4) Equilibrium

* Condition of Static Equilibrium.

1) For Coplaner Force System
(2D-Force system)

*** Concurrent force system.**

$$\boxed{\Sigma F_x = 0 \;,\; \Sigma F_y = 0}$$

*** Non-concurrent force system**

$$\boxed{\Sigma F_x = 0 \;,\; \Sigma F_y = 0 \;,\; \Sigma M = 0}$$

General condition of Equilibrium

2) For Non-Coplaner Force system.
(3D - Force system)

*** Concurrent force system**

$$\boxed{\Sigma F_x = 0 \;,\; \Sigma F_y = 0 \;,\; \Sigma F_z = 0}$$

*** Non-Concurrent force system**

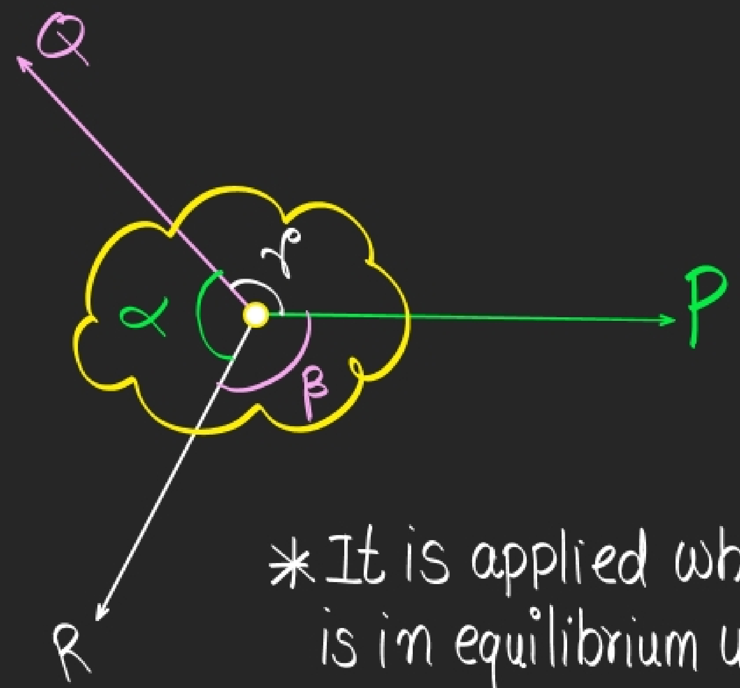
$$\boxed{\begin{array}{ll} \Sigma F_x = 0 & \Sigma M_{xx} = 0 \\ \Sigma F_y = 0 & \Sigma M_{yy} = 0 \\ \Sigma F_z = 0 & \Sigma M_{zz} = 0 \end{array}}$$

* Lami's theorem.

* If three forces acting at a point are in equilibrium, then each force is Proportional to the 'sin' of angle between remaining two forces.

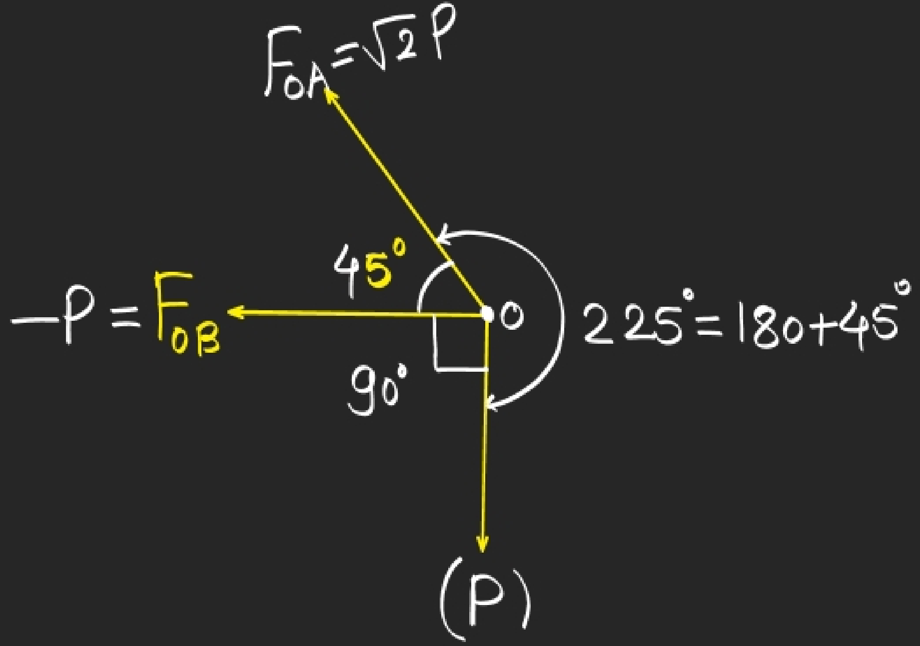
$$P \propto \sin(\alpha)$$
$$Q \propto \sin(\beta)$$
$$R \propto \sin(\gamma)$$

$$\boxed{\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}}$$



* It is applied when body is in equilibrium under the action of three concurrent Coplaner forces.

* Forces should be away from body.



$$\frac{P}{\sin(45°)} = \frac{F_{OB}}{\sin(225°)} = \frac{F_{OA}}{\sin(90°)}$$

$$\frac{P}{\left(\frac{1}{\sqrt{2}}\right)} = \frac{F_{OB}}{\sin(180+45°)}$$

$$\sqrt{2}P = \frac{F_{OB}}{-\sin 45°}$$

$$\sqrt{2}P = \frac{F_{OB}}{-\left(\frac{1}{\sqrt{2}}\right)}$$

$$(\cancel{\sqrt{2}}P) = -\cancel{\sqrt{2}}F_{OB}$$

$$\boxed{F_{OB} = -P}$$

$$\frac{P}{\left(\frac{1}{\sqrt{2}}\right)} = \frac{F_{OA}}{1}$$

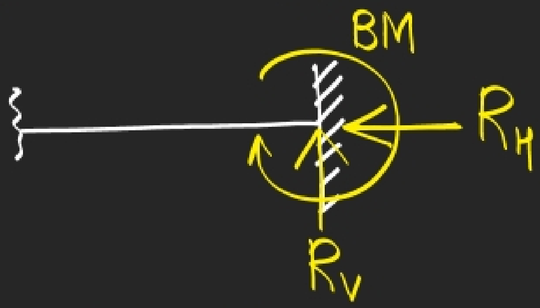
$$\boxed{\sqrt{2}P = F_{OA}}$$

* Supports

* It provides reactions.
* It provides resistance to the motion.

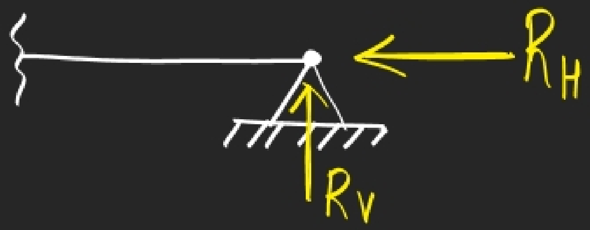
* Types of supports

1) Fixed Support



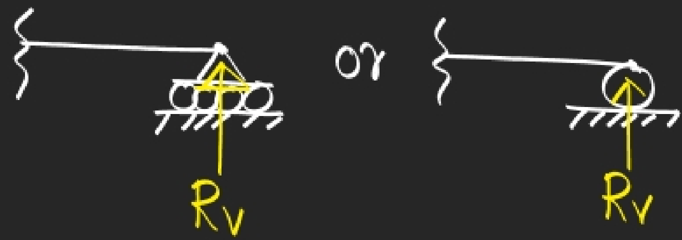
$\boxed{R=3}$

2) Hinge Support (or) Pinned support



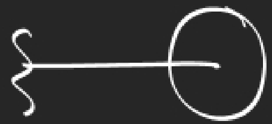
$\boxed{R=2}$

3) Roller Support



$\boxed{R=1}$

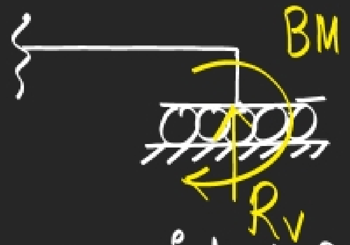
4) Free End (or) Free Support.



$\boxed{R=0}$

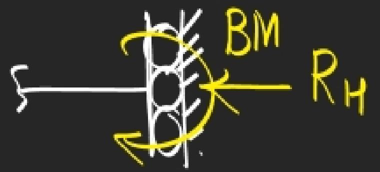
5) Guider Roller supports

A) Horizontal guided roller



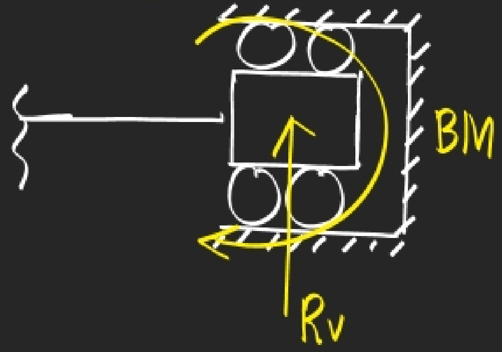
$\boxed{R=2}$

B) vertical guided roller



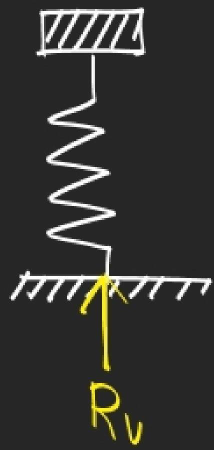
$\boxed{R=2}$

6) Damper supports



$\boxed{R=2}$

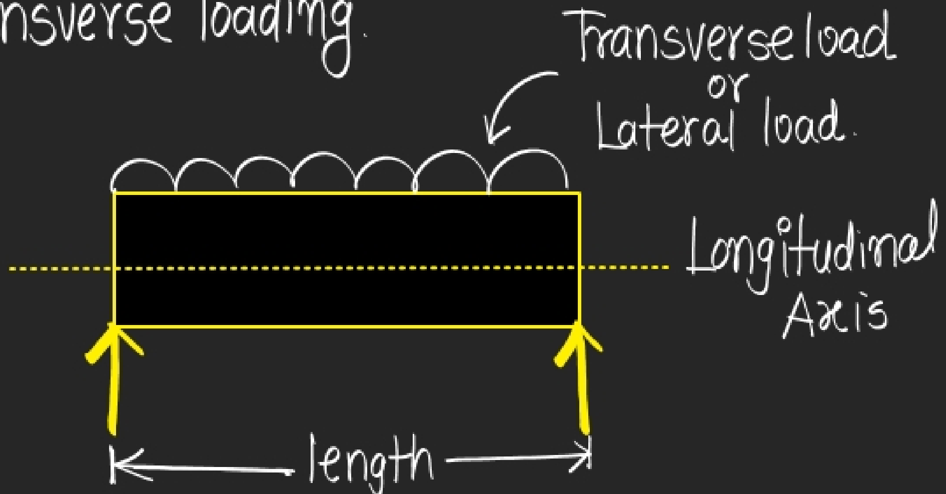
7) Spring support

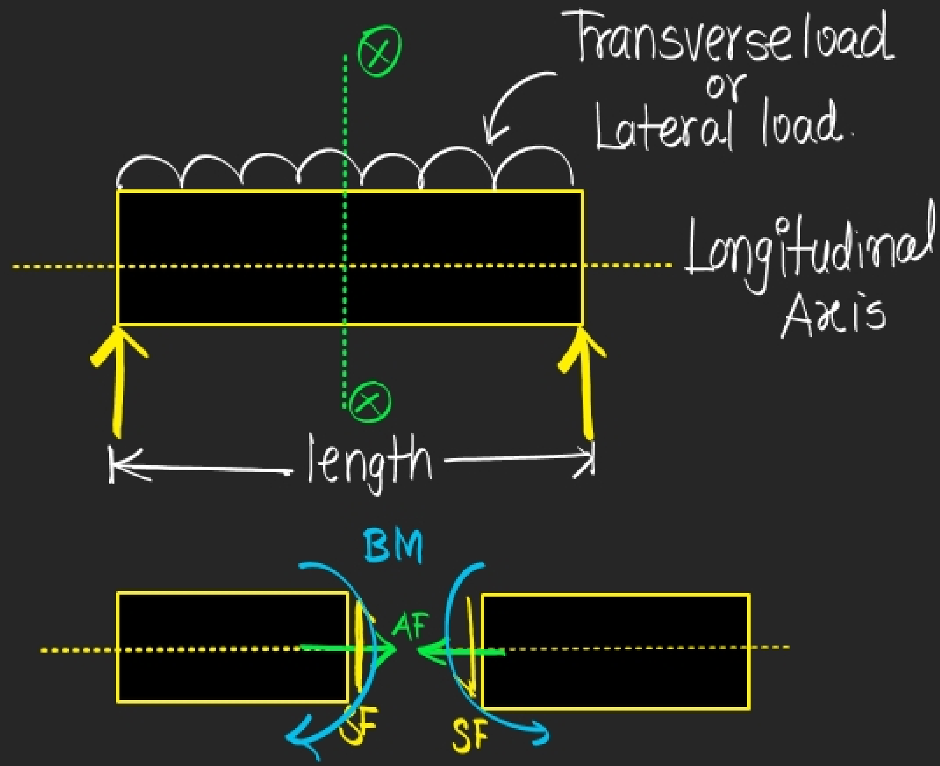


$\boxed{R=1}$

* Beam

* It is Flexural element which supports transverse loading.

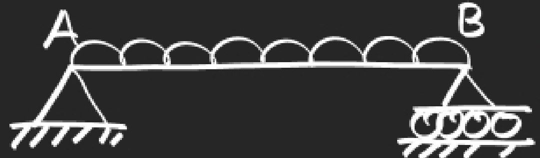




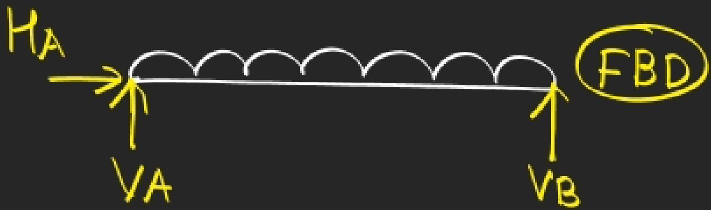
* Internal resisting Forces (Design forces) in Beam are
Axial Force, shear force, Bending moment and Twisting moments etc.

* Types of Beam

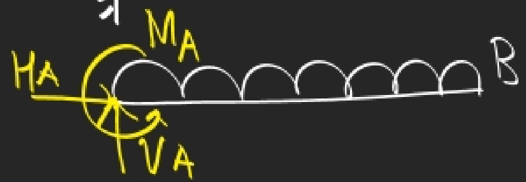
1) Simply Supported Beam



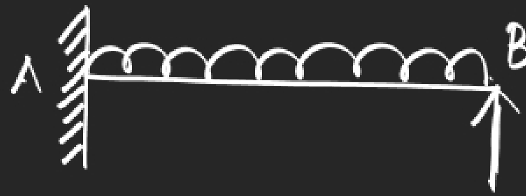
Loading Diagram.



2) Cantilever Beam

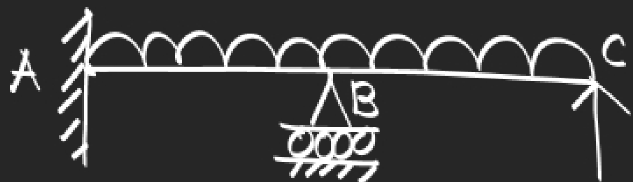


3) Proped cantilever Beam

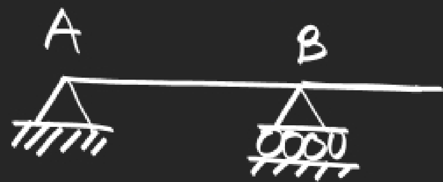


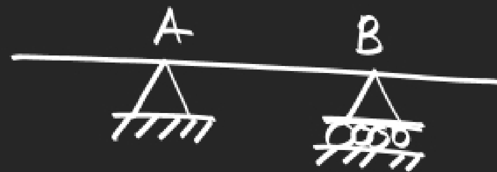
4) Fixed Baam

5) Continuous Beam

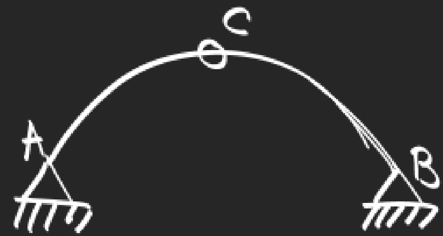


6) Overhang Beam



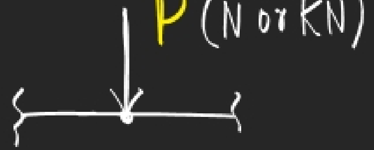


7) Curved Beam (Arch)

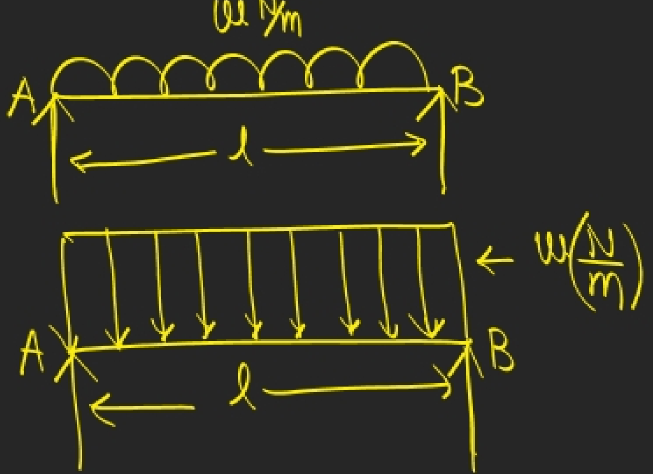


* Types of Loading

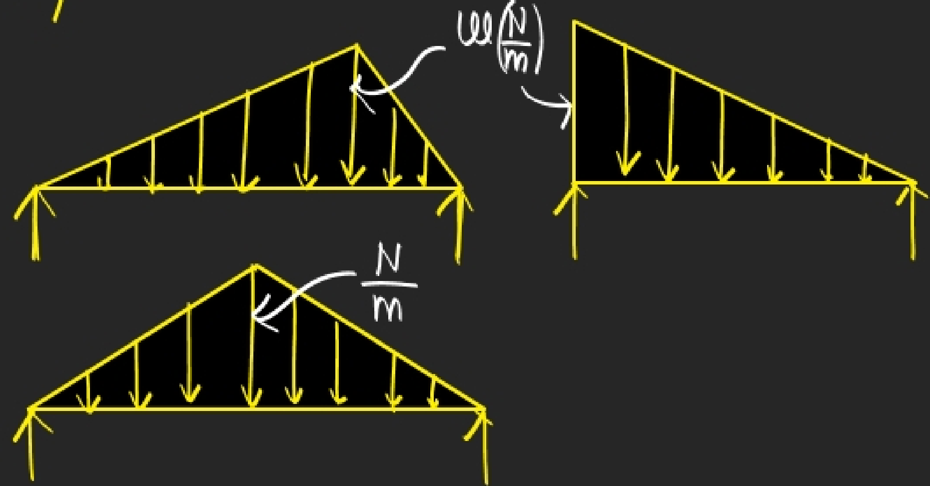
1) Point load (or) Concentrated load (P or W)



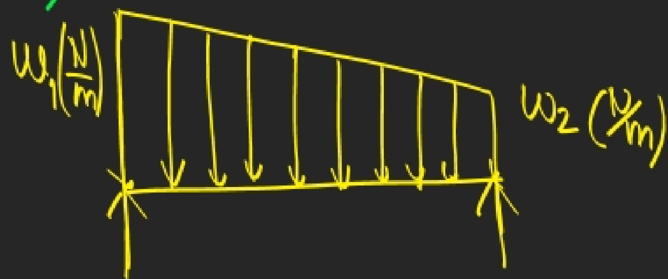
2) Uniformaly Distributed load (UDL)
(or)
Rectangular load (w)



3) Uniformaly Varying load (U.V.L.)
(or)
Triangular Load.

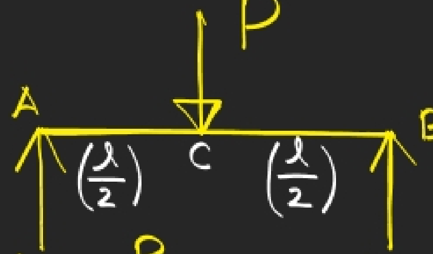


4) Trapezium Loading.

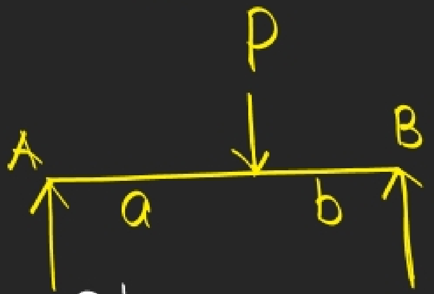


* Equivalent Point load (P) = Area of loading Diagram.

It is acted at centroid of loading diagram.

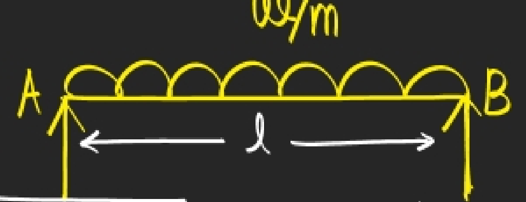
1) 

$V_A = \frac{P}{2}$ $V_B = \frac{P}{2}$

2) 

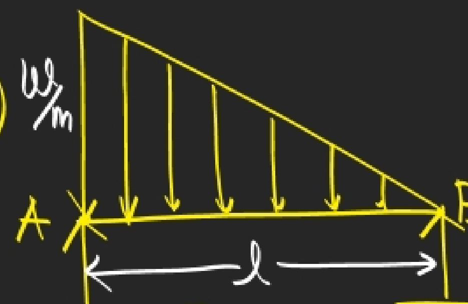
$a+b=l$

$V_A = \frac{Pb}{l}$ $V_B = \frac{Pa}{l}$

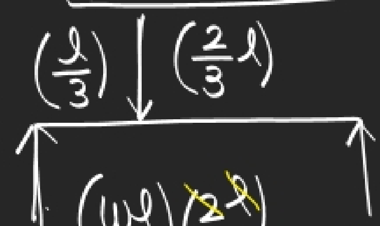
3) 

$P_{equivalent} = (w)\times l$
$= (wl)$

$\boxed{V_A = \frac{wl}{2}}$ $\boxed{V_B = \frac{wl}{2}}$

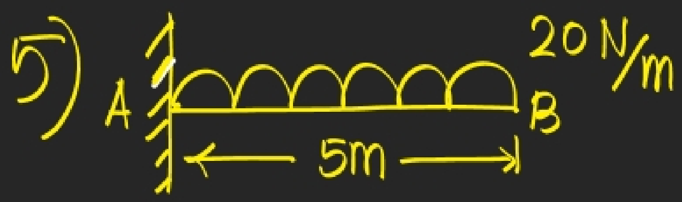
4) 

$\boxed{P = \frac{1}{2}\times w\times l}$

$\simeq$ 

$V_A = \frac{\left(\frac{wl}{\cancel{2}}\right)\left(\frac{\cancel{2}\cancel{l}}{3}\right)}{\cancel{l}}$ $V_B = \frac{\left(\frac{wl}{2}\right)\times\frac{\cancel{l}}{3}}{\cancel{l}}$

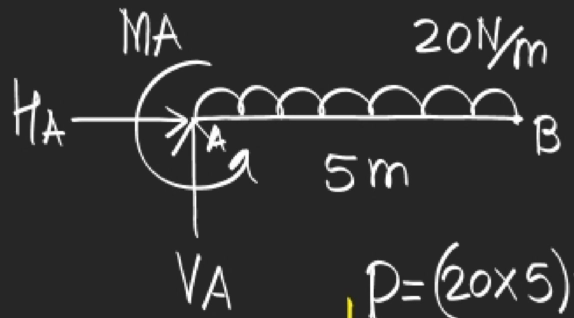
$\boxed{V_A = \frac{wl}{3}}$ $\boxed{V_B = \frac{wl}{6}}$



$V_A =$

$H_A =$

$M_A =$



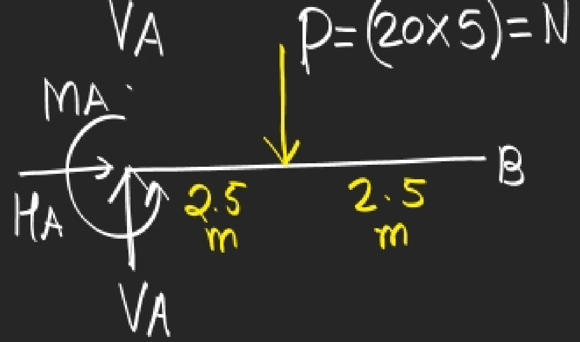
1) $\boxed{\Sigma M_A = 0}$ $\quad + \circlearrowright \quad \circlearrowleft -$

$0 + 0 - M_A + P(2.5) = 0$

$-M_A + 100 \times 2.5 = 0$

$-M_A = -250$

$\boxed{M_A = 250\ \text{Nm}}$



2) $\Sigma f_y = 0$

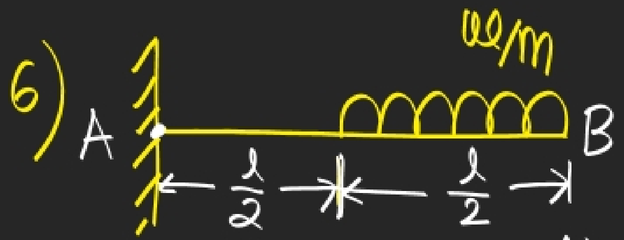
$+V_A - P = 0$

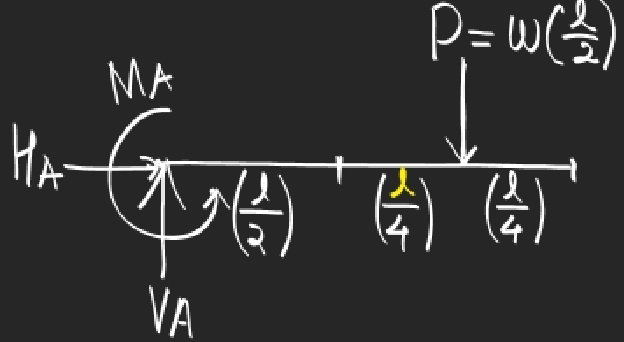
$V_A = +P$

$\boxed{V_A = 100\ \text{N}}$

3) $\Sigma F_x = 0$

$\boxed{+H_A = 0}$





V_A

H_A

M_A

$$\Sigma F_x = 0$$

$$\boxed{H_A = 0}$$

$$\Sigma F_y = 0$$

$$+V_A - P = 0$$

$$\boxed{V_A = +P = \frac{\omega l}{2}}$$

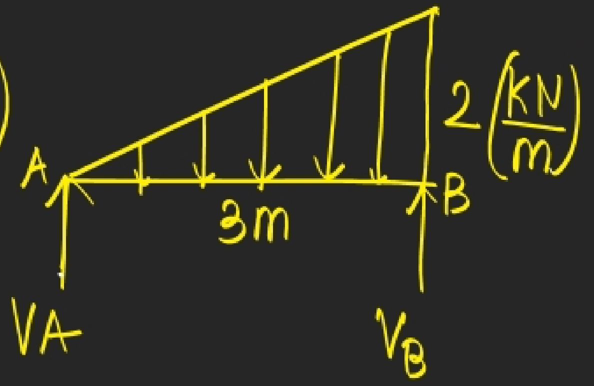
$$\Sigma M_A = 0$$

$$0 + 0 - M_A + P\left(\frac{3l}{4}\right) = 0$$

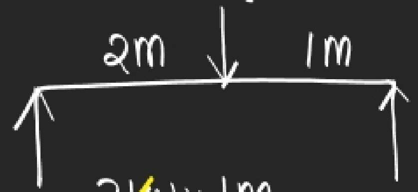
$$-M_A + \left(\frac{\omega l}{2}\right)\left(\frac{3l}{4}\right) = 0$$

$$\boxed{M_A = \frac{3\omega l^2}{8}}$$

7)



$$P = \frac{1}{\cancel{2}} \times \cancel{2} \times 3 = 3\ kN$$



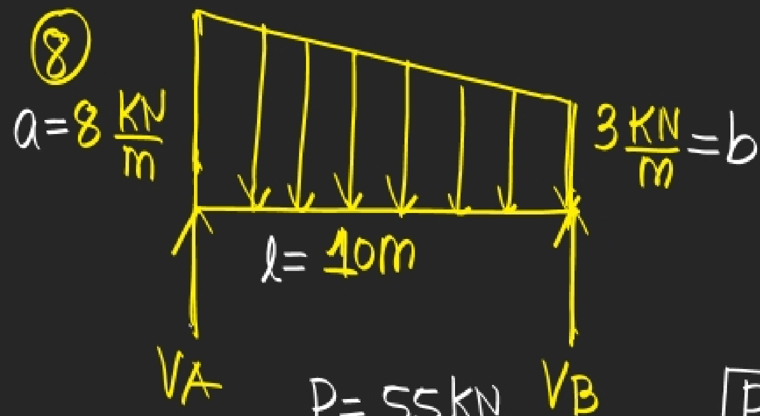
$$V_A = \frac{3\cancel{kN} \times 1m}{\cancel{3m}}$$

$$V_B = \frac{3kN \times 2m}{3m}$$

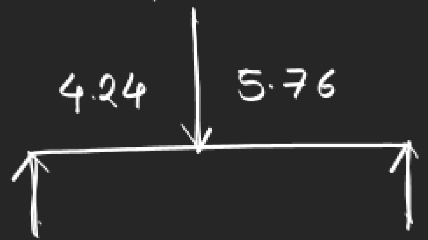
$$\boxed{V_A = 1m}$$

$$\boxed{V_B = 2m}$$

8



$$P = 55\ kN$$



$$V_A = \frac{55 \times 5.76}{10}$$

$$\boxed{V_A = 31.68\ kN}$$

$$V_B = \frac{55 \times 4.24}{10}$$

$$\boxed{V_B = 23.32\ kN}$$

$$P = \text{Area}$$

$$= \left(\frac{a+b}{2}\right) \times l$$

$$= \left(\frac{8+3}{2}\right) \times 10$$

$$= \frac{11}{\cancel{2}} \times \cancel{10}^{5}$$

$$\boxed{P = 55\ kN}$$

$$x_a = \left(\frac{a+2b}{a+b}\right) \times \frac{l}{3}$$

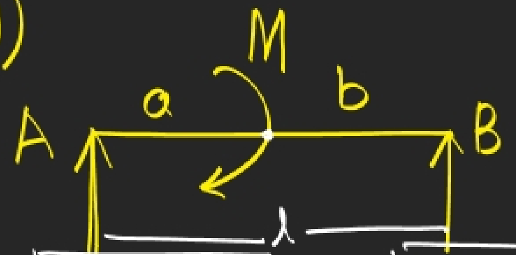
$$= \left(\frac{8+6}{8+3}\right) \times \frac{10}{3}$$

$$= \frac{14}{11} \times \frac{10}{3} = \frac{140}{33}$$

$$x_a = 4.24\ m$$

$$x_b = 5.76\ m$$

9)



$a+b=l$

$\boxed{V_A = \frac{-M}{l}}$ $\boxed{V_B = \frac{M}{l}}$

$\Sigma M_A = 0$

$0 - V_B \times (l) + M = 0$

$-V_B(l) = -M$

$\boxed{V_B = \frac{M}{l}}$

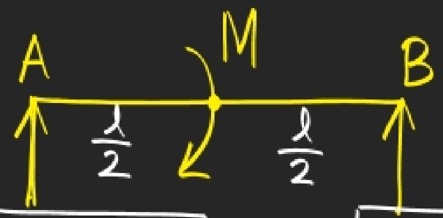
$\Sigma F_y = 0$

$V_A + V_B = 0$

$V_A = -V_B$

$\boxed{V_A = -\frac{M}{l}}$

10)



$\boxed{V_A = \frac{-M}{l}}$ $\boxed{V_B = \frac{M}{l}}$

$\Sigma M_A = 0$

$0 - V_B \times l + M = 0$

$-V_B \times l = -M$

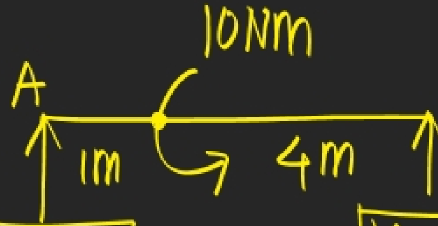
$\boxed{V_B = \frac{M}{l}}$

$\Sigma f_y = 0$

$V_A + V_B = 0$

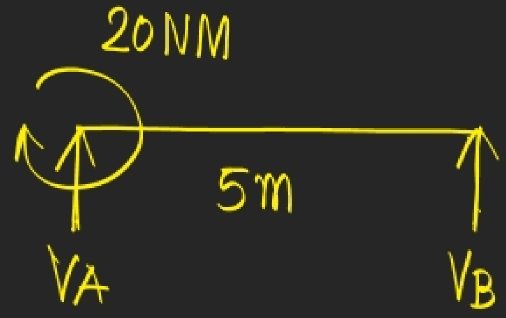
$\boxed{V_A = -V_B = -\frac{M}{l}}$

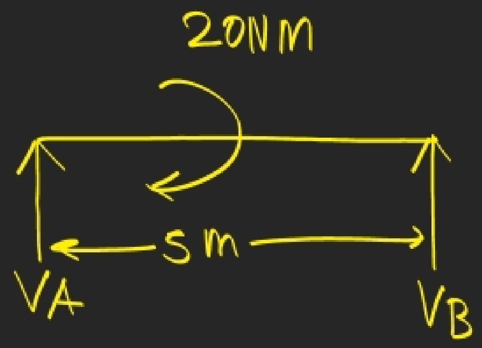
11)



$\boxed{V_A = 2N}$ $\boxed{V_B = -2N}$

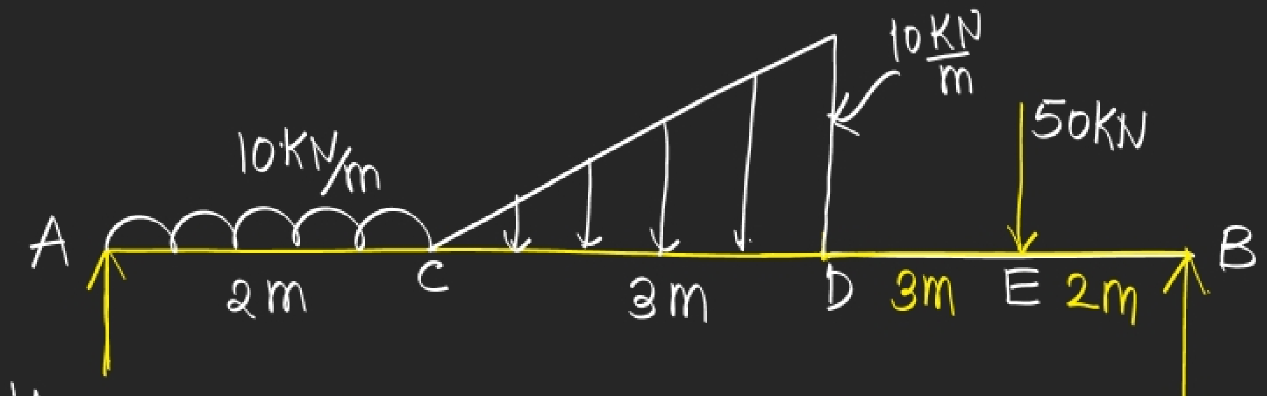
12)

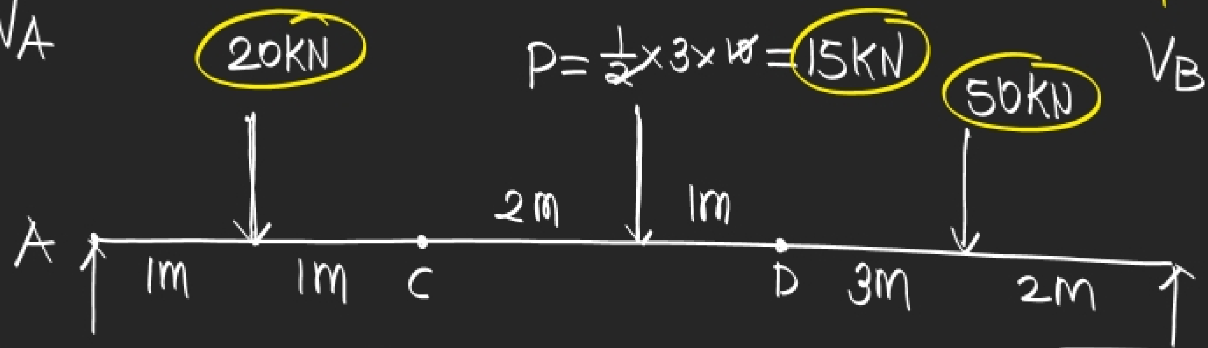




$V_A = -\frac{20}{5} = -4N$

$V_B = +\frac{20}{5} = +4N$





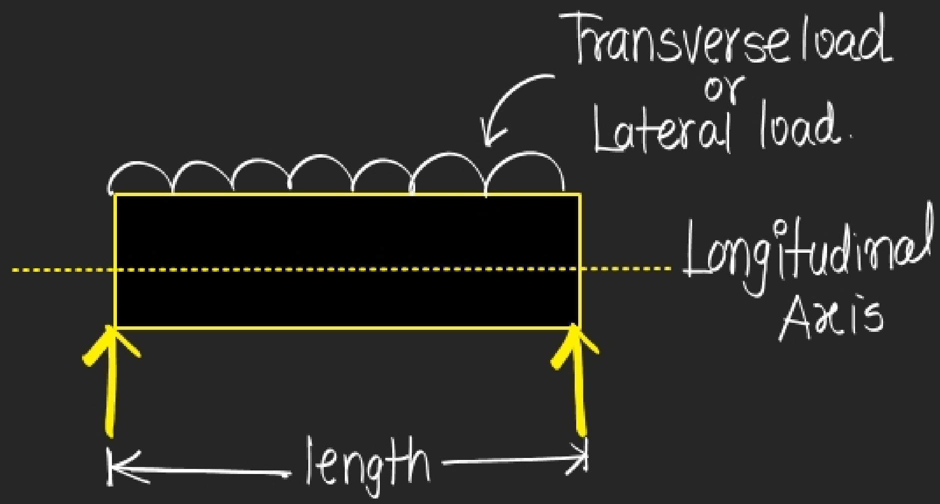
$$\begin{array}{r} 85\,KN \\ -37 \\ \hline 48 \end{array}$$

$$V_A = \frac{(20\times 9)+(15\times 6)+(50\times 2)}{10}$$

$$= \frac{180+90+100}{10}$$

$$= \frac{370}{10} = 37\,KN$$

$$\boxed{V_B = 48\,KN}$$


Transverse load
or
Lateral load.
Longitudinal
Axis
length