Mechanical Advantage of Simple Machine - Technical Notes for RRB ALP CBT II 2018(Part III)

Railways RRB ALP Computer Based Test for Stage II will be conducted on 12th December to 14th December 2018. If you are preparing for the upcoming ALP CBT-II, then it is necessary that you are familiar with the **ALP CBT** II Mechanical Advantage of Simple Machine. Read this article to gear up your preparation. If you haven't yet gone through RRB ALP CBT II Basic Sciences & Engineering Notes on Simple Machines Part I and Part II, then click on the links below:

Basic Sciences & Engineering Notes on Simple Machines - Part I

Basic Sciences & Engineering Notes on Simple Machines - Part II

Mechanical Advantage of Simple Machine - Introduction

In a simple machine when the effort (P) balances a load (W) the ratio of the load to the effort is called the mechanical advantage of the machine.

$$MA = \frac{Load}{Effort} = \frac{W}{P}$$

Velocity ratio

It is the ratio between the distances moved by the effort to the distance moved by the load.

$$Velocity\ ratio = \frac{Distance\ moved\ by\ the\ effort\ (d_p)}{Distance\ moved\ by\ the\ load\ (d_w)}$$

Efficiency of machine

The ratio of output to the input of the machine is known as efficiency.

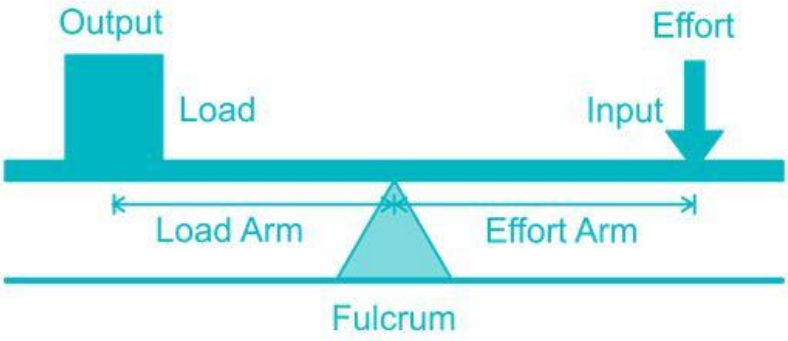
In simple machines, the ratio of mechanical advantage to the velocity ratio is also known as the efficiency of a machine.

$$Efficiency = \frac{Output}{Input} = \frac{MA}{VR}$$

The efficiency of a Simple Machine is always less than 100%.

The efficiency of an Ideal Machine is equal to 100% (MA = VR).

1. Mechanical Advantage of Simple Machine - Lever:

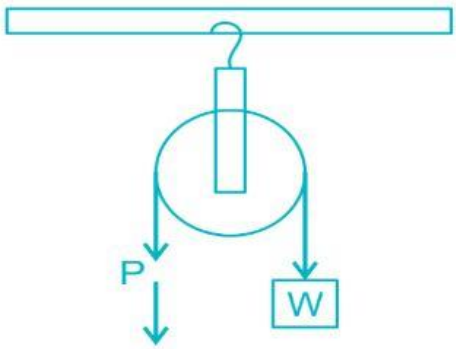


The principle of Lever:

Load × Load arm = Effort × Effort Arm

$$MA = \frac{Load}{Effort} = \frac{W}{P} = \frac{Effort\ Arm}{Load\ Arm}$$

2. Mechanical Advantage of Simple Machine - Ideal Pulley

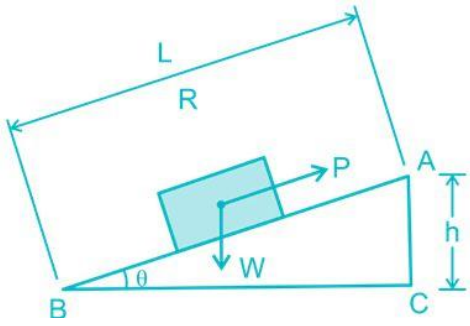


Weight x distance through which weight is lifted = Effort x distance through which effort is acts

$$IMA = \frac{Load}{Effort} = \frac{W}{P} = \frac{Distance\ through\ which\ effort\ is\ acts}{Distance\ through\ which\ weight\ is\ lifted}$$

In a fixed pulley, the distance through which weight is lifted is equal to the distance through which effort is applied. So MA = 1.

3. Mechanical Advantage of Simple Machine - Incline Plane



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

For ideal Machine:

$$IMA = \frac{W}{P} = \frac{L}{h} = \frac{1}{\sin\theta}$$

Example 1: The ideal mechanical advantage for an inclined plane is equal to the length of the incline divided by the _____ .

1) mass of the incline

2) slope of the incline

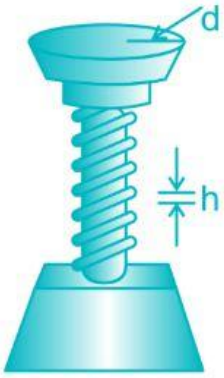
3) height of the incline

4) angle of the incline

Ans: 3

4. Mechanical Advantage of Simple Machine - Wedge

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:

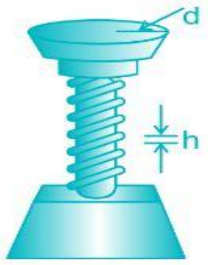


Output = input ⇒ W x h = P x 2πd

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

5. Mechanical Advantage of Simple Machine - 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 x h = P x 2πd

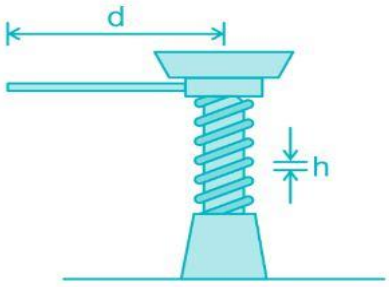
$$IMA = \frac{Load}{Effort} = \frac{W}{P} = \frac{2\pi d}{h}$$

Screw Jack:

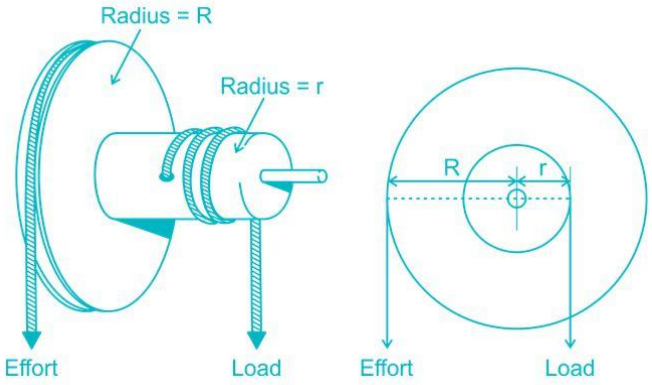
If the length of the handle is "d", the effort "P" applied at the end of the handle acts along a circle of radius "d" and covers a distance of 2πd. For each revolution, the block lifts the load through a distance "h" then:

Output = input ⇒ W x h = P x 2πd

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



6. Mechanical Advantage of Simple Machine - Wheel and Axle



Effort "P" is applied on the rim of the wheel and load is lifted by a string wound around the axle. Hence for one rotation effort, "P" acts along a distance 2πR and the load "W" raises through a distance 2πr then:

Output = input ⇒ W x 2πr = P x 2πR

$$IMA = \frac{Load}{Effort} = \frac{W}{P} = \frac{R}{r}$$

Example 2: The ideal mechanical advantage of a wheel and axle is equal to the_____.

1) radius of the wheel divided by the radius of the axle

2) radius of the axle divided by the radius of the wheel

3) radius of the wheel divided by the length of the axle

4) length of the axle divided by the radius of the wheel

Ans: 1

Note:

Work is defined as the product of force and displacement.

W = F × Δs

Machines are devices by means of which an effort applied over some displacement at one location moves the load at a different location.

The work done on the machine at the effort end is called the **work in** and the work done by the machine at the load end is called the **workout.**

Work done on the machine: $W_{in} = F_{eff} \times \Delta s_{eff}$

Work done by the machine: $W_{out} = F_{load} \times \Delta s_{load}$

For ideal machine:

$$W_{in} = W_{out} \Rightarrow F_{eff} \times \Delta s_{eff} = F_{load} \times \Delta s_{load}$$

For Real machine:

$$W_{in} > W_{out} \Rightarrow F_{eff} \times \Delta s_{eff} > F_{load} \times \Delta s_{load}$$

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