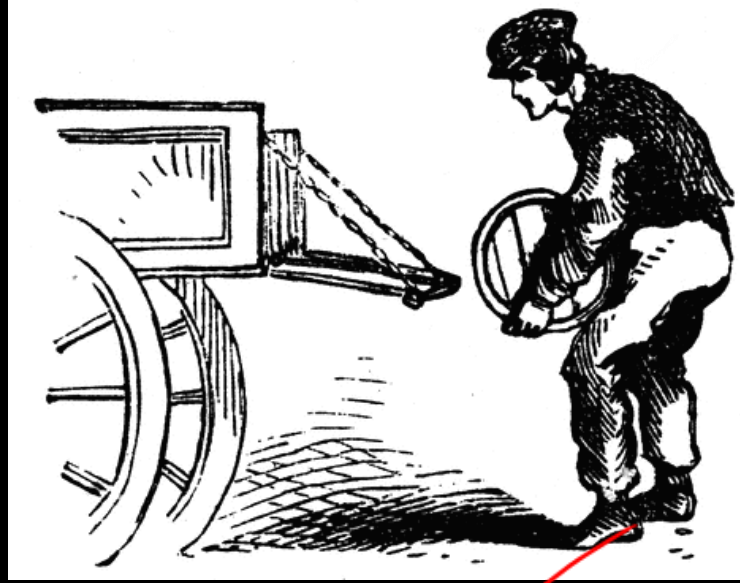
→ Wheel of the pulley also moves with the load.

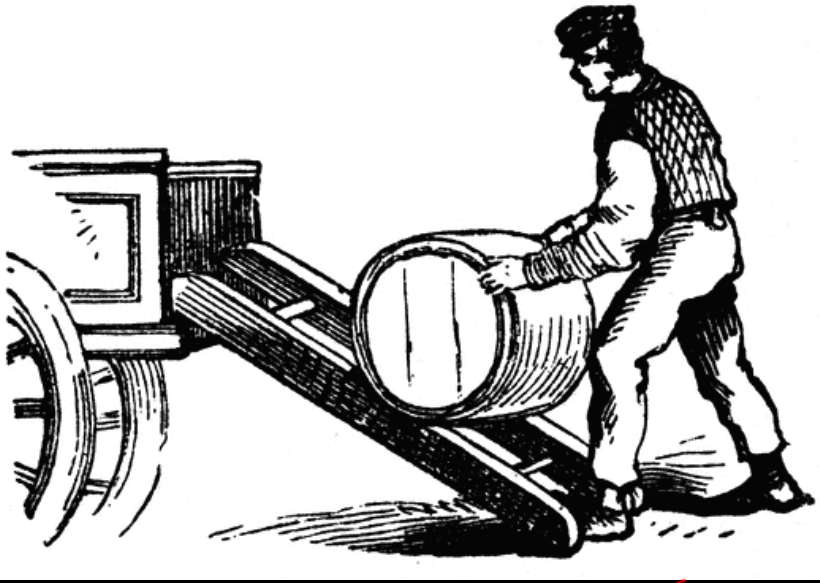
→ It reduces the effort to half; however we need to pull twice the length of the rope.



Inclined Plane

↳ Slope or slanting surface which connects lower level (road) to higher level (cart)





→ It helps to move heavy objects to a height.

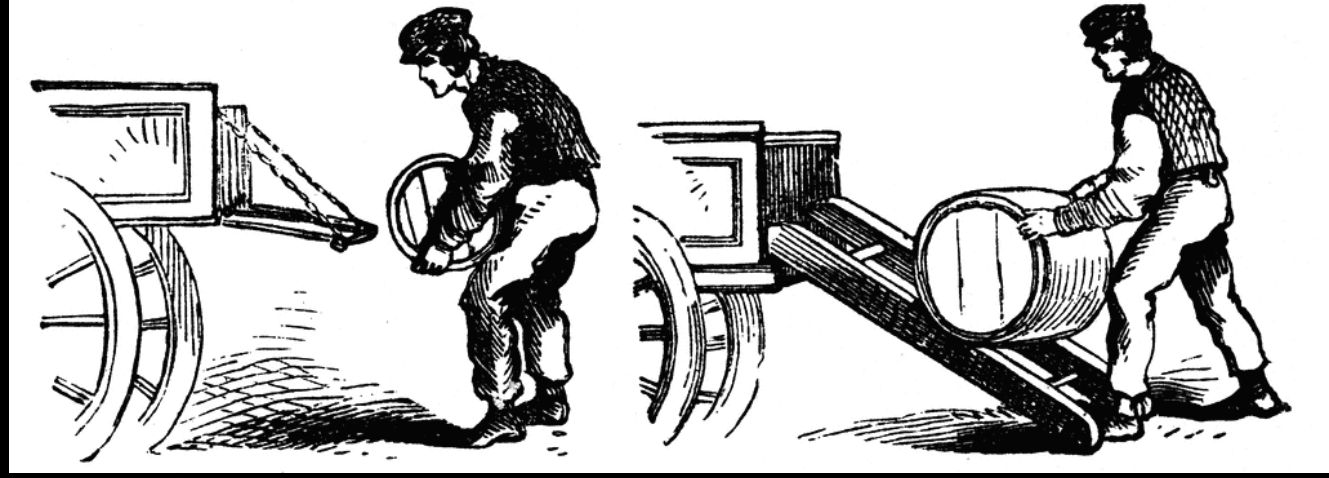
→ An inclined plane does not reduce the amount of work done, but makes it easier to do.

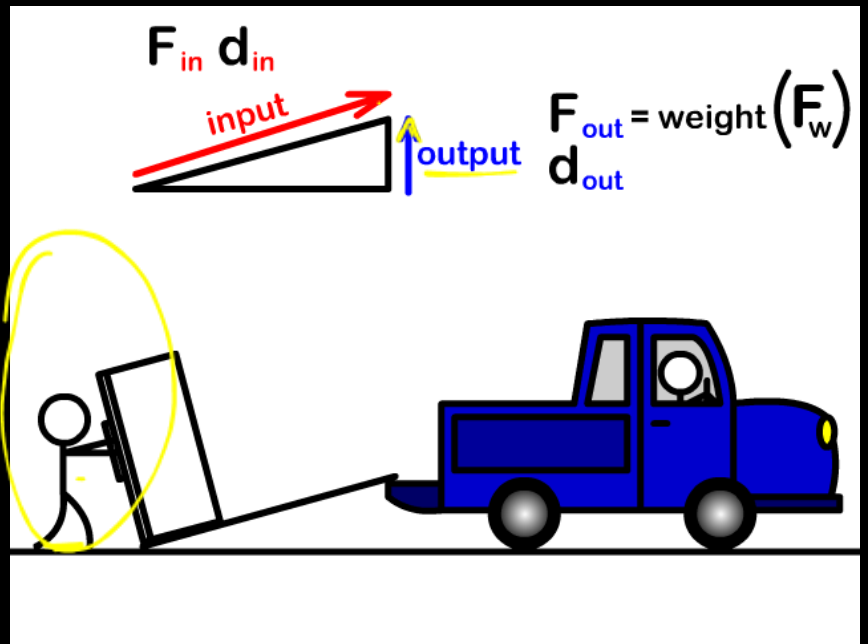
Work done in Fig 1 = **Work done in Fig 2**

- more force, less distance
- Less force, more distance

Word done = Force x distance

Examples: Children's slide, ramps for wheelchairs, threads of screw, sloping road.




F_{in} d_{in}
input
output
F_{out} = weight (F_w)
d_{out}

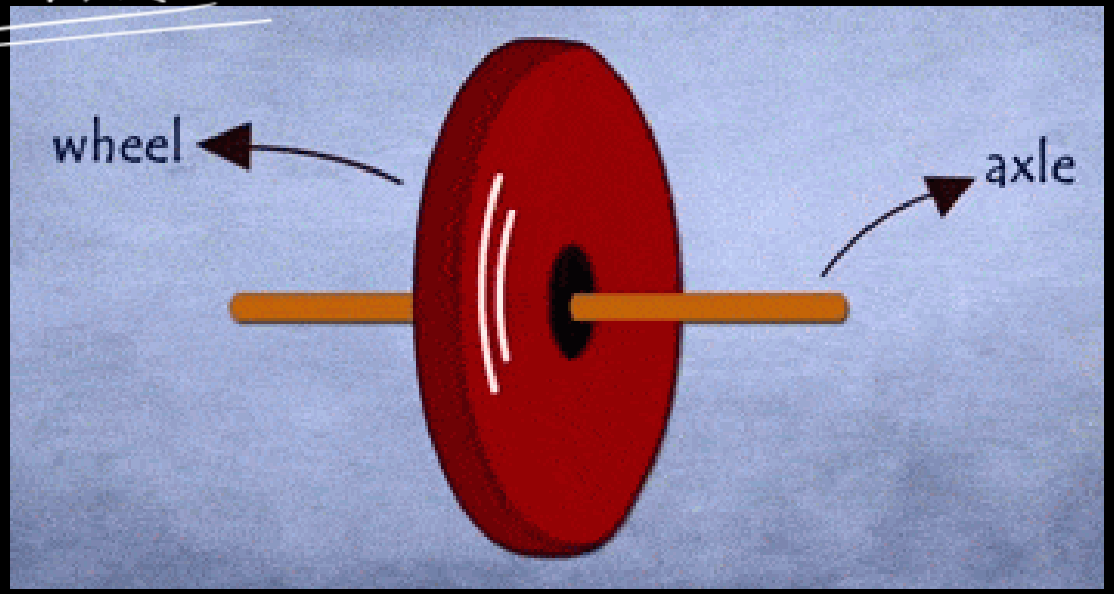

One of them is an inclined plane.
MakeAGIF.com

Wheel & Axle

→ Large wheel is connected to a small rod (axle)

→ Wheel & axle are fixed, i.e. they move together.

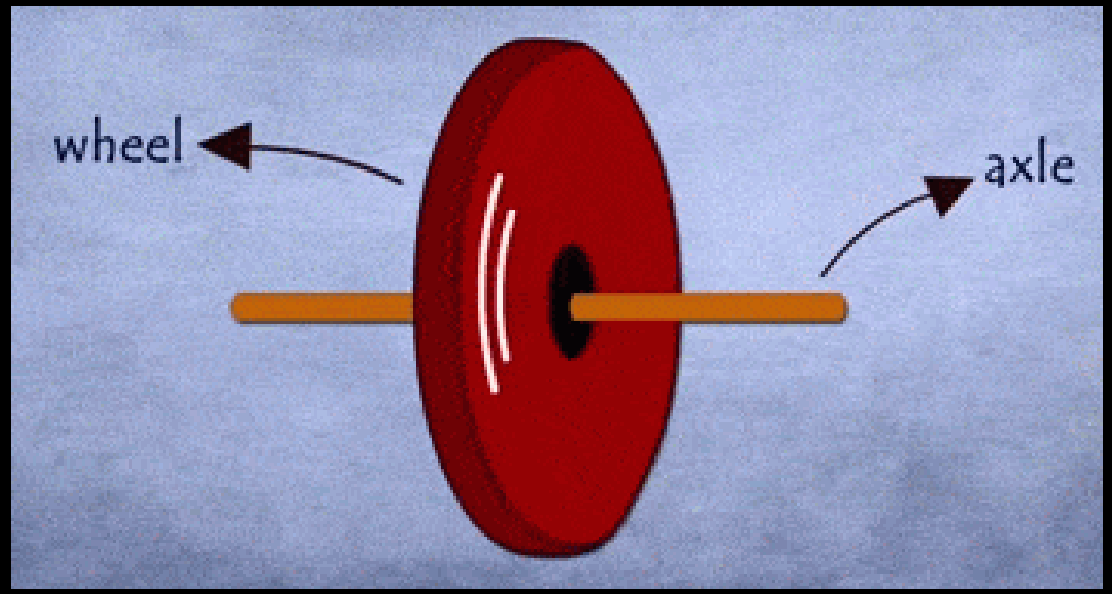
↳ Axle also rotates along with wheel.



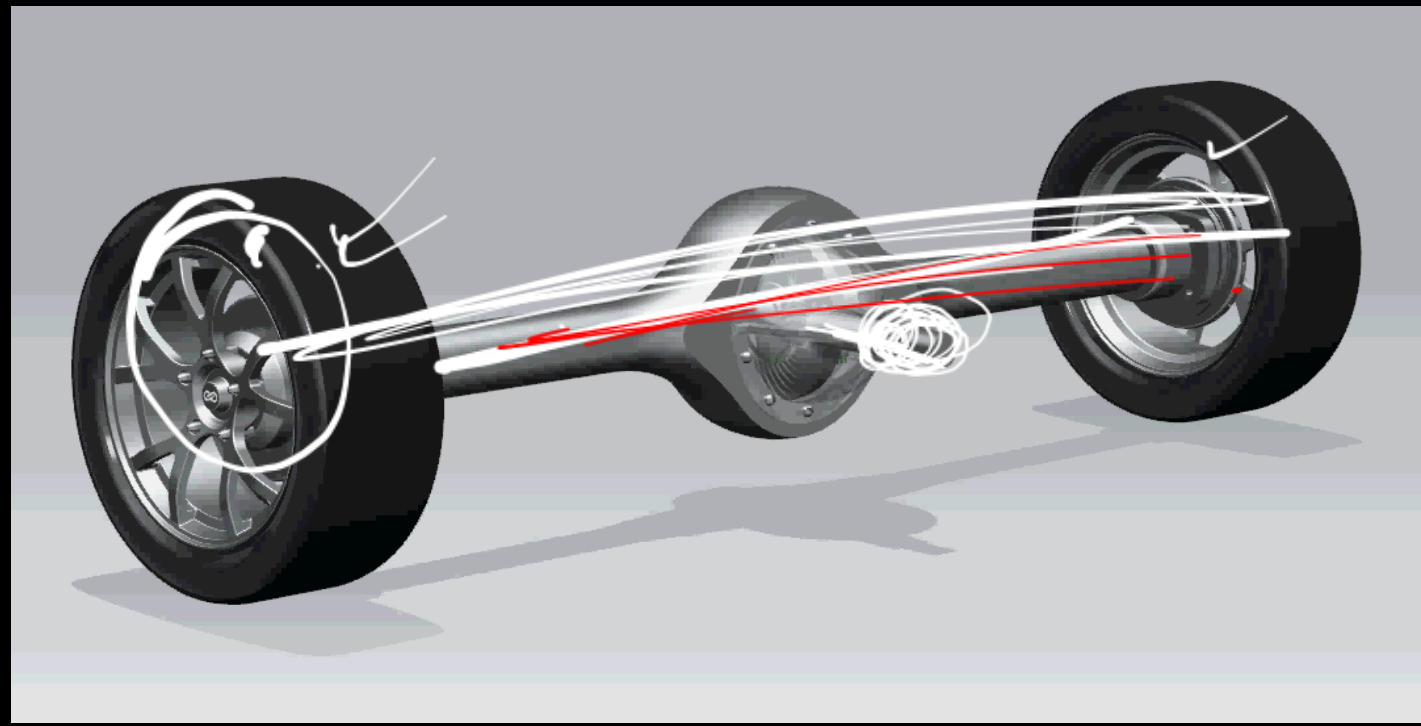
Examples: Steering wheel, screw driver, bicycle pedal, door knob.

Effort → wheel

Load → axle

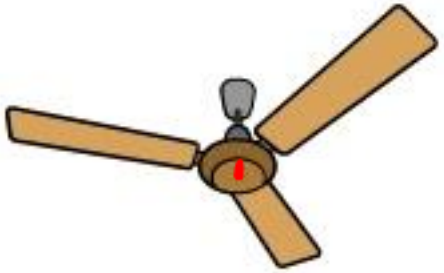


- Greater the radius of the wheel, lesser would be the required effort.

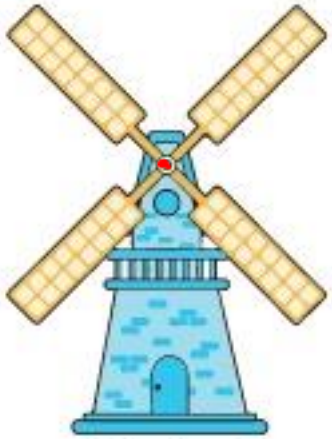


Wheel and Axle Examples

Wheelchair



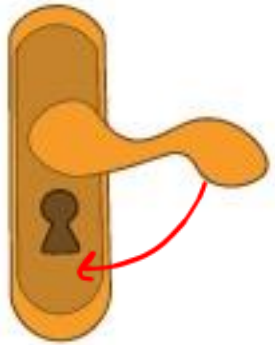
Electric fan



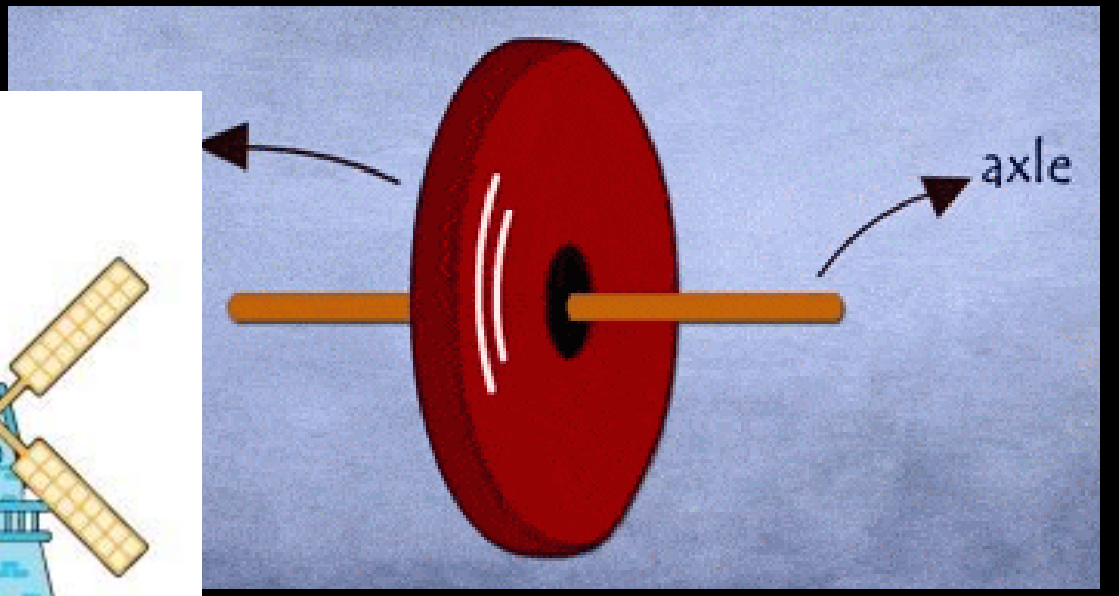
Windmill

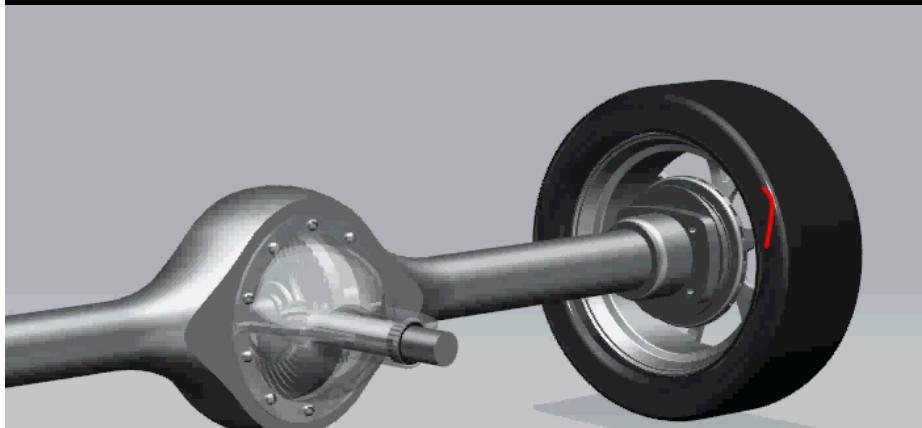
Bicycle

Ferris wheel



Doorknob





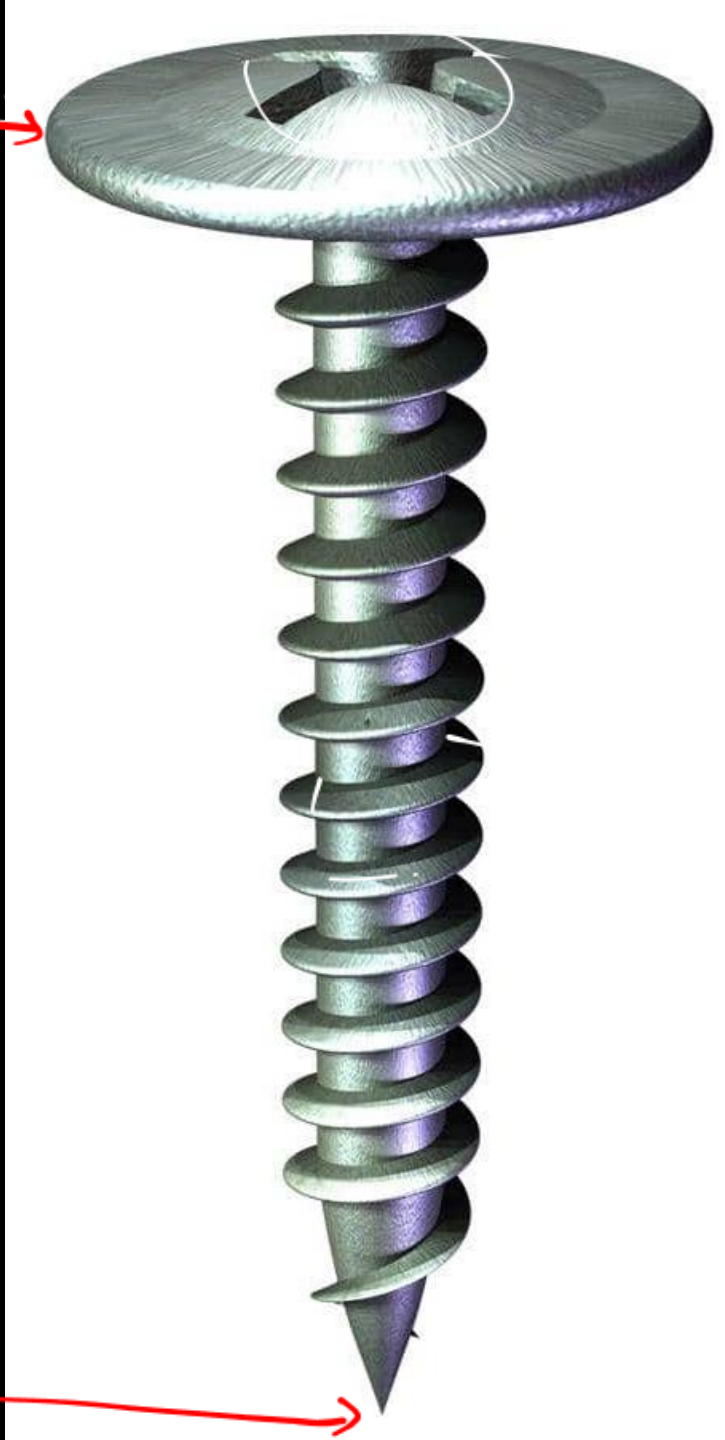
Screw

→ modified inclined plane.

→ Inclined plane is wraped on a straight rod.

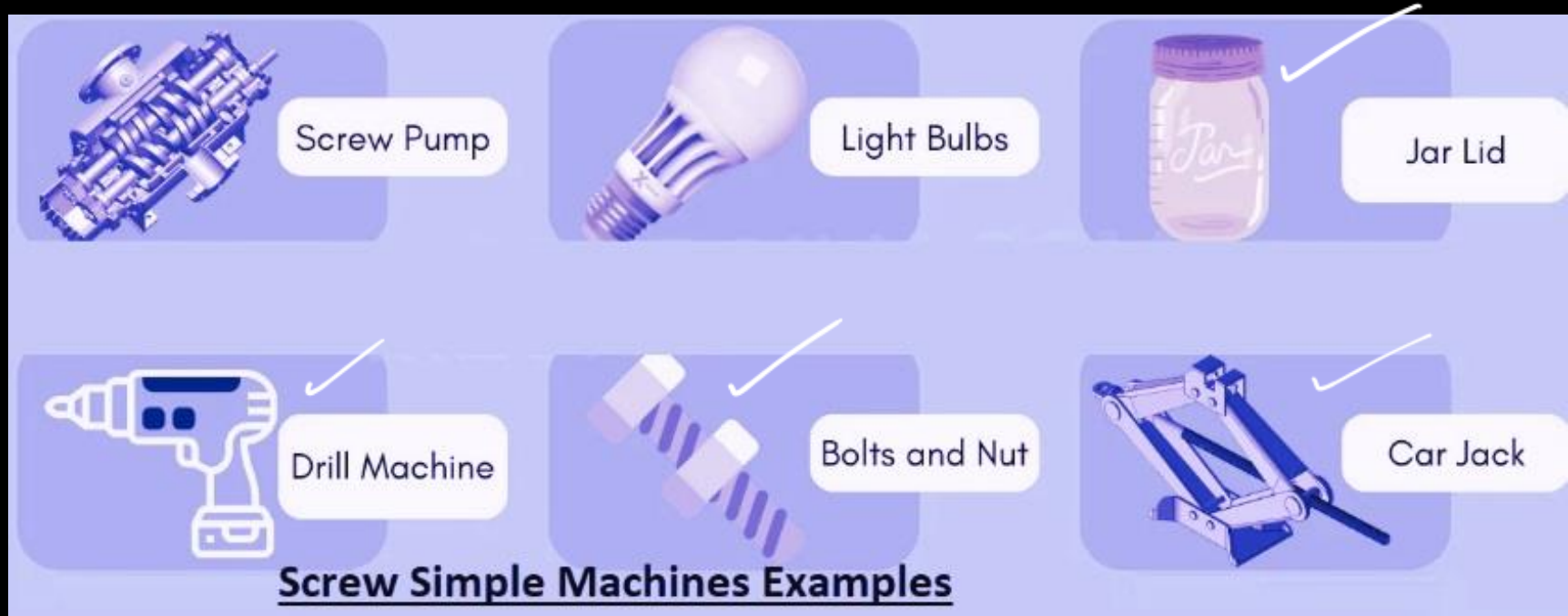
→ Head of a screw has a groove to fix screw driver. and its end is pointed/sharp.

→ It is used to hold things (woods) tightly together.
(Better than nails)



Examples

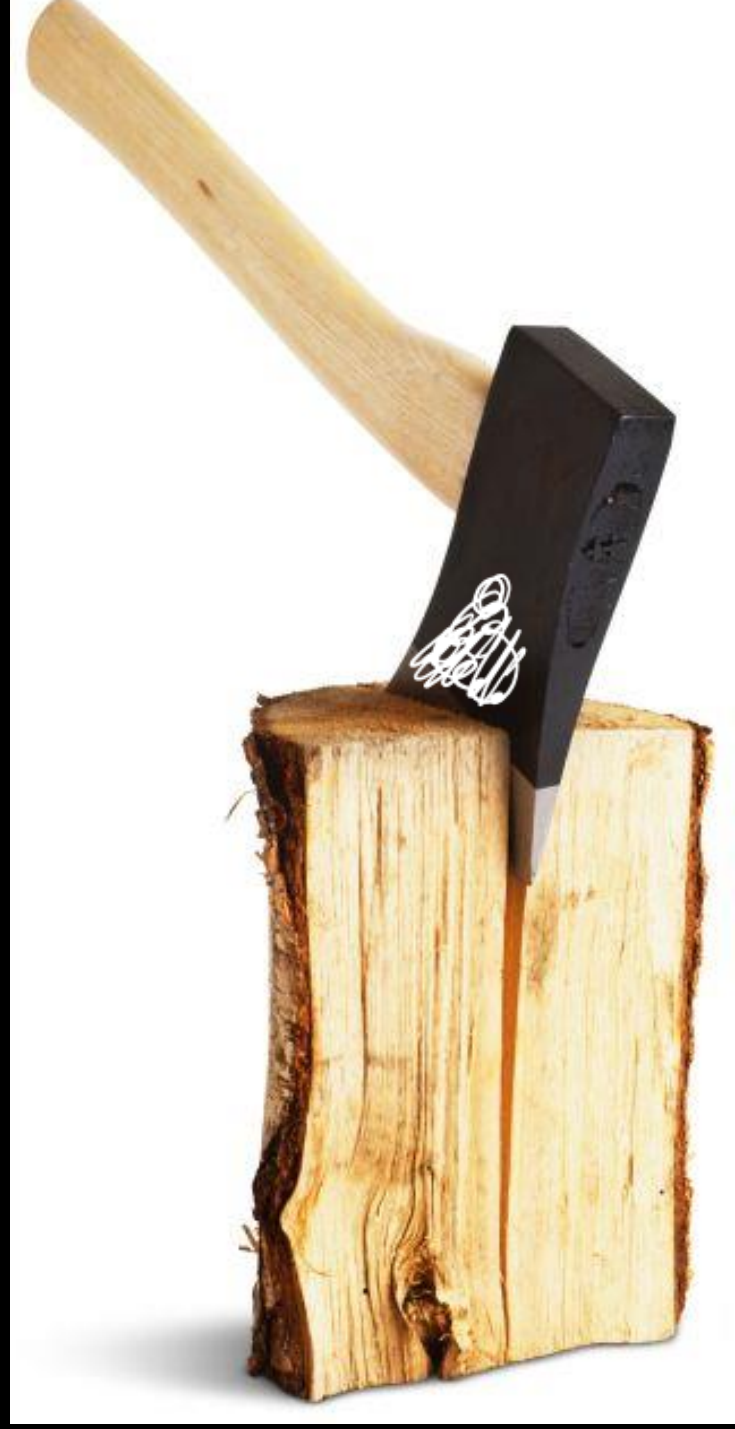
- Jar lids
- Car jack (Screw jack)
- Nut and Bolts
- Drill machine (Drill bits)



Wedge

- It is an object with two inclined planes that ends in a sharp edge.
  - → Sharp edge is used to cut through materials.

examples: axe, knife, blade



a knife

an axe

a wedge

EXAMPLES OF WEDGE

End of the chapter