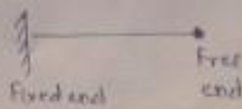
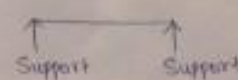
BEAM BASICS

Types of Beams —

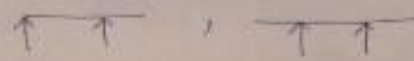
1. Cantilever beam



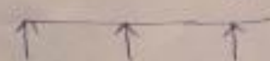
2. Simply Supported beam



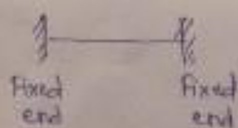
3. Overhanging beam



4. Continuous beam — A beam provided with more than two supports. Further such a beam may or may not have overhang.

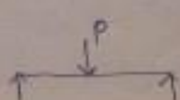


5. Fixed beam — A beam having both of its ends fixed or built in.



Types of loads :-

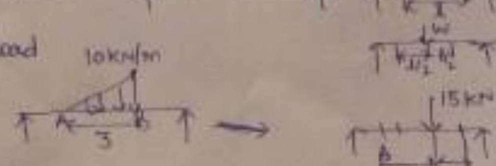
1. Concentrated load



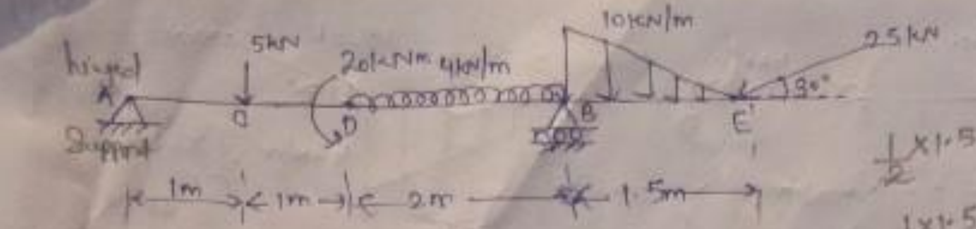
2. Uniformly distributed load

3. Uniformly varying load

$\frac{1}{2} \times 3 \times 10 = 15$



4. A beam may be loaded by a couple.

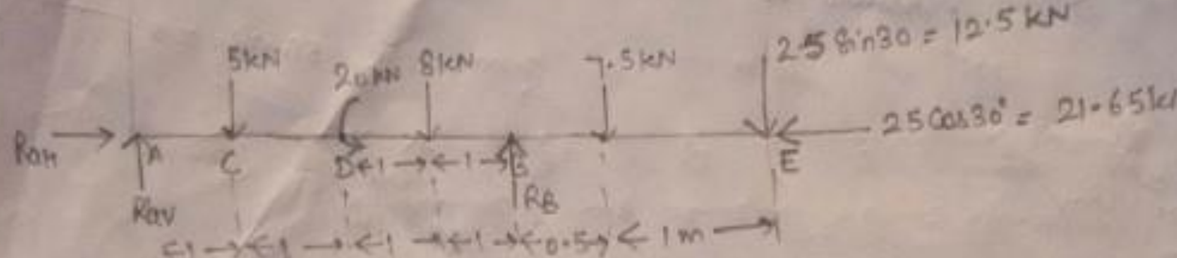


$\frac{1}{2} \times 1.5 \times 10 = 7.5\,kN$

$\frac{1}{3} \times 1.5 = 0.5$

$\boxed{3.22/100 \text{ 03 } ...}$

↑ +ve ↓ -ve Clockwise + ACW −



$\Sigma F_x = 0, \quad \Sigma F_y = 0, \quad \Sigma M = 0$

$\Sigma F_x = 0, \quad R_{aH} - 21.65 = 0 \quad \boxed{R_{aH} = 21.65\,kN}$

$\Sigma F_y = 0 \quad R_{av} - 5 - 8 - 7.5 - 12.5 + R_B = 0 \quad \boxed{R_{av} + R_B = 33}$

Taking moment about A

$+ \quad 5\times1 - 20 + 8\times3 - R_B\times4 + 7.5\times4.5 + 12.5\times5.5 = 0$

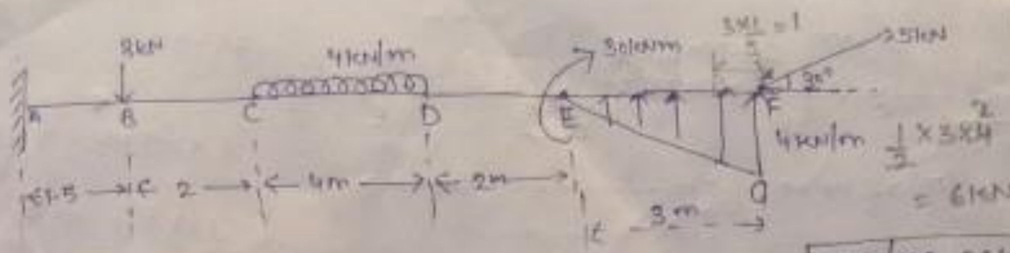
$5 - 20 + 24 - 4R_B + 33.75 + 68.75 = 0$

$4R_B = 111.5 \Rightarrow \boxed{R_B = 27.875\,kN}$

$R_{av} + R_B = 33$

$R_{av} + 27.875 = 33$

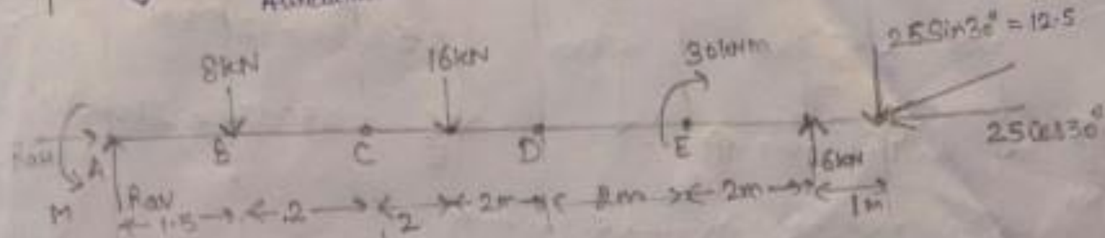
$\boxed{R_{av} = 5.125\,kN} \quad R_{aH} = 21.65\,kN \quad R_B = 27.875\,kN$



3.23 / 102 DS kumar

↑ +ve ↓ -ve

Clockwise +ve
Anticlockwise -ve



$\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma M = 0$ — For equilibrium of beam

$\Sigma F_x = 0$

$R_{aH} - 25\cos30^\circ = 0$

$R_{aH} = 25\times\frac{\sqrt{3}}{2}$ $\boxed{R_{aH} = 21.65 kN}$

$\Sigma F_y = 0 \Rightarrow R_{aV} - 8 - 16 - 12.5 + 6 = 0$

$\boxed{R_{aV} = 30.5 kN}$

Taking moment about A

$-M + 8\times1.5 + 16\times5.5 + 30 - 6\times11.5 + 12.5\times12.5 = 0$

$-M + 12 + 88 + 30 - 69.0 + 156.25 = 0$

$-M + 286.25 - 69 = 0$

$-M + 217.25 = 0$

$\boxed{M = 217.25 kNm}$ Anticlockwise

$R_{aH} = 21.65 kN$ $R_{aV} = 30.5 kN$ $M = 217.25 kNm$

SR

Support Reaction

Introduction :- When a number of forces are acting on a body, and the body is supported on another body, then the second body exerts a force known as reactions on the first body at the point of contact so that the first body is in equilibrium, the second body is known as support and the force, exerted by the second body on the first body, known as support reactions.

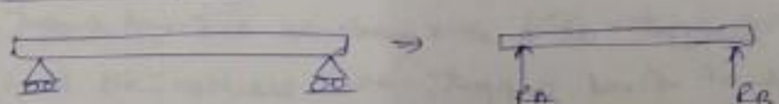
Types of supports

(a) Simply supports or Knife edge supports

(a)

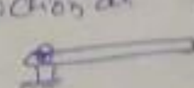
The reactions at A and B in case of Knife edge support will be normal to the surface of the beam.

(b) **Roller support :-**



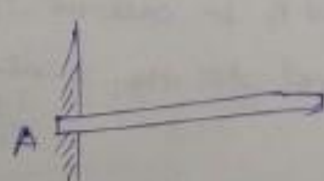
The reactions in case of roller supports will be normal to the surface will be normal to the surface on which roller are placed.

(C) Pin Joint (or hinged) support: A Beam, which is hinged (or pin Joint) at point A. The reaction at the hinged end may be either vertical or inclined depending upon the type of loading. If the load is vertical, the reaction will also be vertical. But the load is inclined, then the reaction at the hinged end will also be inclined



(D) Smooth surface support :- A body in contact with a smooth surface. The reaction will always act normal to the support .

(E) Fixed or built in support :



The end of A of a beam, which is fixed, Hence the support at A is known as a fixed support. In case of fixed support, the reaction will be inclined . Also the fixed support will provide a couple.

Types of loading :-

The following are the important types of loading

ⓐ Concentrated or point load :-

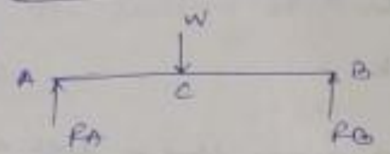
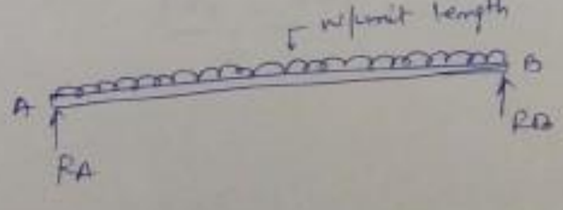


Fig. shows a beam AB, which is simply supported at the ends A and B. A load W is acting at the point C. This load is known as point load (or concentrated load). Hence any load acting at a point on a beam, is known as point load.

In actual practice, it is not to apply a load at a point (i.e at a mathematically point) as it must have some contact area. But this area in comparison to the length of the beam is very - very small (or area is negligible).

ⓑ Uniform distributed load :- If a beam is loaded in such a way that each unit length of the beam carries same intensity of the load, then that type of load (UDL) uniformly distributed load

For finding the reactions the total UDL is assumed to act the C.G. of the load.



(c) Uniform varying load (UVL) :-

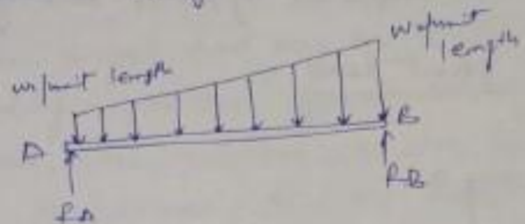


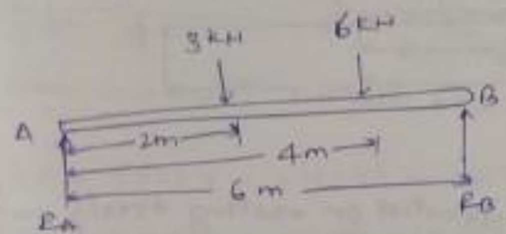
Fig. shows a beam AB, which carries load in such a way that the rate of loading each unit length of the beam varied uniformly. This type of load is Known as UVL. The total load on the beam is equal to the area of the load diagram. The total load acts at C.G of the load diagram.

OR.

A load which is spread over the beam, in such a manner that rate of loading varies from one point to another, is Known as uniformly varying load.

problem ①. A simply supported beam AB of span 6m carries point load of 3KN and 6KN at a distance of 2m and 4m from the left end A in fig-1. Find the reactions at A and B analytical method

Sol



As the beam is in equilibrium, the moment of all the forces about any point should be zero

Taking the moment about A point

$\Sigma F_y = 0$,

$w_1 + w_2 = R_A + R_B$.

$3 + 6 = R_A + R_B \Rightarrow 9KN = R_A + R_B$ — ①

$3 \times 2 + 6 \times 4 = 0 + 6R_B$

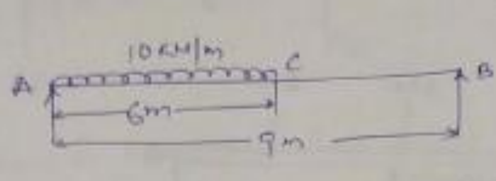
or, $6R_B = 06 + 24 = 30$

$\boxed{R_B = 5KN}$

From eq ①

$\boxed{R_A = 4KN}$

② A simply supported beam AB of length 9 m. carries a uniformly distributed load of 10 KN/m for a distance of 6m from the left end. calculate the reactions A and B.



(downward $-$, upward $+$)

Note -

A beam supported or resting freely on the supported at its both ends, is known as simply or freely supported beam. The supported may be in the form of walls or column.
The whole length of the beam is known as its total span.

Sol.

Total load due to U.D.L = (length of U.D.L) × (Rate of U.D.L.)

$= 6 \times 10\ KN/m$

$= 60\ KN/\cancel{m} \times \cancel{m}$

$\boxed{\text{Load} = 60\ KN}$

This load of 60KN will be acting at the middle point of AC i.e at the distance of $\frac{6}{2} = 3m$ from A.

$0 + R_B \times 9 = (6 \times 10) \times 3$

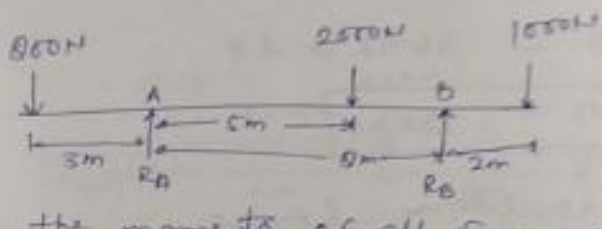
$\boxed{R_B = 20\ KN}$

$R_A + R_B = w.$

$R_A = 60 - 20 = 40\ KN$

$\boxed{R_A = 40\ KN}$

(1) A beam AB of span 8m, overhanging on both side is loaded as shown in fig. Calculate the reactions at both ends



Taking the moments of all forces about point A

$$R_B \times 8 + 800 \times 3 - 2000 \times 5 - 1000 \times 10 = 0$$

$$8R_B + 2400 - 10{,}000 - 10{,}000 = 0$$

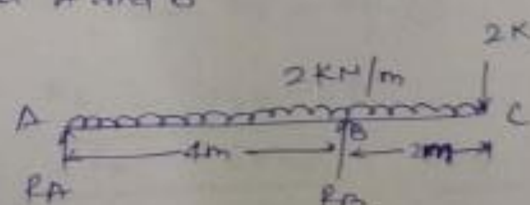
$$8R_B = 20{,}000 - 2400$$
$$= 17600$$
$$R_B = \frac{17600}{8} = \underline{\underline{2200N}}$$

$$R_A + R_B = 800 + 2000 + 1000$$
$$= 3800$$

$$\therefore \; R_A = 3800 - 2200$$

$$\boxed{R_A = 1600N}$$

(2) A beam AB of span 4m, overhanging on one side upto a length of 2m, carries a uniformly distributed load of 2KN/m over the entire length of 6m and a point load of 2KN/m as shown in fig. Calculate the reactions at A and B.



Total load = 2×6
= 12 KN

Taking the moment about point A.

$R_B \times 4 - (2\times6)\times3 - 2(4+2) = 0$

$4R_B = 36+12 = 48$

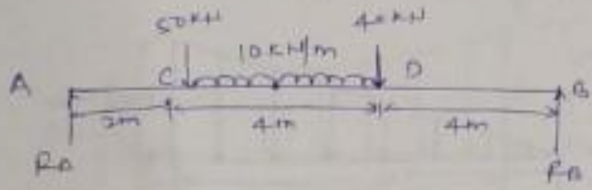
$\boxed{R_B = 12KN}$

Also for equilibrium $\Sigma F_y = 0$

$12+2 = R_A + R_B \rightarrow R_A + R_B = 14KN$ — ①

$\boxed{R_A = 2KN}$ Ans

③ A simply supported beam of length 10m carries the uniformly distributed load and two points load as shown in fig. Calculate the RA and RB.



Total load due to UDL = 4×10 = 40 KN

This load of 40 KN due to UDL will be acting at the middle point of CD i.e at a distance of $4/2 = 2m$ from C and from (2+2) = 4m A point

Taking the moments of all forces about point A and equating the resultant moment to zero.

$$0 + 10R_B = 2\times50 + (40\times4) + 40\times6$$
$$= 150 + 160 + 240$$
$$R_B = \frac{500}{10} = 50\ KN$$
$$\boxed{R_B = 50\ KN}$$

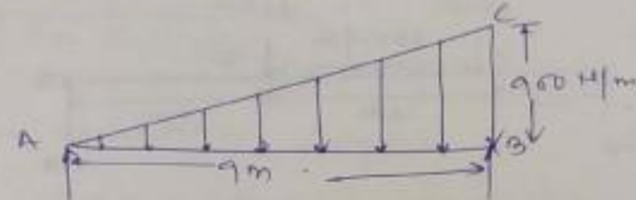
And Also
$$\Sigma F_y = 0$$
$$R_A + R_B = 50 + 40 + 40$$
$$= 130\ KN \quad —①$$

put the value RB in eq. ①

$$R_A = 130 - 50$$
$$\boxed{R_A = 80\ KN}$$ Ans

②

A simply supported beam of span 9m carries a uniformly varying load from zero at end A to 900 N/m at end B. Calculate the reactions at the two ends of the support.



Sol. Total span = 9m, load at end A = 0,
Load at end B = 900 N/m

Now, Total load on the beam

$= \text{Area of } ABC = \frac{AB \times BC}{2}$

$= \frac{9 \times 900}{2}$ (m × N/m)

$= \underline{4050\ N}$

This load will be acting at the C.G of a ΔABC
be at a distance of $\frac{2}{3} \times AB = \frac{2}{3} \times 9 = 6\text{m}$ from end A

$R_B \times 9 = 4050 \times 6$

$\therefore R_B = \frac{4050 \times 6}{9} = \underline{2700\ N}$

$\Sigma F_y = 0,$

$R_A + R_B = 4050$

$R_A = 4050 - 2700$

$\boxed{R_A = 1350\,N}$

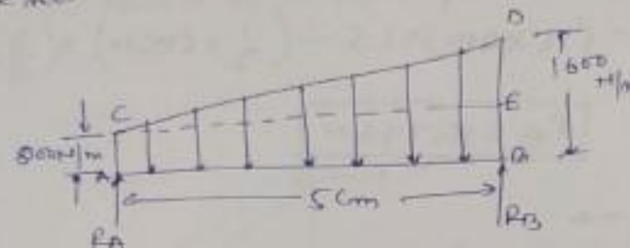
Average intensity of loading

$= (0+900)/2$

$= 450$ N/m

Total load $= 9 \times 450 = \underline{4050\ N}$

(8) A simply supported beam of length 5m carries a uniformly increasing load of 800 N/m at one end A to 1600 N/m at the other end. Calculate the reactions at both ends



Sol Given data

length of Beam = 5m, load at A = 800 N/m

B = 1600 N/m

Total load on the beam = Area of load diagram ABCD

= Area of rectangle ABEC + Area of ΔCED

$= (AB \times AC) + \frac{1}{2}(CE \times DE)$

$= (5 \times 800) + \frac{1}{2}(5 \times 800)$

$= 4000 + 2000$

$\boxed{T.L. = 6000N}$

The C.G. of the rectangle ABEC will be at a distance of $5/2 = 2.5$m from A, where the C.G. of triangle CED will a distance of $\frac{2}{3} \times 5 = 3.33$m from A.

Now, taking the moments of all forces about A and equating the resultant moment to zero, we get

$R_B \times 5$ − (load due to rectangle) × distance of C.G of rectangle from A) − (load due to Triangle) × Distance of CG from A = 0

$$5R_B - (5\times 800)\times 2.5 - \left(\frac{1}{2}\times 5\times 800\right)\times\left(\frac{2}{3}\times 5\right) = 0$$

$$\boxed{R_B = 3333.3\ N}$$

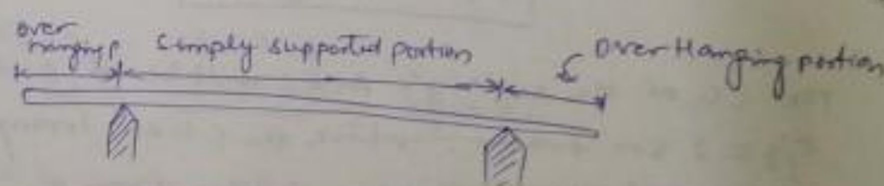
$\Sigma f_y = 0$

$R_A + R_B = 6000$

$$\boxed{R_A = 2666.67\ N}$$

problem on over-hanging Beam

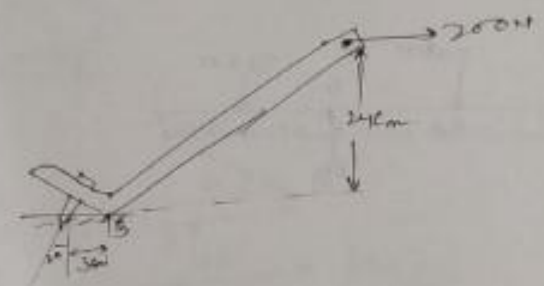
If the end portion of the beam is extended beyond the support, then the beam is known as over hanging beam. over hanging beam may be at one end of the beam or at both ends of the beam as shown in fig



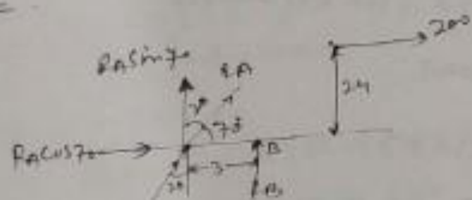
moment – force to move a object / – static force / used for no rotation

Torque – Force to rotate an object / – movement force / used for rotation

Q.1 Determine the magnitude of the pull exerted on the nail A if a horizontal force of 200 N is applied to handle of a nail-puller as shown in fig.



Sol.

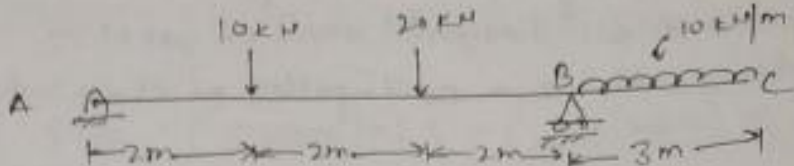


Taken moment about B.

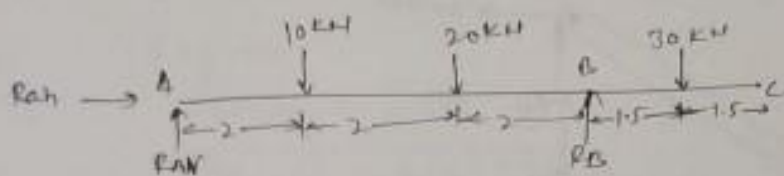
$RA \sin 70 \times 3 = 200 \times 24$

$RA = \frac{4800}{2.81} = \underline{1702\ N}$

(2) Determine the reactions at A and B.



Sol



$\Sigma F_x = 0.$

$R_{ah} = 0$

$\Sigma F_y = 0$

$R_{av} + R_B = 10 + 20 + 30 = 60 \text{ KN} \quad \text{---(1)}$

Taken moment about A point

$10 \times 2 + 20 \times 4 - R_B \times 6 + 30 \times 7.5 = 0$

$20 + 80 - 6R_B + 225 = 0$

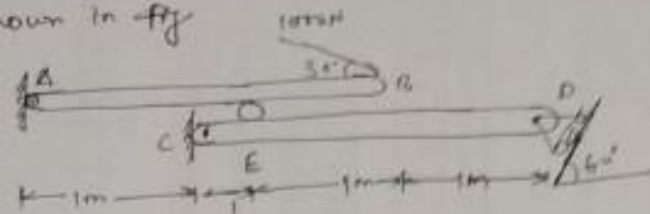
$6R_B = 325$

$\boxed{R_B = 54.16 \text{ KN}}$

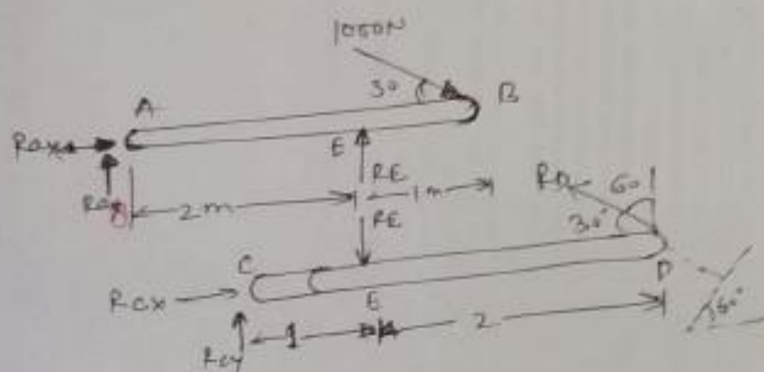
from eq. (1) $\boxed{R_{AV} = 5.83 \text{ KN}}$

Q 3 A weightless bar AB is placed in horizontal position on smooth inclines as shown in Fig. calculate the distance x at which the 100N load be placed from end B so that the bar remains horizontal.

(3) Two beam AB and CD are arranged and supported as shown in fig find the reaction at D due to force of 1000N acting at B as shown in fig



Sol F.B.D. of fig



Consider Body AB

$R_{ax} = 1000\cos 30 = 866.0\ N$

$R_{ay} + R_E = 1000\sin 30 = 500$ — eq

Taking moment about A

$1000\sin 30 \times 3 = R_E \times 2$

$\boxed{R_E = 750N}$

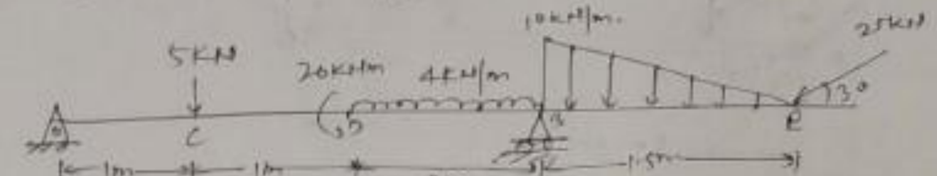
Body CD

$M_C = 0,\quad R_E \times 1 = R_D \sin 30 \times 3$

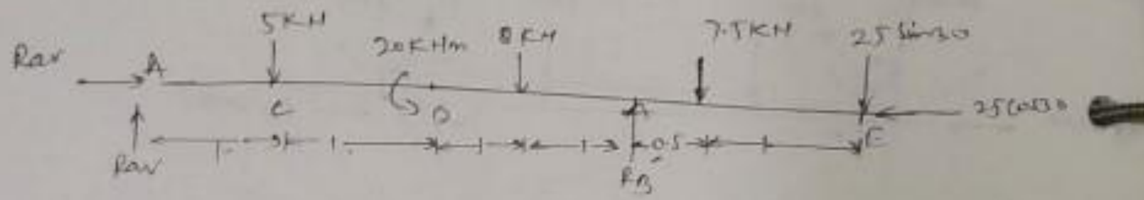
$R_D = \dfrac{R_E}{3\sin 30} = \dfrac{1500}{3} = 500N$

$\boxed{R_D = 500N}$

A beam has been loaded and supported as shown in fig. Determine the reactions at A and B.



Sol.



$\Sigma f_x = 0,$

$R_{ah} = 25 \cos 30 = \underline{\underline{21.6 \text{ KN}}}$

$\Sigma f_y = 0$

$R_{av} + R_B = 5 + 8 + 7.5 + \cancel{21.6}\ 12.5$

$= \underline{\underline{33 \text{ KN}}}$ —— (1)

Taken moment about A

$0 + 5 \times 1 - 20 + 8 \times 3 - R_B \times 4 + 7.5 \times 4.5 + 25 \sin 30 \times 5.5$

$5 - 20 + 24 - 4R_B + 33.3 + 68.75 = 0$

$4R_B = 111.05$

$\boxed{R_B = 27.8 \text{ KN}}$

$\boxed{R_{av} = 52 \text{ KN}}$