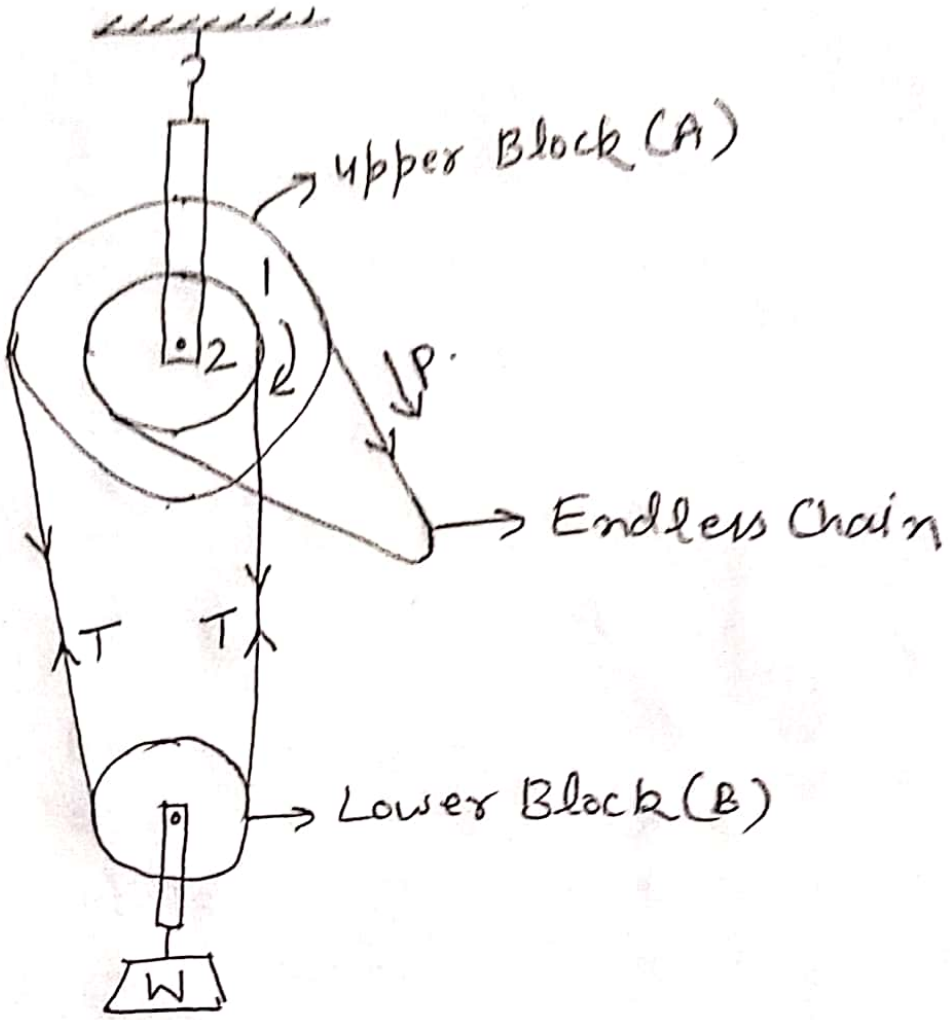
Weston Differential Pulley Block



It consists of two blocks A & B as shown in figure. Upper block is fixed and lower block is moveable.

* Upper block has two pulleys 1 and 2 of different diameter fixed to common axle. These pulleys are cast together to form one pulley with two grooves.
* The lower block consists of a single pulley. The load (W) to be lifted is attached to this pulley.

... to raise a load of 1600 N.

⇒ An endless chain or rope passes round the pulley 1, then round the pulley of lower block and finally round the pulley 2.

* The remaining chain hangs slack and joined to first portion of the chain passing over pulley 1.

⇒ The effort P is applied to the chain passing over pulley 1.

Let D = diameter of larger pulley 1.
d = diameter of smaller pulley 2.
W = Load to be lifted
P = Effort applied to lift the load.

In one revolution of upper pulley block by application of effort P, :-

Length of chain pulled over larger Pulley = πD. → Equal to distance moved by effort.

∴ Distance moved by effort = πD ✓

∵ Pulley 2 also turns with pulley 1.

So length of chain released by smaller pulley 2 = πd. ✓

So Net shortening of chain $= \pi D - \pi d$

$= \pi (D-d)$ ✓

* This shortening of chain will be equally divided between two portions of the chain supported the load,

∴ Distance moved by load $= \frac{\pi (D-d)}{2}$ ✓

$V.R = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}}$

$= \frac{\pi D}{\pi (D-d)} = \boxed{\frac{2D}{D-d}}$ ✓

$\boxed{M.A. = \frac{W}{P}}$ Efficiency $\boxed{\eta = \frac{MA}{VR}}$

Note:- If N_1 and N_2 are the number of recesses (teeth) in larger and smaller pulley of upper block; then

$$\boxed{V.R = \frac{2N_1}{N_1 - N_2}}$$

Problem: In a Weston differential pulley block, upper block has two pulleys, one with radius 16 cm and other 14.5 cm. If efficiency is 45%. Find the effort to raise a load of 1600 N.

Soln:- Given, $R = 16\ cm$, $r = 14.5\ cm$

$\eta = 45\% = 0.45$, $W = 1600\ N$.

Let P = Effort required ✓

$$V.R = \frac{2D}{D-d} = \frac{2R}{R-r} = \frac{2\times16}{16-14.5} = \boxed{21.33}$$ ✓

$$\eta = \frac{MA}{V.R.} \quad \text{or} \quad MA = \eta \times V.R.$$

$$= 0.45 \times 21.33 = (9.6)$$ ✓

Now, $MA = \frac{W}{P}$ or $P = \frac{W}{MA}$

or $P = \frac{1600}{9.6} = \boxed{166.66\ N}$ ✓.

Prob-2:- In a differential pulley block, the ratio of number of recesses in smaller pulley to larger pulley is 9:10. If efficiency is 70%, Find ~~effort~~ required to lift 3000 N load

Soln:- Given :- $N_2 : N_1 = 9:10$, $\eta = 70\%$, $W = 3000\ N$

$N_2 : N_1 = 9:10$ or $\frac{N_2}{N_1} = \frac{9}{10}$ or $\boxed{N_2 = \frac{9}{10} N_1}$

$$V.R. = \frac{2N_1}{N_1 - N_2} = \frac{2N_1}{N_1 - 0.9N_1} = \frac{2N_1}{0.1N_1} = \boxed{20}$$ ✓

Efficiency, $\eta = \frac{MA}{VR}$ or $MA = \eta \times VR$

$\therefore MA = 0.7 \times 20 = (14)$ ✓

But $MA = \frac{W}{P}$ or $P = \frac{W}{MA} = \frac{3000}{14}$

$\boxed{P = 214.28\ N}$ ✓