CH # 09 MACHINES

MACHINES:

"A machine is a device which converts a given form of energy into useful work in a convenient manner."

EFFORT:

"Effort is the force directly applied on the machine for doing work.

- It is represented by P.
- Unit of effort is Newton.

LOAD:

"It is the weight lifted or the resistance overcomes by machine."

- It is represented by W.
- Unit of effort is Newton.

MECHANICAL ADVANTAGE:

"Mechanical advantage of the machine is the ratio of load and effort applied on it."

$$\text{Mechanical advantage} = \frac{\text{Load}}{\text{Effort}}$$

$$\boxed{\text{M.A} = \frac{\text{W}}{\text{P}}}$$

- Mechanical advantage is the ratio of two similar quantities therefore it has no unit.
- A machine who's M.A greater than "1" can lift heavier load by the application of smaller effort.

INPUT:

"Input is the work done "on" the machine by the effort."

Input = Effort x Distance

Input = P x d

- Where "d" is the distance through which effort is applied.
- The unit of input is Joule.

OUTPUT:

"The useful work done "by" the machine is called output."

Output = Load x Distance

Output = W x h

- Where "W" is the distance through which load moves.
- The unit of input is Joule.

EFFICIENCY:

"The ratio between the useful works done by the machine to the work done on the machine is called efficiency."

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} \text{ x } 100\%$$

$$\text{Efficiency} = \frac{\text{W x h}}{\text{P x d}} \text{ x } 100\%$$

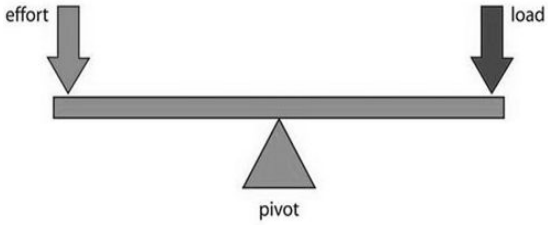
- Efficiency is the ratio of two similar quantities therefore it has no unit.
- It is expressed in percentage.

TYPES OF SIMPLE MACHINE:

i) Lever.
ii) Wheel and axel.
iii) Pulley.
iv) Inclined plane.
v) Wedge
vi) Screw Jack.

i) LEVER:

"It is simplest machine. It consists of rigid rod which can be rotated freely about a fixed point. Load can be lifted at one end of the lever by applying suitable effort at the end."



PARTS OF LEVER:

- **Fulcrum/pivot:**
  "It's a fixed point about which lever can be rotated."

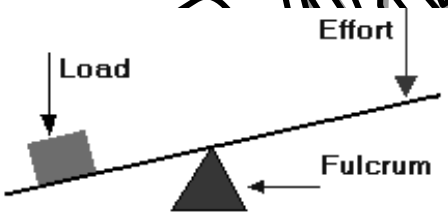
- **Weight arm/effort:**
  "It is the perpendicular distance between the weight and the fulcrum."

- **Effort arm/load:**
  "It is the perpendicular distance between effort and fulcrum."

KINDS OF LEVER

Lever of first kind:

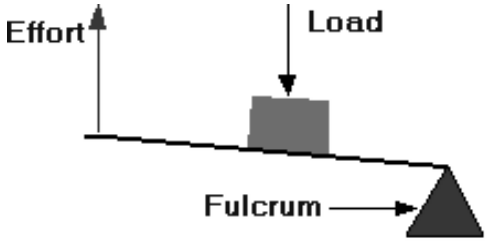
"In this kind of lever fulcrum is located between the effortand load."



Example:
Common balance, a pair of scissors, sea saw, handle of a pump etc.

Lever of second kind:

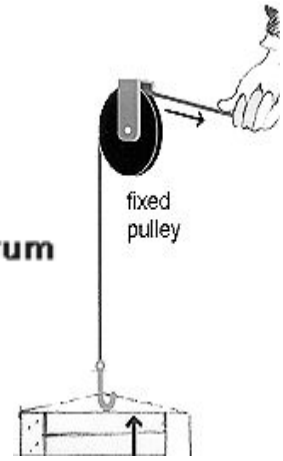
"In this kind of lever weight is located between the fulcrum and effort."



Examples:
Loader, Nut cracker, the door, bottle opener, punching machine etc.

Lever of third kind:

"In this kind of lever the effort is between fulcrum and weight."



Example:
Fire tong, human force arm, upper and lower jaws in the mouth.

PRINCIPLE OF LEVER:

"Torque of the effort is equal to the torque of the weight."

Torque of effort=torque of weight

But,

Torque of effort=Effort x effort arm

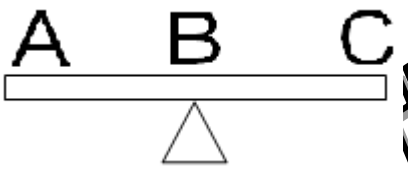
Torque of weight=Weight x weight arm

Hence,

Effort x effort arm = weight x weight

MECHANICAL ADVANTAGE OF LEVER (M.A):

Let "AB" be the effort arm and "BC" be the weight arm of a lever then according to the principle of lever.



Weight x weight arm= Effort x effort arm

W x BC = P x AB

$$\frac{W}{P} = \frac{AB}{BC}$$

$$\frac{W}{P} = M.A$$

$$M.A \text{ of lever} = \frac{W}{P} = \frac{\text{Effort arm}}{\text{Weight arm}}$$

M.A of lever can be increased by increasing the effort arm as compared to weight arm.

ii) PULLEY:

"A grooved wheel mounted on an axle is called pulley"

The axle is fixed to the frame which is known as Block A rope is passing through the groove round the pulley is used to rotate pulley in a block about axle It help us to change the direction of the applied force.

TYPES OF PULLEY

Basically pulleys are of two types:

1. Fixed pulley.
2. Movable Pulley.

1. **FIXED PULLEY:**

"Fixed pulley is that whose block is fixed to a strong beam or ceiling the pulley does not move is called fixed pulley"

MECHANICAL ADVANTAGE OF FIXED PULLEY:

Assuming that the pulley to be frictionless and neglecting the weight of the rope we can write:

Weight x distance through which weight is lifted = Effort x distance through which effort is acts

$$\frac{W}{P} = \frac{\text{Effort x distance through which effort is acts}}{\text{distance through which weight is lifted}}$$

In a fixed pulley the distance through which weight is lifted is equal to the distance through which effort is applied, hence:

$$\frac{W}{P} = 1$$

2. **MOVEABLE PULLEY:**

"In this pulley, one end of the rope which is passing around the pulley is tied to a firm support and effort "P" is applied at its other end the load or weight "W" to be lifted, the hung from the hook of the block"

MECHANICAL ADVANTAGE OF MOVEABLE PULLEY:

The moveable pulley move upward from the two sides therefore

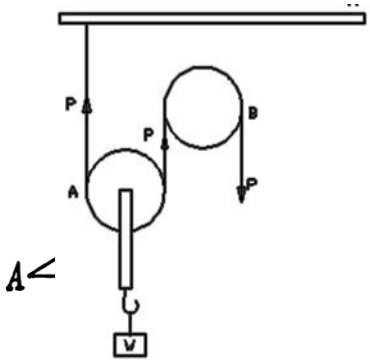
$$2P = W$$

$$\text{M. A of fixed pulley} = \frac{W}{P}$$

iii) INCLINED PLANE:

"Inclined plane is a plane surface which makes a certain angel "θ" with the horizontal."

- Inclined plane is a simple machine it help us to raises heavy load by applying a relatively much smaller force.



MECHANICAL ADVANTAGE OF INCLINED PLANE:

In order to raise load "W" the effort "P" must be applied parallel to the plane if effort is applied through a distance "l" due to which load is lifted through height "h" then for a frictionless inclined plane:

$$\text{Output} = \text{Input}$$

$$W \times h = P \times l$$

$$\frac{W}{P} = \frac{l}{h}$$

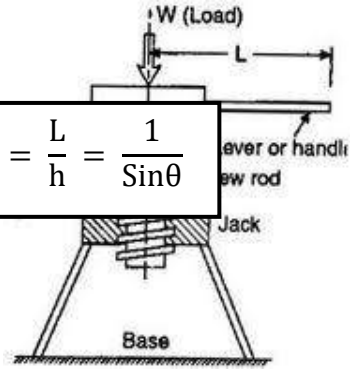
$$\text{M. A of inclined plane} = \frac{W}{P} = \frac{L}{h}$$

If the inclined plane makes a certain angle "θ" with the horizontal then:

$$\text{Sin}\,\theta = \frac{h}{L}$$

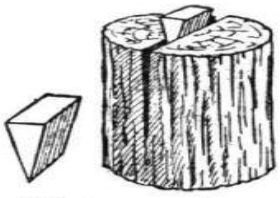
$$\frac{L}{h} = \frac{1}{\text{Sin}\theta}$$

$$\text{M. A of inclined plane} = \frac{W}{P} = \frac{L}{h} = \frac{1}{\text{Sin}\theta}$$



iv) WEDGE:

"Wedge is simple machine it is made up two inclined planes together. It is used to cut wood or use as a fulcrum in lever"



Wedge; wedge splitting a log.

MECHANICAL ADVANTAGE OF WEDGE:

$$\text{M. A of wedge} = \frac{\text{Lenght of the inclinde suface of a wedge}}{\text{Thickness of the wedge}}$$

*M.A of sharp wedge is high.

v) SCREW:

"Screw is a simple machine. It consist of a threaded rod with a head called screw head."

MECHANICAL ADVANTAGE OF SCREW:

To turn the screw effort "P" is applied at the screw head. Let "d" be the radius and effort acts along a distance of 2πd As a result screw covered distance "h". The screw overcomes an opposition "W" then:

Output = input

$W \times h = P \times 2\pi d$

$$\frac{W}{P} = \frac{2\pi d}{h}$$

$$\text{Mechanical advantage of screw} = \frac{W}{P} = \frac{2\pi d}{h}$$

vi) SCREW JACK:

"Screw jack is a simple machine used to raise the automobile. It consists of a longthreaded rod passing through a threaded block. A handle is also provided to turnthe thread block."

Mechanical advantage of screw jack:

If the length of the handle is "d", the effort "P" applied at the end of the handle acts along a circle of radius "d" and covers a distance of $2\pi d$ where as for each revolution the block lifts the load through a distance "h" then:

Output = Input

$W \times h = P \times 2\pi d$

$$\frac{W}{P} = \frac{2\pi d}{h}$$

Mechanical advantage of screw jack $= \frac{W}{P} = \frac{2\pi d}{h}$

vii) WHEEL AND AXLE:

"Wheel and axle is a simple machine. It consists of wheel of large radius "R" and the cylinder of smaller radius "r", the cylinder is called wheel and axel."

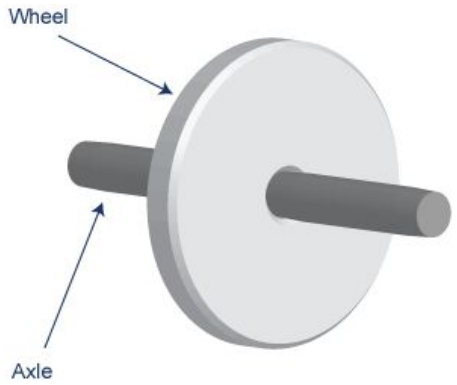
MECHANICAL ADVANTAGE OF WHEEL AND AXLE:

Effort "P" is applied on the rim of the wheel and load is lifted by a string wound round the axle. Hence for one rotation effort "P" acts along a distance $2\pi R$ and the load "W" raises through a distance $2\pi r$ then:

Output =Input

$$W \times 2\pi r = P \times 2\pi R$$

$$\frac{W}{P} = \frac{2\pi R}{2\pi r}$$



Mechanical advantage of wheel and axle $= \frac{W}{P} = \frac{R}{r}$