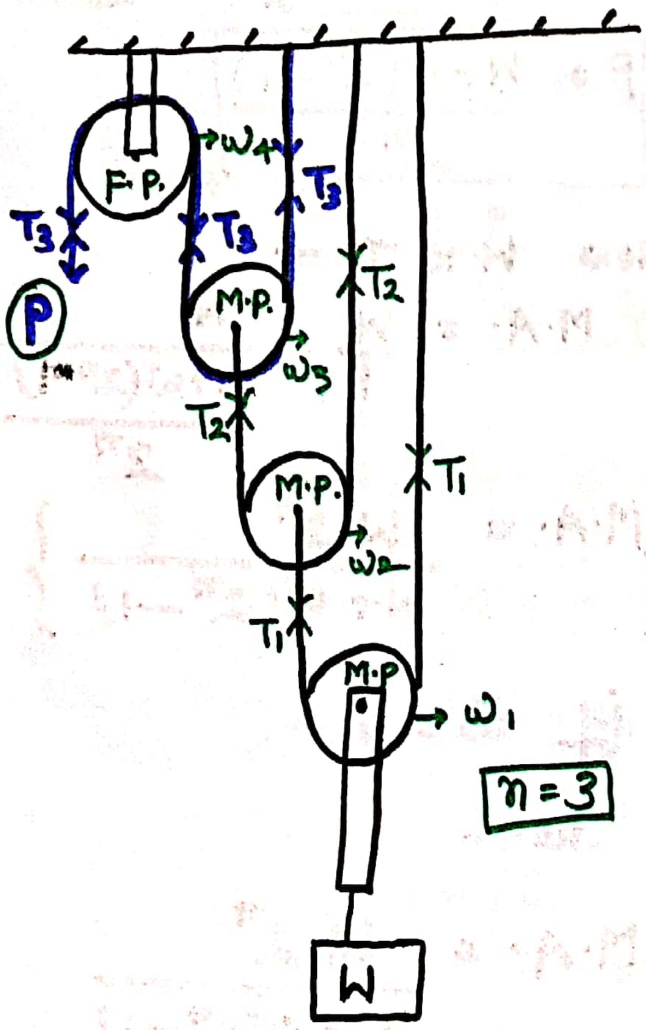
System of pulley :- 1- First System of pulleys :-

→ No. of string = No. of Moving pulleys

Single fixed pulley and 2 or more than 2 Moving pulleys.



$\boxed{n=3}$

Case - (I) Weight of the pulleys $(\omega) = 0$

At equilibrium -

$2T_1 = W$

$$\boxed{T_1 = \frac{W}{2}}$$

→ $2T_2 = T_1 = \frac{W}{2}$

$$\left\{T_2 = \frac{W}{2\times 2} = \frac{W}{2^2}\right\}$$

Similarly -

$2T_3 = T_2 = \frac{W}{2^2}$

$$\boxed{T_3 = \frac{W}{2^3}}$$

⋮

$$\boxed{T_n = \frac{W}{2^n}}$$

where : n = No. of Moving pulleys.

→ And also $T_3 = P$

$\therefore$ $T_n = P \Rightarrow P = \frac{W}{2^n}$

$M.A. = \left(\frac{W}{P}\right) = \frac{W}{\frac{W}{2^n}}$

$$\boxed{M.A. = 2^n}$$

→ If $n = 3$

the $M.A. = 2^3 = 8$

that means only 1 N Effort is required to lift 8 N load in First System of pulleys.

Case - (II) :- when weight of the pulleys are $\omega_1, \omega_2, \omega_3 \cdots - \omega_n$ then at equilibrium-

$$2T_1 = W + \omega_1$$

$$\left\{ T_1 = \frac{W+\omega_1}{2} = \frac{W}{2} + \frac{\omega_1}{2} \right\}$$

$\rightarrow$ $2T_2 = (T_1) + \omega_2$

$$2T_2 = \left(\frac{W}{2} + \frac{\omega_1}{2}\right) + \omega_2$$

$$\left[T_2 = \frac{W}{2^2} + \frac{\omega_1}{2^2} + \frac{\omega_2}{2} \right]$$

$\rightarrow$ $2T_3 = T_2 + \omega_3$

$$2T_3 = \left(\frac{W}{2^2} + \frac{\omega_1}{2^2} + \frac{\omega_2}{2}\right) + \omega_3$$

$$\left[T_3 = \frac{W}{2^3} + \frac{\omega_1}{2^3} + \frac{\omega_2}{2^2} + \frac{\omega_3}{2} \right]$$

But $\boxed{P = T_3}$ $\boxed{n=3}$

$$\left\{ P = T_n = \frac{W}{2^n} + \frac{\omega_1}{2^n} + \frac{\omega_2}{2^{n-1}} + \frac{\omega_3}{2^{n-2}} + \cdots \frac{\omega_n}{2^{n-n}} \right.$$

X by 2^n on both the sides-

$$\left[2^n \cdot P = W + \omega_1 + 2\omega_2 + 2^2 \cdot \omega_3 + \cdots + 2^{n-1}\omega_n \right]$$

if $\omega_1 = \omega_2 = \omega_3 = \omega_n = \omega$

$$\left[2^n \cdot P = W + \omega + 2\omega + 2^2\omega + \cdots 2^{n-1}\omega \right]$$

$$2^n \cdot P = W + \omega \left[1 + 2 + 2^2 + 2^3 + \cdots 2^{n-1} \right]$$

$$2^n \cdot P = W + \omega \left[2^n - 1 \right]$$

$$\boxed{P = \frac{W + \omega(2^n - 1)}{2^n}}$$

Now W.K.T. —

① $M.A. = \dfrac{W}{P} = \dfrac{W}{\frac{W+\omega(2^n-1)}{2^n}}$

$$\left\{ M.A. = \frac{W \cdot 2^n}{W + \omega(2^n - 1)} \right\}$$

if $\omega = 0$

then-

$$M.A. = \frac{W \cdot 2^n}{W + 0(2^n - 1)}$$

$$= \frac{\cancel{W} \cdot 2^n}{\cancel{W}}$$

$$\left[M.A. = 2^n \right]$$

as case (I)

$$\frac{2^n}{2^{n-1}} = 2^n \times 2^{-1}$$

Question :- In a system of pulleys, there are 5 moving pulleys and every pulleys is having individual string. Find the relation b/w effort (P) and load (W). Weight of every pulley is $\omega = P$

Solve:- Given data -

$W, \; P, \; \boxed{n = 5}$

$w = P$

first system of pulleys.

$$2^n \cdot P = W + \omega(2^n - 1)$$

$$2^5 \times P = W + P(2^5 - 1)$$

$$32 \times P = W + 31P$$

$$32P - 31P = W$$

$$\boxed{P = W}$$

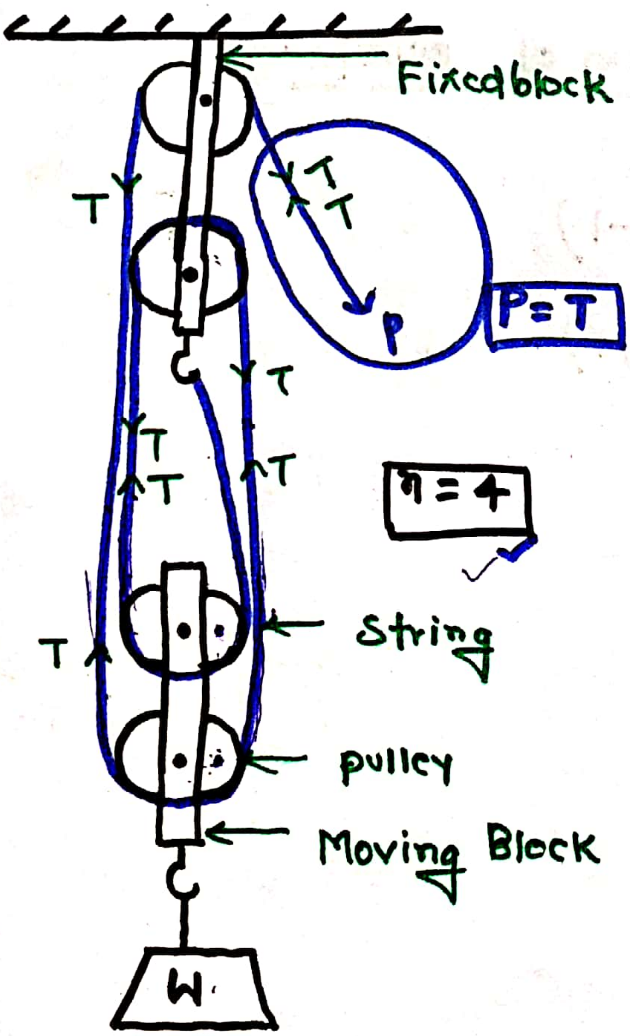
2- Second System of Pulleys :- (String → Rope)

There are 2- block. Single string is passed over all pulleys.

→ upper block is fixed

→ Lower block, which is having load is movable.

→ upper block is having either same No. of pulleys (or) more than one with lower block.



2- Moving Pulleys.

2- Fixed pulleys.

Total No. of pulleys $\boxed{(n) = 4}$

⇒ At equilibrium Condition-

Total tension = Total weight

$[4T = W] \Rightarrow 4P = W$ $\left(P = \frac{W}{4}\right)$

$\therefore M.A. = \frac{W}{P} = \frac{W}{\frac{W}{4}}$

$[M.A. = 4 = n]$

⇒ if weight of the Lower block pulleys is ω -

$W + \omega = 4T = nT$

÷ by P on both sides

$\frac{W+\omega}{P} = \frac{nT}{P}$

$\frac{W}{P} + \left(\frac{\omega}{P}\right) = \frac{n\cancel{T}}{\cancel{P}}$ ∵ T = P

$\left(\frac{W}{P}\right) = n - \left(\frac{\omega}{P}\right)$

$\left[M.A. = n - \left(\frac{\omega}{P}\right)\right]$

* $[V.R. = n]$

Note:- (i)

(ii) —