Al-Saudia Virtual Academy
Pakistan Online Tuition – Online Tutor Pakistan

Machines

Machines:
Definition: “A device which performs the work in convenient (useful) manner is called machine.” OR
“A device which applies the force in such a way that it performs greater work is called a machine.”
Example:

i. Lever
ii. Pulley
iii. Trolley

Effort:
Definition: “The force directly applied on the machine is called effort.” It is denoted by “P “.
Load:
Definition: “The weight lifted by machine is called load. “It is denoted by “W”.
Mechanical Advantage:
Definition: “The ratio of load to effort is called mechanical advantage.”
Mathematical form:

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

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

Unit: It has no unit because it is the ratio between similar quantities.
Input: “The work done on a machine is called input.” OR “The product of effort and the distance moved by effort is called input.”
Mathematical form: If effort “P “acts through a distance “d “, then

Input=P x d

Output:
Definition:
“The work done by a machine is called output.” OR “The product of load and the distance moved by load is called output.”
Mathematical form:
If load “W” is lifted through a height “h”, then,

Output=W x h

Efficiency:

Definition:

"The ratio of output to input is called efficiency." OR

"The ratio of work done by a machine to the work done by a machine is called efficiency."

Mathematical form: $Efficiency = \frac{Output}{Intput}$

It always calculated in percentage.

$$Efficiency = \frac{Output}{Intput} x\ 100\%$$

Or

$$Efficiency\ = \frac{work\ done\ by\ a\ machine\ x\ 100}{Work\ done\ on\ a\ machine}$$

A machine is said to be ideal if output is equal to input. For this machine the efficiency is 100%. Hence for ideal machine.

$$Output\ =\ Input$$
$$W\ x\ h\ =\ P\ x\ d$$
$$\frac{W}{P} = \frac{d}{h}$$

Hence the mechanical advantage of 100% efficient machine is given by the above relation.

Lever:

Definition:

A simplest kind of machine which consists of rigid capable of rotating about a fixed point (fulcrum) is called lever. The turning point about which lever rotates is called Fulcrum. The perpendicular distance between load "w" and fulcrum is called weight arm or load arm. The perpendicular distance between effort "p" and the fulcrum is called effort arm.

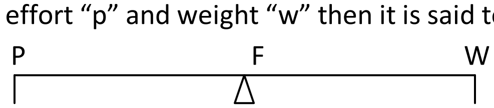
Kinds of Lever:

There are three kinds of lever.

1. Lever of first kind.
2. Lever of second kind.
3. Lever of third kind.

Lever Of first kind:

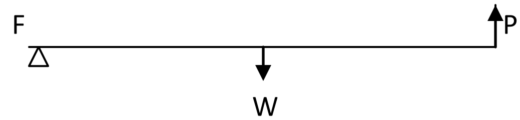
If fulcrum "F" lies is in between effort "p" and weight "w" then it is said to be lever of first kind.



Example: Balance, handle of a pump, a pair of scissors, see-saw.

Lever Of second kind:

If load "W" is in between fulcrum " f " and effort "p " then it is called lever of second kind.

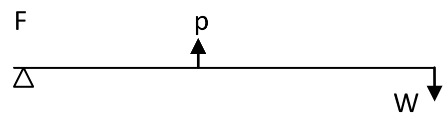


Example:

Door, the nut cracker, punching machine etc.

Lever Of third kind:

If effort "E" is in between fulcrum " f " and load " w " then it is called lever of third kind.



Example:

Human air, upper and lower jaws in the mouth, a pair of forceps etc.

Principle of Lever:

In all kinds of lever.

$$Torque\ of\ effort\ =\ Torque\ of\ load$$
$$Effort\ x\ Effort\ arm\ =\ Load\ x\ Load\ arm$$

Mechanical Advantage of Lever

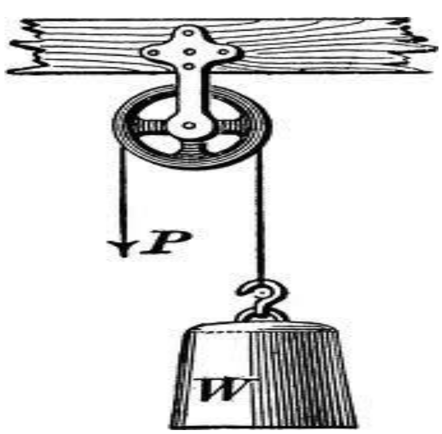
$$\boldsymbol{p\ x\ d\ =\ w\ x\ h}$$
$$\frac{W}{P} = \frac{d}{h}$$

Pulley:

A pulley is grooved wheel supported in a frame called block such that wheel can turn about an axle in the block. The pulley can be suspended from a fixed beam by means of a hook. A rope can pass over the pulley. The pulley can be used in two ways.

1. Fixed Pulley:

The block of the pulley is fixed to the ceiling as shown in fig.



Load “w” is tied to one end of the rope and effort “p “is applied at the other end.
If we neglect the weight of the rope and friction then

$$W \, x \, OB \; = \; P \, x \, OA$$

As OB and OA are equal, therefore they cancel out hence,

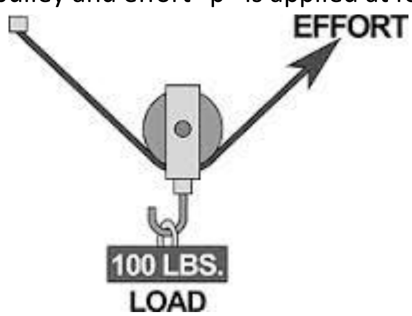
$$W \; = \; P$$

$$\frac{W}{P} = M.A. = 1$$

The effort applied “P” is equal to the weight “w “. This pulley is used only to change the direction of force.

2. Moveable Pulley:

In this case the block of moveable pulley and effort “p “is applied at force and of the rope shown in fig.



Two segments of the rope are lifting “w”; the tension in each segment is “p” hence,

$$W \; = \; 2\,p$$

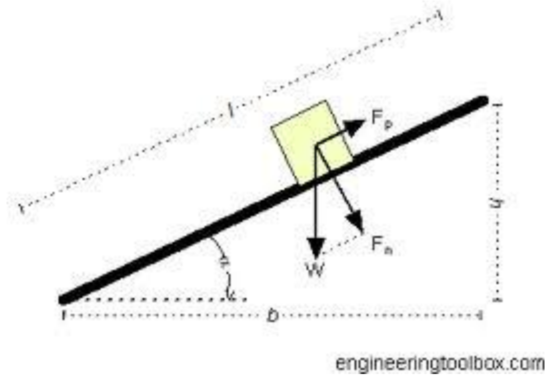
Now

$$M.A. = \frac{W}{P} = \frac{2P}{P} = 2$$

Inclined Plane:

Definition:

A surface which makes certain angle “0” (0” < 0 < 90o) with the horizontal surface is called Inclined plane. It is used in raising heavy loads. The load “w” is lifted through a height “h“ by applying through a distance “I “along the plane as shown in fig.



$$\boldsymbol{Output = Input}$$
$$\boldsymbol{W \; x \; h = p \; x \; I}$$
$$\frac{W}{P} = \frac{I}{h}$$

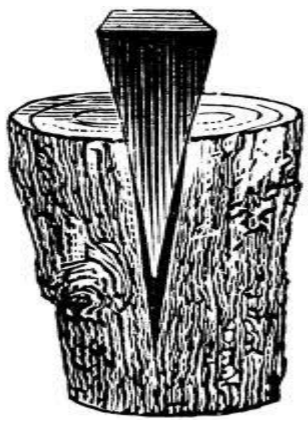
But $M.A. = W/P$

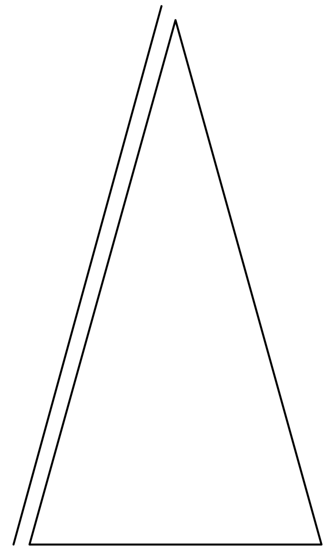
$$M.A. = \frac{l}{h} = \frac{Length\ of\ Inclined\ Plane}{Height\ of\ Inclined\ Plane}$$

From fig

$$\sin\theta = \frac{Perp}{Hyp} = \frac{h}{l}$$
$$\frac{1}{\sin\theta} = \frac{l}{h}$$

Wedge:
Definition:” It consists of two inclined planes put together as shown in fig, it is used to split wood Into pieces.





Mechanical advantage:

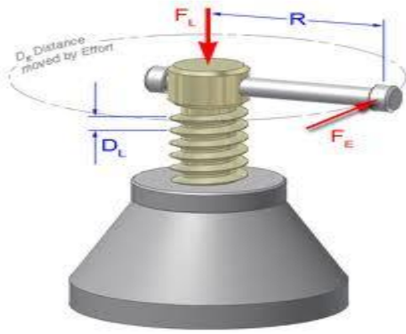
$$M.A. = \frac{Length\ of\ inclined\ surface\ of\ the\ wedge}{Thickness\ of\ the\ Wedge}$$

Screw: Definition: “It consists of threaded rod with head, called the screw head. The distance between two adjacent threads is called its pitch. When a screw is turned one revolution by an effort “P” applied at the screw head, the screw moves forward into the wood through a distance Equal to its pitch. If ‘d ‘be the radius of screw head then the effort “P“ move through a distance $2\pi d$.
If there is no loss of energy due to friction then

$$Output = Input$$
$$W\ x\ h = P\ x\ 2\pi d$$
$$\frac{W}{P} = \frac{2\pi d}{h} = M.A.$$

Screw Jack:

It is a simple machine used to lift a car or other automobiles. The car or automobile of weight "w" is placed on the plate form provided for this purpose. The pitch of the screw is "h". The effort "p" is applied at the handle H. when effort moves a distance 2nd (one rotation) where "d" is the length of the rod, the load "w" is lifted through a height "h".



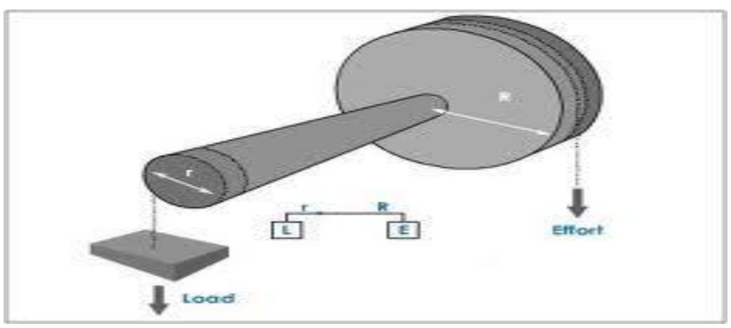
$$Output = Input$$

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

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

Wheel and Axle:

A wheel with larger radius (R) and another with smaller radius (r) are fixed on the same shaft and are called wheel and axle respectively. It is often used to lift bucket of water from the well. The shaft in clamp so that it can rotate freely. The effort "P" is applied at the rim of wheel of radius R while the load W is lifted by a string wound around the axle.



For one complete rotation, the effort moves through a distance $2\pi R$ raised through a distance$2\pi r$. If friction is neglected, then

$$Output = Input$$

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

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

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