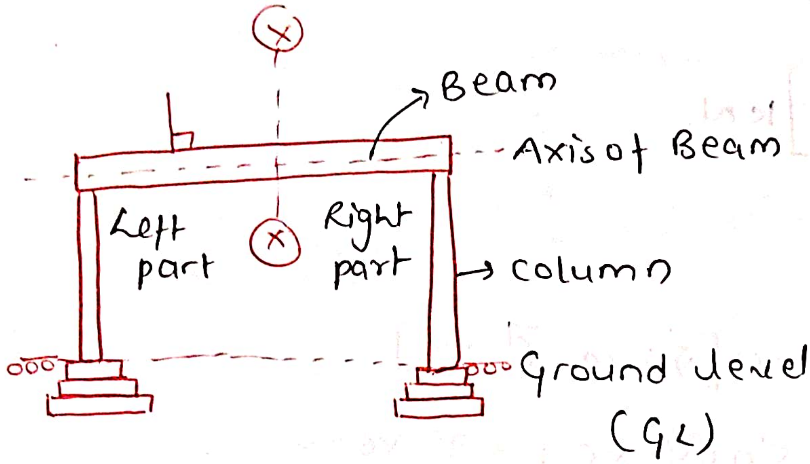
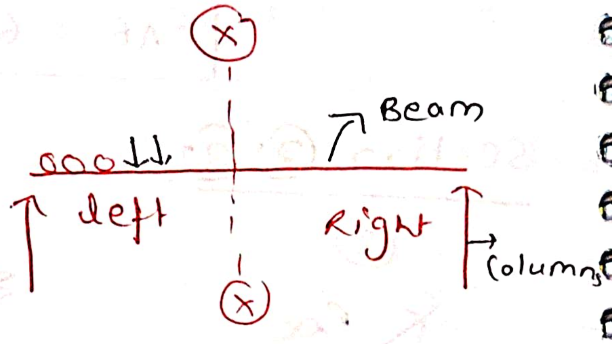
(SFD & BMD)

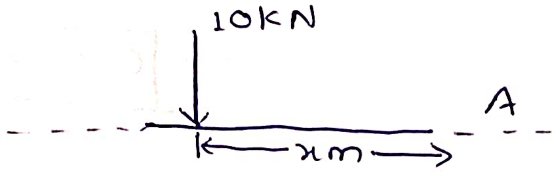
SHEAR FORCE DIAGRAMS & BENDING MOVEMENT DIAGRAMS





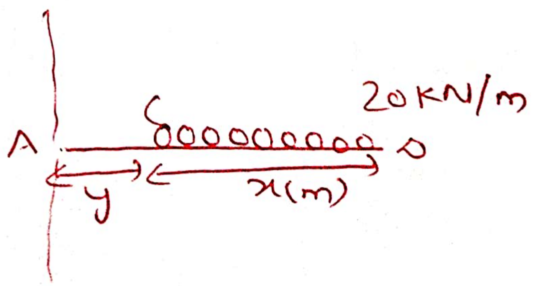
Beam:- Beam is a structural member which is acted upon by a system of external loads at right angles to the axis of beam.

Loads :- ①. Point load / concentrated load :-



→ moment at A = $10x$ KNm

②. Uniformly distributed load (UDL) :-



→ moment at A,

$$\boxed{= \text{load} \times \text{span} \times \left(\tfrac{1}{2}\text{span} + \text{remaining distance}\right)}$$

$$= 20 \times x * \left(\frac{x}{2} + y\right)$$

→ moment at C,

$$= 20 \times x \times \left(\frac{x}{2} + 0\right) = 20x\left(\frac{x}{2}\right)$$

→ Moment at D,

$$= 20 \times x \times \left(\frac{x}{2}\right)$$

- **Shear force:-** The algebric sum of all vertical forces at any section of a beam to the right or left of the section is known as shear force.

- **Bending moments:-** The algebric sum of the moments of all the forces acting to the right or left of the section is known as bending ~~movement~~.

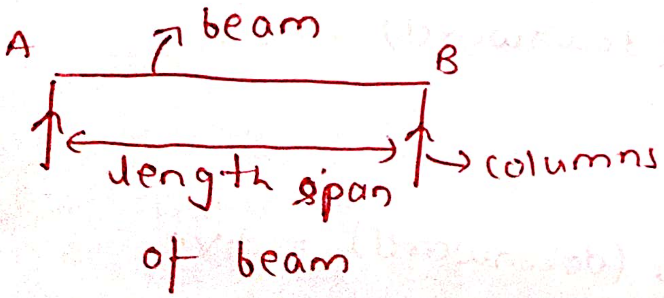
- **Shear force diagrams:- (SFD)** A SFD is one which showing the variation of shear force along the length of the beam.

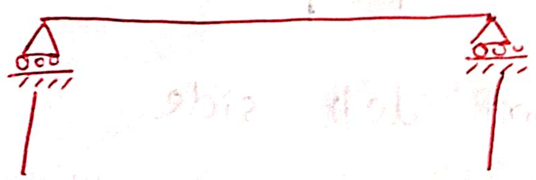
- **Bending moment Diagram (BMD):-** A BMD is one which showing variation of bending moment along the length of the beam.

- **Classification / Types of beams:-**

1. **Simply supported / Roller supported beam:-**

When a beam is supported with simply supported support or roller supported support at both the ends. It is known S.S. / R.S. beam.

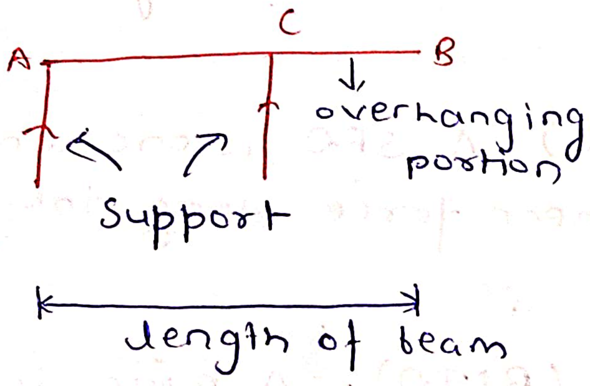


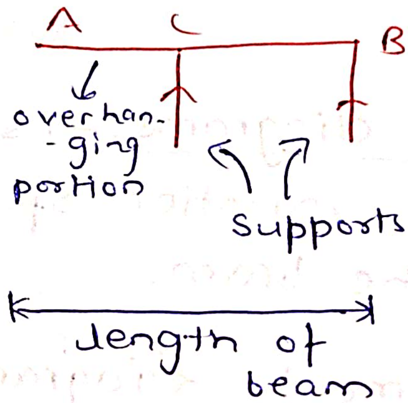


2. **Cantilever Beam:-** (one end fixed another in air)

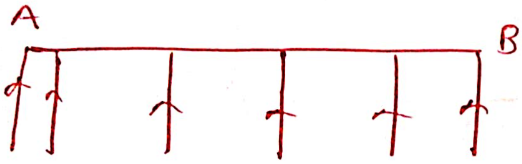
3. **Fixed beam** :- (beam supported by fixed supporting support at both the ends)

4. **overhanging beam** :-

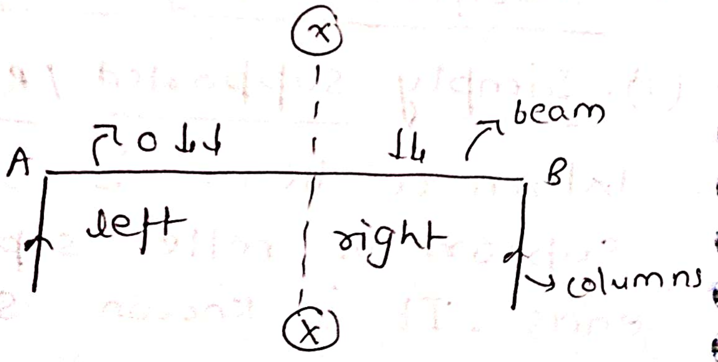




5. **Continous Beam** :- (Beam having multiple supports more than 2).



— **Sign conventions** :-



for shear force,

from right side,

⇒ ↑ (upward) = +ve , ↓ (downward) = -ve

from left side,

⇒ ↑ (upward) = -ve , ↓ (downward) = +ve

for bending moments,

from right side → ↺(ACW) → +ve , ↻(CW) → -ve

from left side → ↺(ACW) = -ve , ↻(CW) = +ve

$\longrightarrow$ = $\longrightarrow$ sagging moment = +ve
(concavity)

$\longrightarrow$ = $\longrightarrow$ Hogging moment = -ve
(convexity)

- Point for drawing the SFD and BMD:-

① Consider the left or right portion of the section.

②. Add the forces including reaction normal to beam on one of the portion.

* If right portion is considered, a force in right portion acting upward is positive and downward is negative

* If left portion of section is considered, a force in left portion acting downward is positive and upward is negative.

③. The positive values of shear force and bending moment are plotted above the base line & negative values below the base line

④. The shear force diagram will increase or decrease suddenly by a vertical straight line at a section where there is vertical point load.

⑤. The shear force between any two vertical loads will be constant and hence SFD between two vertical loads will be horizontal.

⑥ The bending moment at two supports of a simply supported beam and end of free end of cantilever beam will be zero.

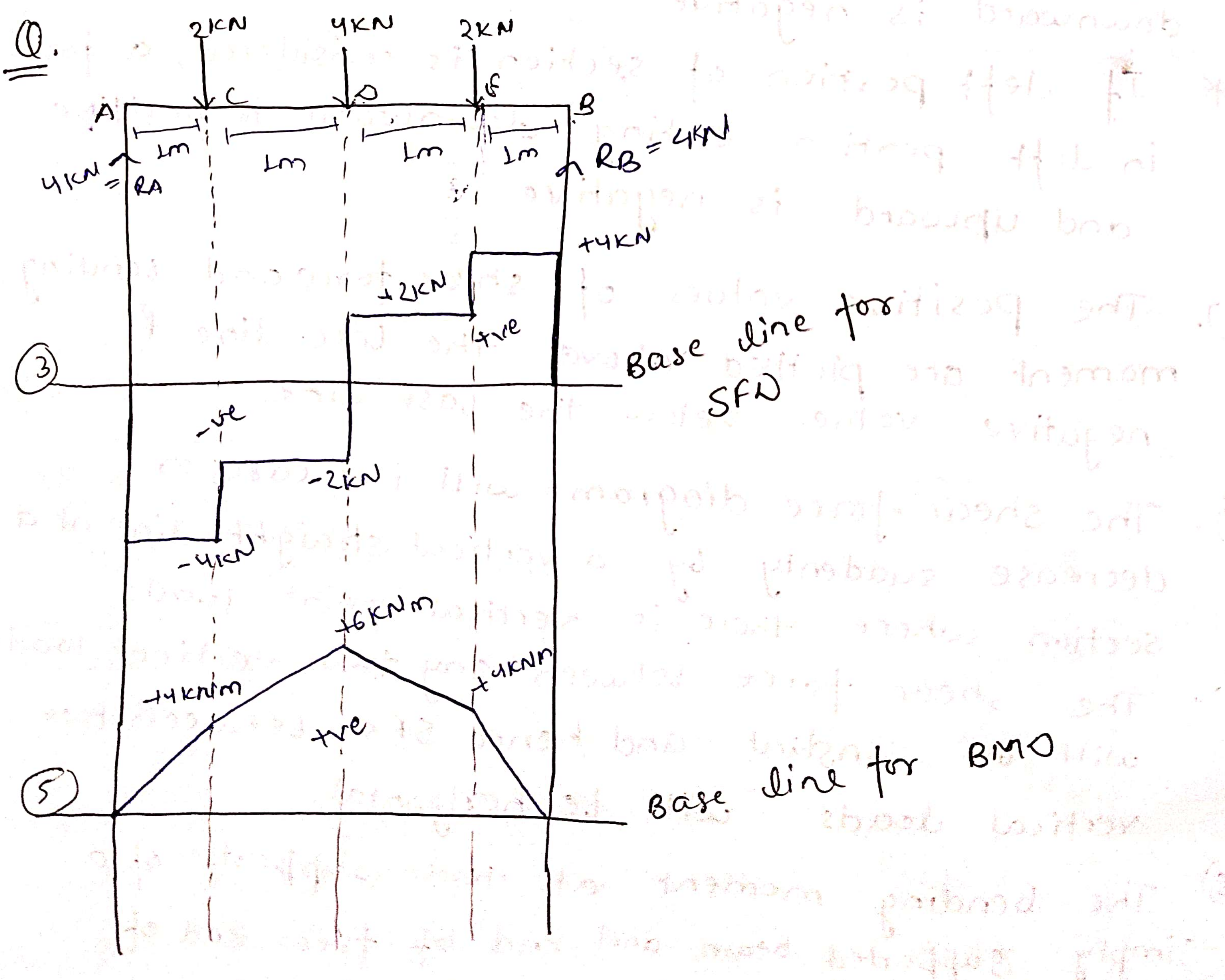
(7). The SFD for uniformly distributed load will be straight inclined line.

(8). The BMD for uniformly distributed load will be a parabolic curve.

(9). The BM will be maximum where there is zero shearing forces and changing its sign from +ve to -ve and -ve to +ve.

(10). The point of contraflexure will occur when there is zero bending moment and changing its sign from +ve to -ve and -ve to +ve.

Q.



→ ①. Reactions:-

Let the R_A and R_B be reactions at A and B respectively.

Taking moment about A,

$$\Sigma M_A = 0 \quad [\circlearrowright +ve, \circlearrowleft -ve]$$

$$-2\times1 - 4\times2 - 2\times3 + R_B\times4 = 0$$

$$\boxed{R_B = 4\,KN}$$

Consider vertical equillibrium,

$$\Sigma v = 0 \quad [\uparrow +ve, \downarrow -ve]$$

$$+R_A + R_B - 2 - 4 - 2 = 0$$

$$R_A = 8 - 4$$

$$\boxed{R_A = 4\,KN}$$

②. Shear force calculation:-

[from right side – ↑ +ve]

$SF_B = +4\,KN$

$SF_E = +4-2 = +2\,KN$

$SF_D = +4-2-4 = -2\,KN$

$SF_C = +4-2-4-2 = -4\,KN$

(Since, $SF \neq 0$, so we will calculate upto last load only).

④. Bending moment calculation:- [from right side – ↻ +ve]

$BM_B = 0$

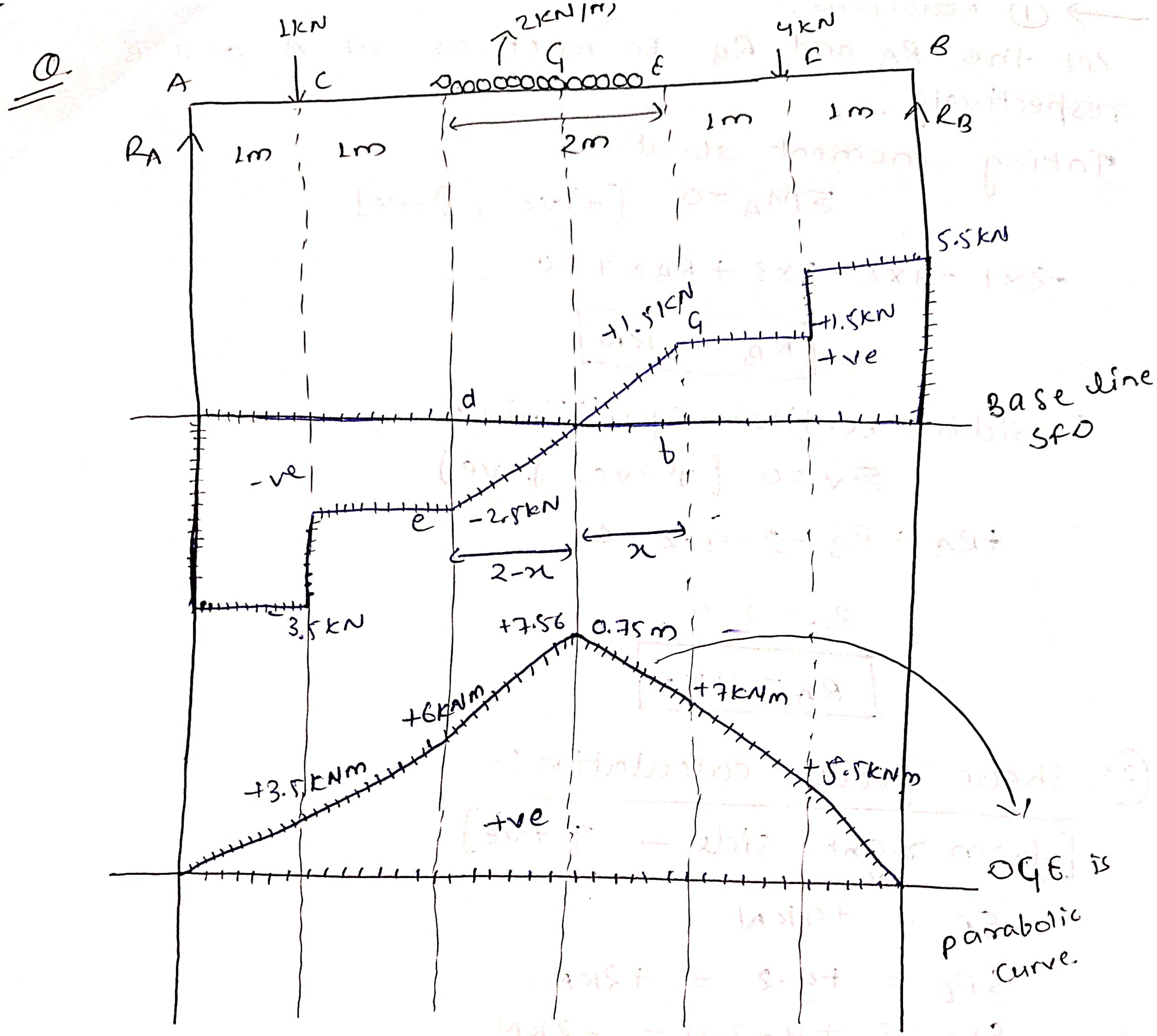
$BM_E = 4\times1 = +4\,KNm$

$BM_D = (4\times2) + (-2\times1) = 6\,KNm$

$BM_C = (4\times3) + (-2\times2) + (-4\times1) = 4\,KN$

$BM_A = (4\times4) - (2\times3) - (4\times2) - (2\times1) = 0$

Q



→ **Reactions:-**

Let RA and RB be reactions at A and B..

Now, taking moment about A.

$$\Sigma M_A = 0 \quad [\circlearrowright +ve, \circlearrowleft -ve]$$

$$R_B \times 6 - 4\times5 - (2\times2 * (1+2)) - 1\times1 = 0$$

$$\boxed{R_B = 5.5 \, KN}$$

Consider vertical equillibrium,

$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$R_A + R_B - 4 - 1 - 2\times2 = 0$

$R_A = 9 - 5.5$

$\boxed{R_A = 3.5\,kN}$

<u>SF calculations :-</u>

$SF_B = +5.5\,kN$

$SF_F = +5.5 - 4 = +1.5\,kN$

$SF_E = +5.5 - 4 - 2\times0 = +1.5\,kN$

$SF_D = +5.5 - 4 - 2\times2 = -2.5\,kN$

$SF_C = +5.5 - 4 - 2\times2 - 1 = -3.5\,kN.$

<u>Reaction of zero s.f. :-</u>

From Δabc and Δade

$$\frac{ab}{bc} = \frac{ad}{de} \quad \text{[similarity]}$$

$$\frac{x}{1.5} = \frac{2-x}{2.5}$$

$2.5x = 3 - 1.5x$

$4x = 3$

$\boxed{x = 0.75\,m}$

<u>Bending moment calculation:</u>

[from right side → ↻ +ve]

$BM_B = 0$

$BM_F = +5.5\times1 = 5.5\,kNm$

$BM_E = (+5.5\times2) - (4\times1) = +7\,kN$

$BM_D = (+5.5\times4) - (4\times3) - (2\times2\times(1+0)) = +6\,kN$

$BM_C = +(5.5\times5) - (4\times4) - (2\times2\times(1+1)) = +3.5\,kN$

$BM_A = 0.$

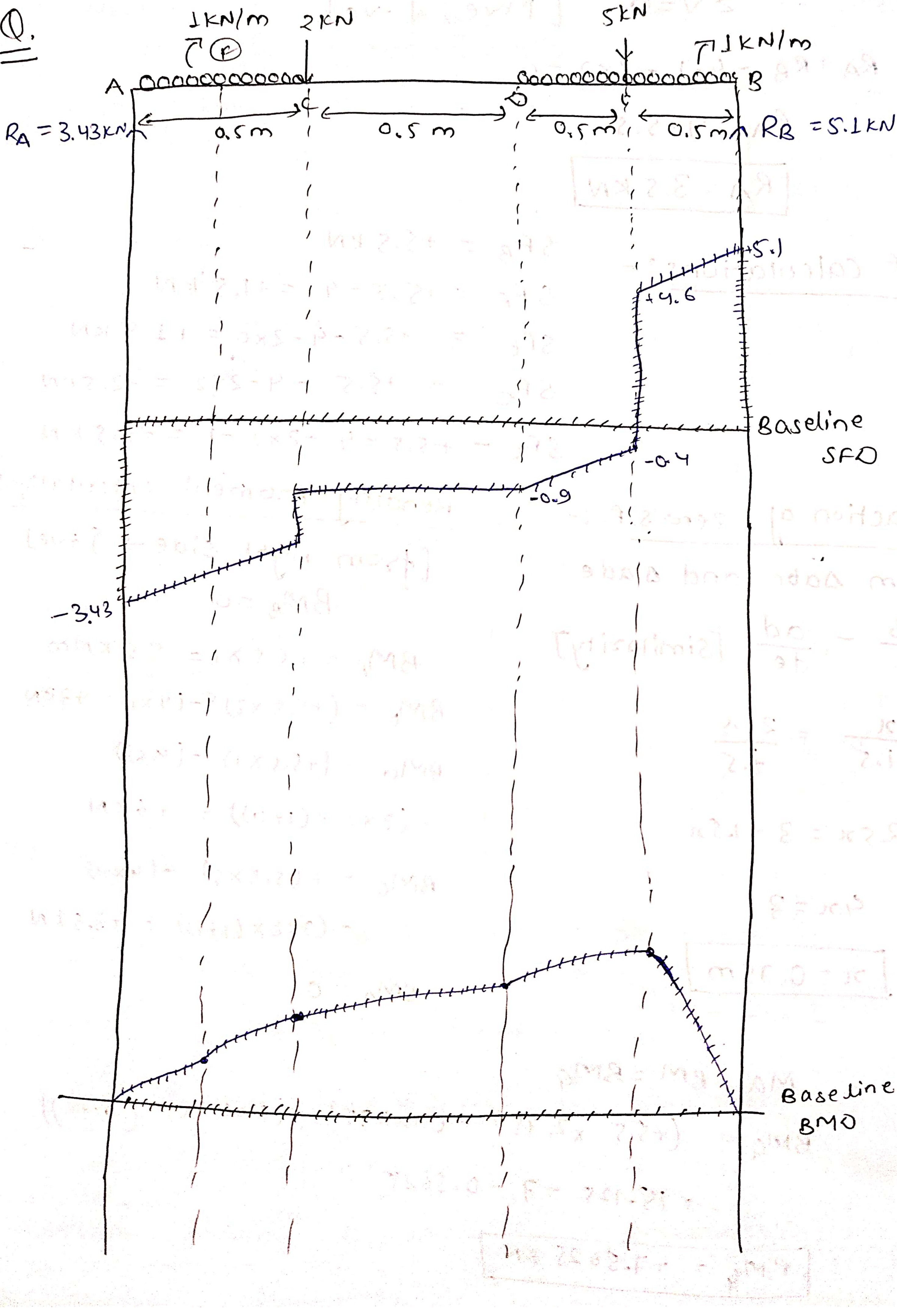
Max BM $= BM_G$

$BM_G = (+5.5\times2.75) - (4\times1.75) - \left(2\times0.75\times\left(\frac{0.75}{2}\right)\right)$

$= 15.125 - 7 - 0.5625$

$\boxed{BM_G = +7.5625\,kN}$

Q.



1KN/m
2KN
5KN
1KN/m
A
B
C
D
E
F
$R_A = 3.43KN$
0.5m
0.5 m
0.5m
0.5m
$R_B = 5.1KN$
5.1
+4.6
Baseline
SFD
-0.4
-0.9
-3.43
Baseline
BMD

→ Reactions :- Let R_A and R_B be reactions at A and B respectively.

$$\Sigma M_A = 0 \; [\circlearrowright +ve, \circlearrowleft -ve]$$

$$R_B \times 2 - \left(1\times1\times\left(\tfrac{1}{2}+1.5\right)\right) - (5\times1.5) - (3\times0.5) - \left(1\times0.5\times\left(\tfrac{0.5}{2}\right)\right) = 0$$

$$2R_B = 7 + 0.125$$

Consider vertical eq^m,

$$\Sigma V = 0 \; [\uparrow +ve, \downarrow -ve]$$

SF calculations :- [from right side → ↑ +ve]

$$SF_B = 5.1 \text{ kN}$$

$$SF_E = +5.1 - (1\times0.5) = +4.6 \text{ kN}$$

without point load

$$SF_E = 5.1 - (1\times0.5) - (5\times1) = -0.4 \text{ kN}$$

with point Load.

$$SF_D = +5.1 - 5 - \left(1\times1\times\left(\tfrac{1}{2}\right)\right) =$$

$$SF_C =$$

BM calculations :- [from right side → $\circlearrowright$ +ve]

$$BM_B = 0$$

$$BM_E = -\left(1\times0.5\times\frac{0.5}{2}\right) + (5.1\times0.5) = 4.25 \text{ kNm}$$

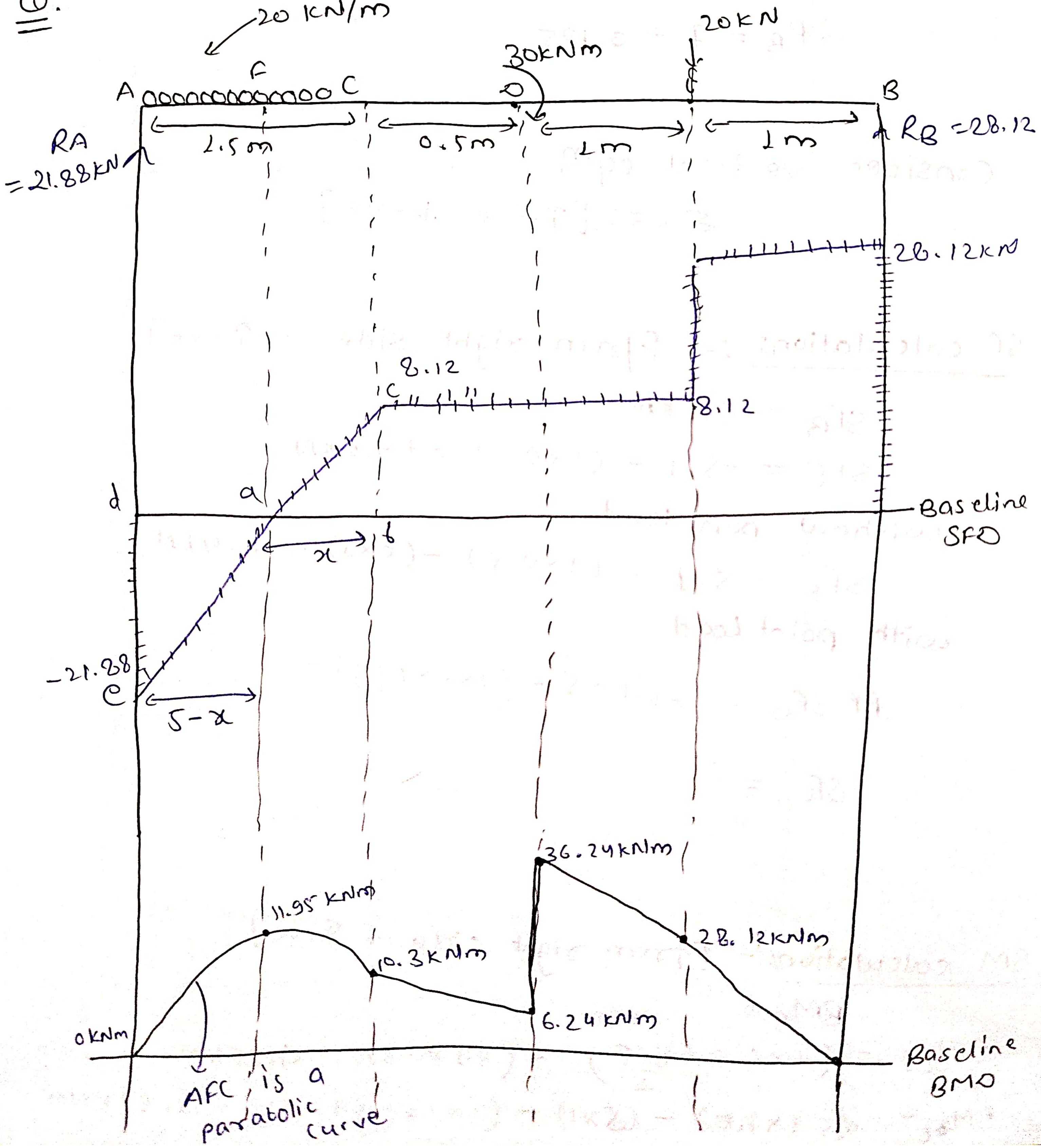
$$BM_C = (5.1\times1.5) - (5\times1) - \left(1\times1\times\left(\tfrac{1}{2}+0.5\right)\right) = 1.65 \text{ kNm}$$

$$BM_D = (5.1 \times 1) - (5 \times 0.5) - (1 \times 1 \times \tfrac{1}{2}) = 2.1 \text{ KNm}$$

$$BM_A = 0$$

$$BM_F = (5.1 \times 1.75) - (5 \times 1.25) - (1 \times 1 \times (\tfrac{1}{2} + 0.75)) - (2 \times 0.25) - (1 \times 0.5 \times (\tfrac{0.5}{2}))$$

$\underline{\underline{Q}}$.



→ Let R_A and R_B be reactions at A and B resp.

Taking moment at A,

$$\Sigma M_A = 0 \quad [\circlearrowright +ve, \circlearrowleft -ve]$$

$$R_B \times 4 - 20 \times 3 - 30 - \left(20 \times 1.5 \times \left(\frac{1.5}{2} + 0\right)\right) = 0$$

$$R_B = \frac{22.5 + 30 + 60}{4}$$

$$\boxed{R_B = 28.125 \text{ KN}}$$

Considering vertical equillibrium,

$$\Sigma V = 0 \quad [\uparrow +ve, \downarrow -ve]$$

$$+28.12 - 20 - (20 \times 1.5) + R_A = 0$$

$$\boxed{R_A = 21.88 \text{ KN}}$$

SF calculations :- [from right side - ↑+ve]

$SF_B = 28.12$ KN

$SF_E = +28.12 - 20 = 8.12$ KN

$SF_D = +28.12 - 20 = 8.12$ KN

$SF_C = +28.12 - 20 = 8.12$ KN

$SF_A = +28.12 - 20 - 20(1.5) = -21.88$ KN

from Δabc & Δade,

$$\frac{ab}{bc} = \frac{ad}{de}$$

$$\frac{x}{8.12} = \frac{5-x}{21.88}$$

$$21.88x = 8.12 \times 5 - 8.12x$$

$$\boxed{x = 0.406 \text{m}}$$

BM calculations :- [from right side ↺ +ve]

$BM_B = 0$

$BM_E = 28.12 \times 1 = +28.12\ kNm$

$BM_D = 28.12 \times 2 - 20 \times 1 = +36.24\ kNm$

without moment

$BM_D = +28.12 \times 2 - 20 \times 1 - 30 = 6.24\ kNm$

with moment

$BM_C = +28.12 \times 2.5 - 20 \times 1.5 - 30 = 10.3\ kNm$

Maximum BM will be at BM_F,

$BM_F = +28.12 \times 2.906 - 20 \times 1.906 - 30$

$- \left(20 \times 0.406 \times \frac{0.406}{2}\right)$

$$\boxed{BM_F = +11.95\ kNm}$$

Q. ⟹ Reactions :-

Let R_A and R_B be the reaction of A & B resp.

Taking momets about A,

$\Sigma M_A = 0$ [↻ +ve, ↺ -ve]

$-2 \times 7 + R_B \times 5 - \left(2 \times 5 \times \frac{5}{2}\right) - 5.5 \times 2 = 0$

$5R_B = 14 + 11 + 25$

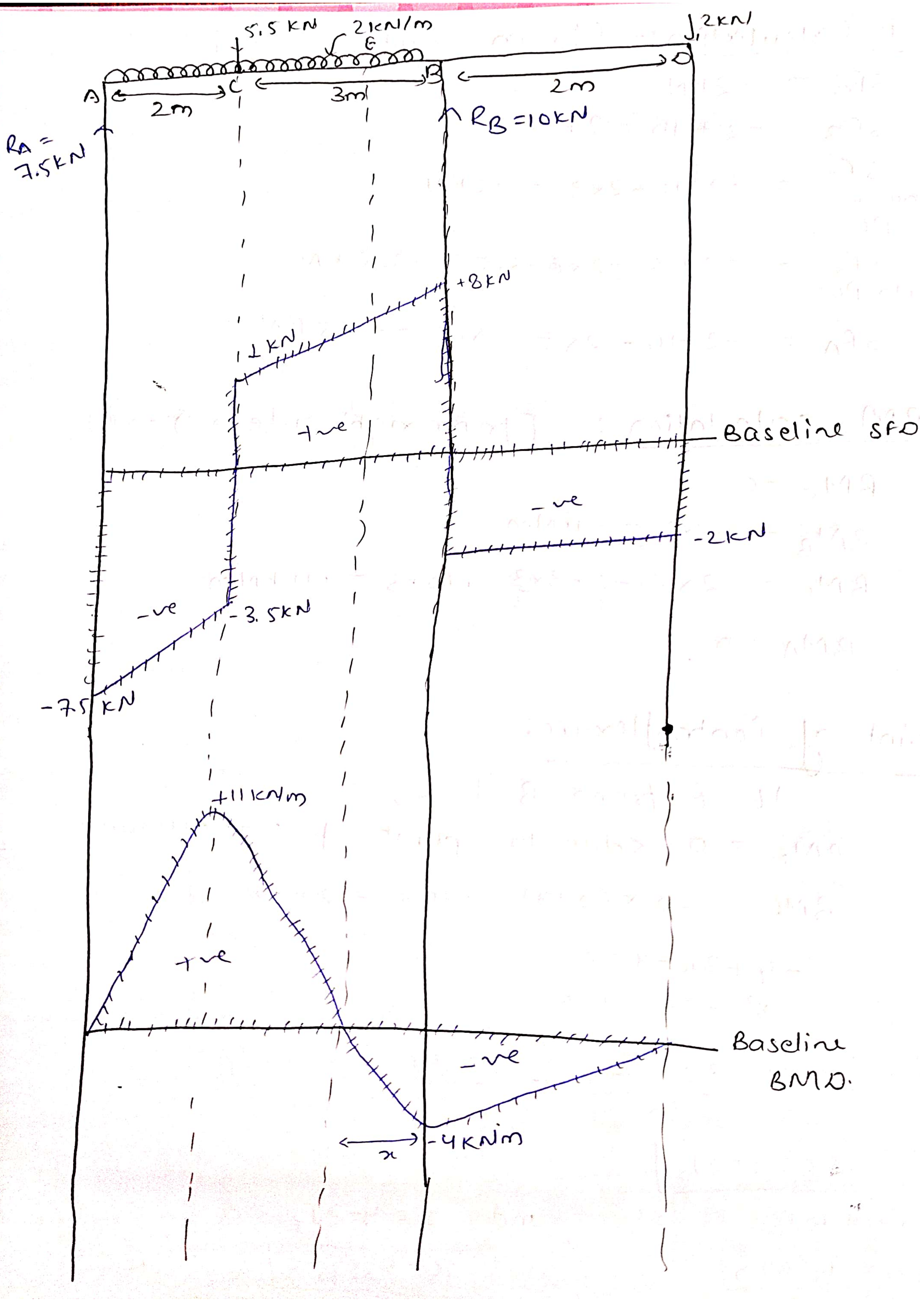
$$\boxed{R_B = 10\ kN}$$

Consider vertical equillibrium,

$\Sigma V = 0$

$+R_A + R_B - 2 - 2.5 - 5.5 = 0$

$$\boxed{R_A = 7.5\ kN}$$


5.5 kN
2 kN/m
E
2 kN
A
C
B
D
2m
3m
2m
RA = 7.5 kN
RB = 10 kN
+8 kN
1 kN
+ve
Baseline SFD
-ve
-2 kN
-ve
-3.5 kN
-7.5 kN
+11 kN/m
+ve
Baseline BMD.
-ve
-4 kN/m
x

SF Calculation :- [from right side → ↑ +ve]

$SF_D = -2\,kN$

$SF_B = -2 + 10 = +8\,kN$

SF_C without PL $= -2+10-2\times3 = +2\,kN$

SF_C with PL $= -2+10-2\times3-5.5 = -3.5\,kN$

$SF_A = -2+10-2\times5-5.5 = -7.5\,kN$

BM calculation :- [from right side → ↺ +ve]

$BM_D = 0$

$BM_B = -2\times2 = -4\,kNm$

$BM_C = -2\times5 - 2\times3\times\frac{3}{2} + 10\times3 = +11\,kNm$

$BM_A = 0.$

Point of Contraflexure :-

At E from B to C,

$BM_E = 0$ <due to point of contraflexure>

$BM_E = -2\times(2+x) + 10x - 2x\times\frac{x}{2} = 0$

$-4 + 8x - x^2 = 0$

$x^2 - 8x + 4 = 0$

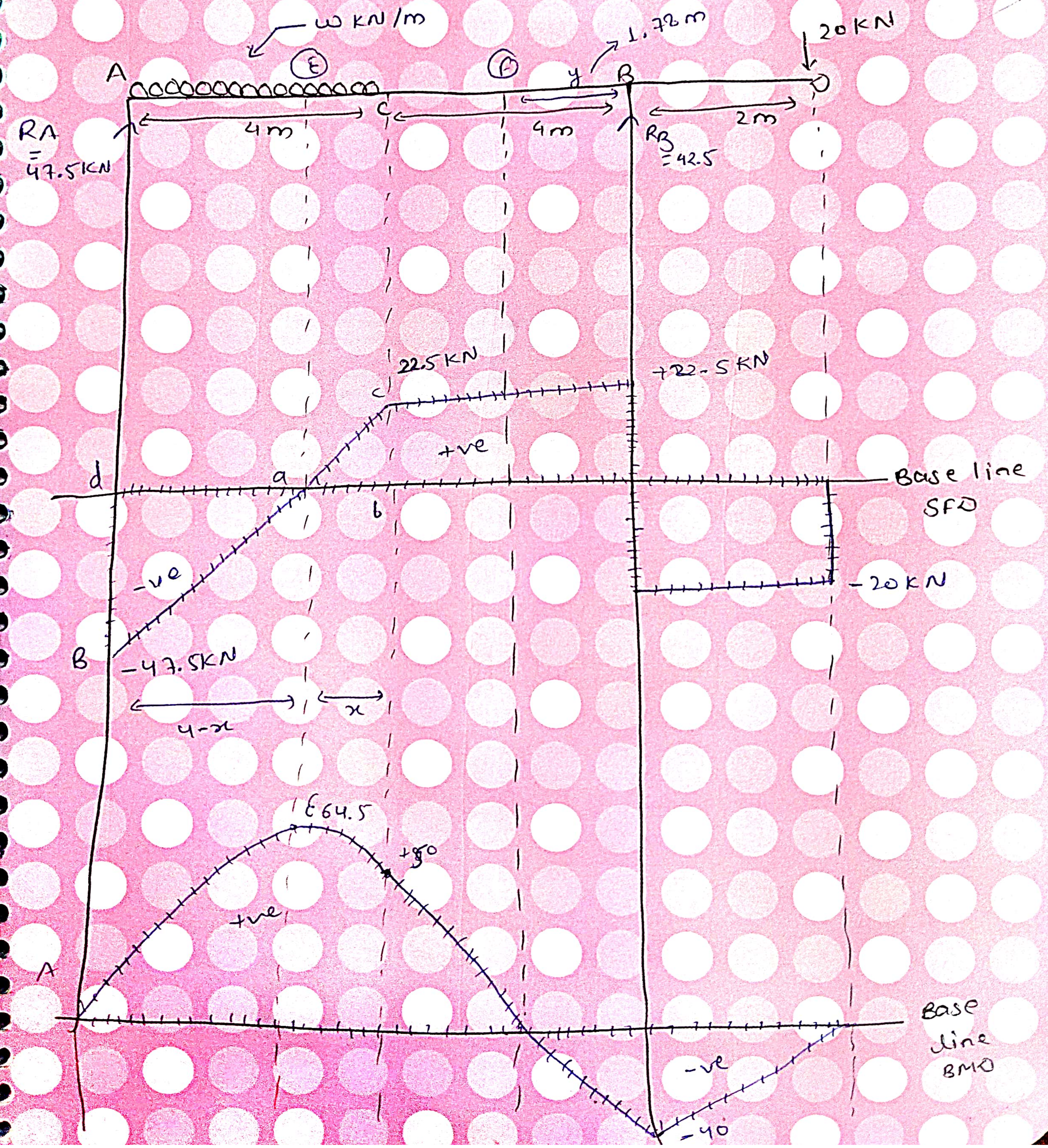
$x = \frac{8\pm\sqrt{64-16}}{2} = \frac{8\pm\sqrt{48}}{2} = \frac{8\pm4\sqrt{3}}{2}$

$\boxed{x = 4\pm2\sqrt{3}}$

$x = 4+2\sqrt{3}$ and $x = 4-2\sqrt{3}$

$\boxed{x = 7.464\,m}$ $\boxed{x = 0.535\,m}$

Q. Determine the value of UDL so that the BM at section C is 50 kN-m for the beam loaded as shown in fig. Draw the SFD and BMD. For this beam, for the calculated value of UDL, also noted the point of contraflexure if any.



→ Reactions:- Let R_A and R_B be the reactions at A and B respectively.

Let w kN/m be the intensity of UDL.

Taking moment about A,

$$\Sigma M_A = 0 \quad [\circlearrowright +ve, \circlearrowleft -ve]$$

$$-20 \times 10 + R_B \times 8 - \left(w \times 4 \times \frac{4}{2}\right) = 0$$

$$8R_B - 8w = 200$$

$$\boxed{R_B - w = 25} \quad \text{—(1).}$$

Considering vertical equillibrium,

$$\Sigma V = 0 \quad [\uparrow +ve, \downarrow -ve]$$

$$-20 + R_B - w \times 4 + R_A = 0$$

$$\boxed{R_B + R_A - 4w = 20} \quad \text{—(2).}$$

∵ BM. at C is 50 KN.m.

– BM Calculation at C:- [from right side, $\circlearrowright$ +ve]

$$BM_C = -20 \times 6 + R_B \times 4 = 50$$

$$4R_B = 170$$

$$\boxed{R_B = 42.5 \text{ KN}}$$

from (1),

$$42.5 - w = 25$$

$$\boxed{w = 17.5 \text{ KN}}$$

from (2),

$$42.5 + R_A - 4 \times 17.5 = 20$$

$$R_A = 20 + 70 - 42.5$$

$$R_A = 90 - 42.5$$

$$\boxed{R_A = 47.5 \text{ KN}}$$

from Δabc & Δade,

$$\frac{ab}{ad} = \frac{bc}{de}$$

$$\Rightarrow \frac{x}{4-x} = \frac{22.5}{47.5}$$

$$47.5x = 90 - 22.5x$$

$$70x = 90$$

$$x = \frac{9}{7} = 1.28$$

$$\boxed{x = 1.28\,m}$$

- BM Calculation :-

$BM_D = 0$

$BM_B = -20 \times 2 = -40\,KNm$

$BM_C = -20 \times 6 + 42.5 \times 4$

$BM_C = 50\,KNm$

$BM_A = 0$

Maximum BM will be BM at E,

$$BM_E = -20 \times 7.28 + 42.5 \times 5.28 - 17.5 \times 1.28 \times \left(\frac{1.28}{2}\right)$$

$$-145.6 + 224.4 - 14.3$$

$$\boxed{BM_E = 64.5\,KNm}$$

- SF Calculation :-

[from right side - ↑ +ve]

$SF_D = -20\,KN$

$SF_B = -20 + 42.5 = 22.5\,KN$

$SF_C = -20 + 42.5 = 22.5\,KN$

$SF_A = -20 + 42.5 - 17.5 \times 4$

$SF_A = -47.5\,KN.$

- Point of contraflexure :-

At F, BM = 0

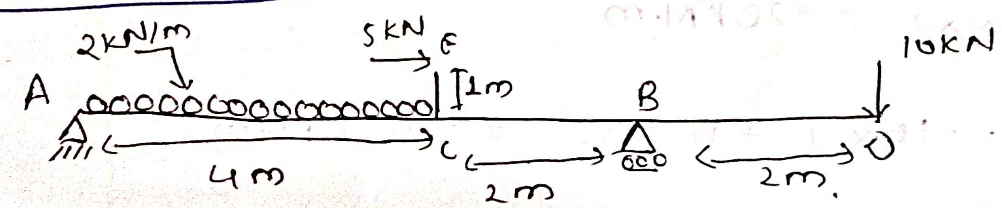
$BM_F = -20(2+y) + 42.5y = 0$

$\Rightarrow -40 - 20y + 42.5y = 0$

$\Rightarrow 22.5y = 40$

$$\boxed{y = 1.78\,m}$$

Q.



→ Let R_{AV} and R_B be the reactions of A and B respectively.

Taking moment about A,

$\Sigma M_A = 0$ [↻ +ve, ↺ -ve]

$-10 \times 8 + R_B \times 6 - 5 - 4 \times 2 \left(\frac{4}{2}\right) = 0$

$-80 + 6R_B - 5 - 16 = 0$

$R_B = \frac{101}{6}$

$\boxed{R_B = 16.8 \text{ KN}}$

Considering vertical equilibrium,

$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$-10 + R_B - 2 \times 4 + R_{AV} = 0$

$R_{AV} = 18 - 16.8$

$\boxed{R_{AV} = 1.2 \text{ KN}}$

- SF calculation :- [from right side – ↑ +ve]

$SF_D = -10 \text{KN}$

$SF_B = -10 + 16.8 = 6.8 \text{KN}$

$SF_C = -10 + 16.8 = 6.8 \text{KN}$

$SF_A = -10 + 16.8 - 8 = -1.2 \text{KN}$

- BM calculation :- [from right side – ↻ +ve]

$BM_D = 0$

$BM_B = -10 \times 2 = -20 \text{KN.m}$

BM_C without moment $= -10 \times 4 + 16.8 \times 2 = -6.4 \text{KNm}$

$BM_A = -10\times 8 + 16.8\times 6 - 5 - \left(2\times 4\times \frac{4}{2}\right)$

$= 0$

BM_C with moment $= -6.4 - 5 = -11.4$ KN m

$BM_F = -10 \times 7.4 + 16.8 \times 5.4 - 5 - 2 \times 3.4 \times \frac{3.4}{2}$

$BM_F = -7.4 + 90.72 - 5 - 11.56$

$\boxed{BM_F = 0.16 \text{ KN}}$

from Δabc & Δade

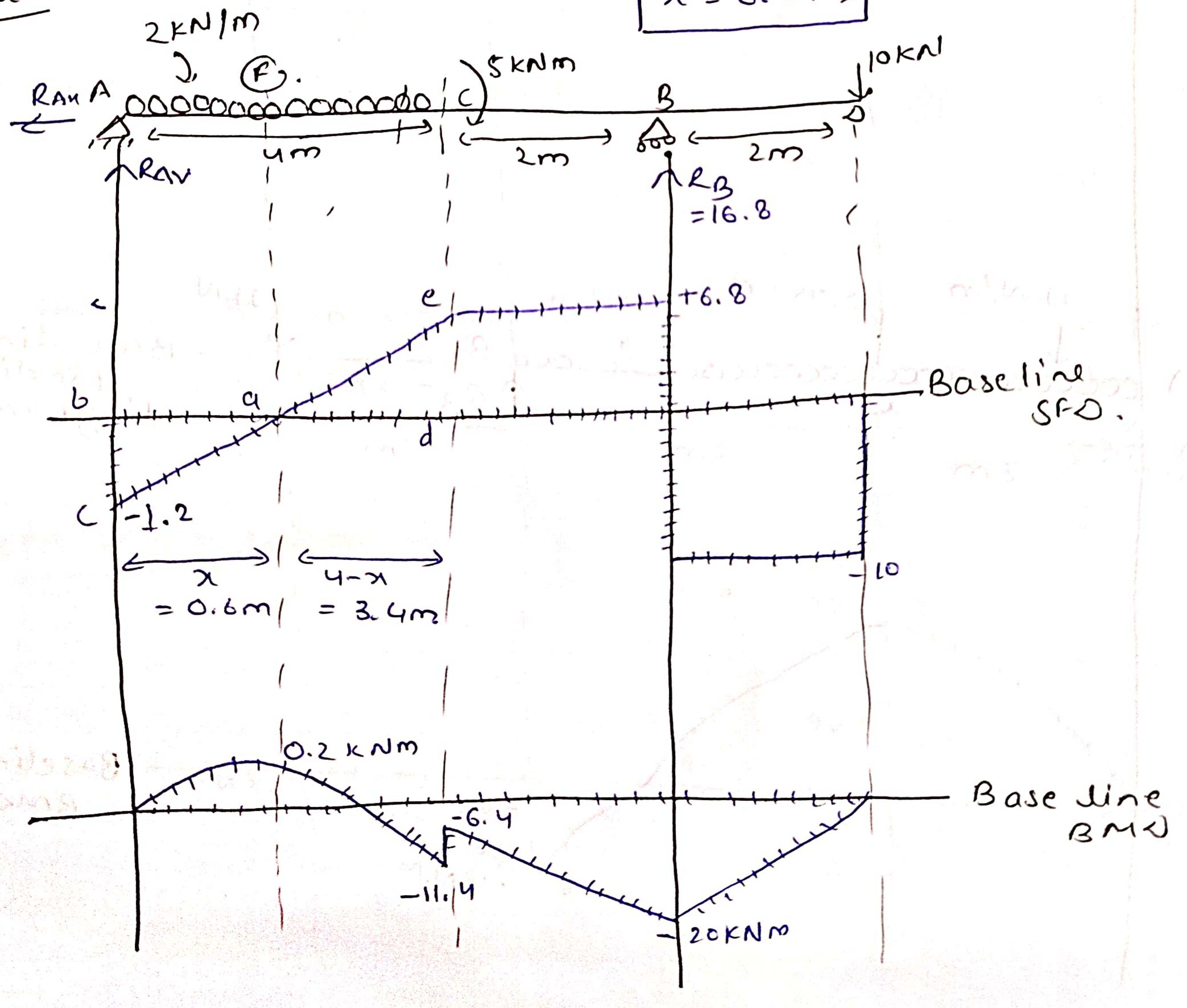
$\frac{ab}{ad} = \frac{bc}{de}$

$\Rightarrow \frac{x}{4-x} = \frac{1.2}{6.8} \Rightarrow 6.8x = 4.8 - 1.2x$

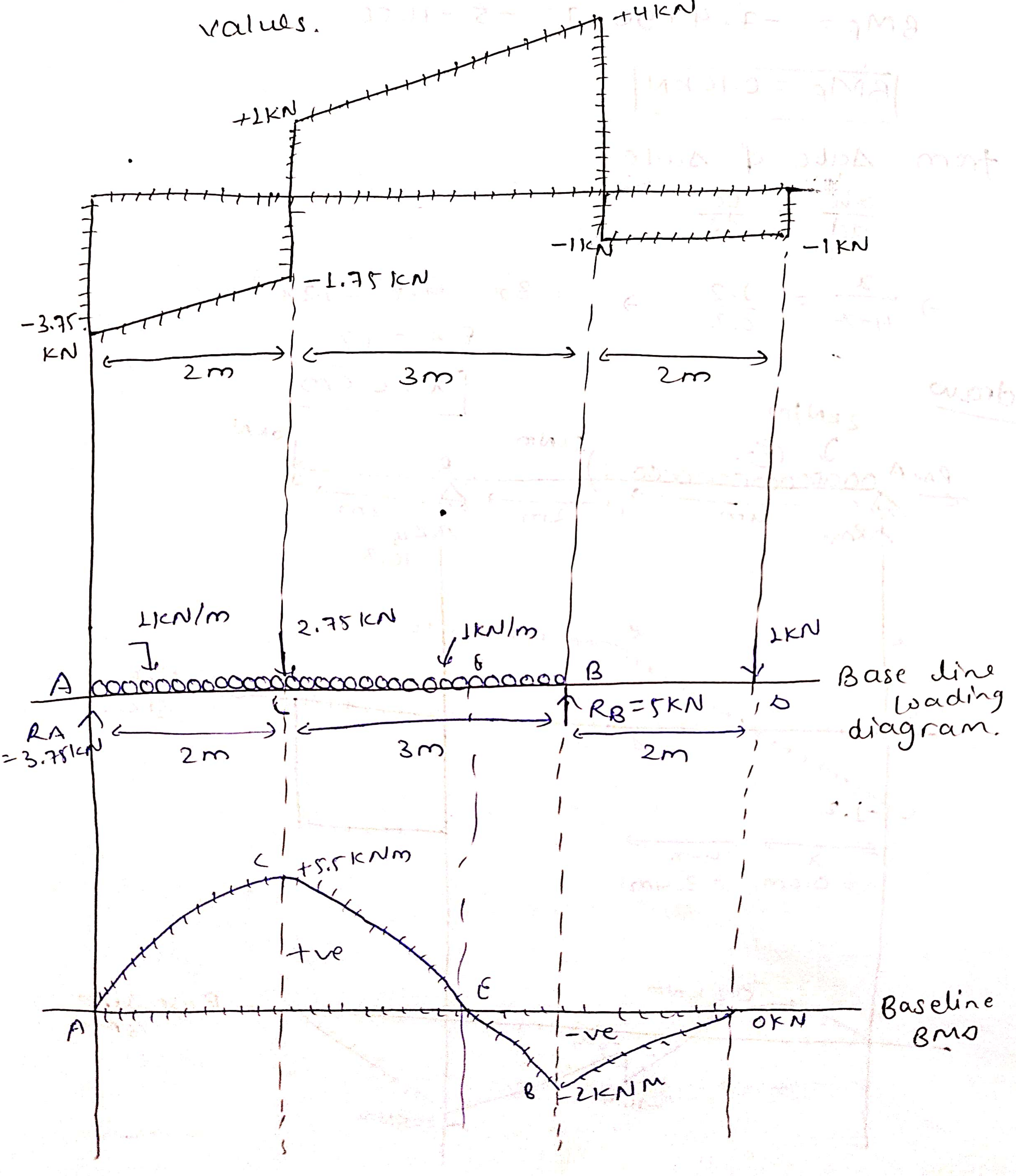
$8x = 4.8$

$\boxed{x = 0.6 \text{ m}}$

Redraw



Q. The SFD for the beam rest on 2 supports one being at the left hand side as shown in fig. Determine the values of loads & draw the loading diagram. Also calculate the values of BMs and draw the BMD with principle values.



→ By the inspection of diagram. The other support will be at B whose SF increasing suddenly in upward direction.

→ As given in fig. (problem) - one support is at LHS of fig.

→ The SF is constant D to B and it is going down at D so there is point load of 1KN in downward direction.

→ The value of reaction of B. R_B will be

$$R_B = 4+1 = 5\ KN$$

∵ SF decreasing from 4KN to 1KN, from B to C, linearly, there should be a UDL with intensity

$$= \frac{+4-(+1)}{3} = \boxed{+1\ KN/m}$$

→ There is a drop of SF from 1KN to -1.75 KN at C there is point load of (1+1.75)

$$\boxed{= 2.75\ KN}$$

∵ The SF again varies from -1.75 to -3.75 KN linearly from C to A, there should be a UDL of intensity

$$= \frac{(-1.75) - (-3.75)}{2} = \boxed{1\ KN/m}$$

- BM calculation :-

$BM_D = 0$

$BM_B = -1 \times 2 = -2\ KN\text{-}m$

$BM_C = (-\times 5) - (1 \times 3 \times \frac{3}{2}) = +5.5\ KN$
$+5 \times 3$

$BM_A = 0\ KN.$

- Point of contraflexure :- At E from B to C.

$$BM_E = 0$$

$$BM_E = -1\times(2+x) + 5x - 1\times x\times\frac{x}{2} = 0$$

$$\Rightarrow -2 + 4x - \frac{x^2}{2} = 0$$

$$-4 + 8x - x^2 = 0$$

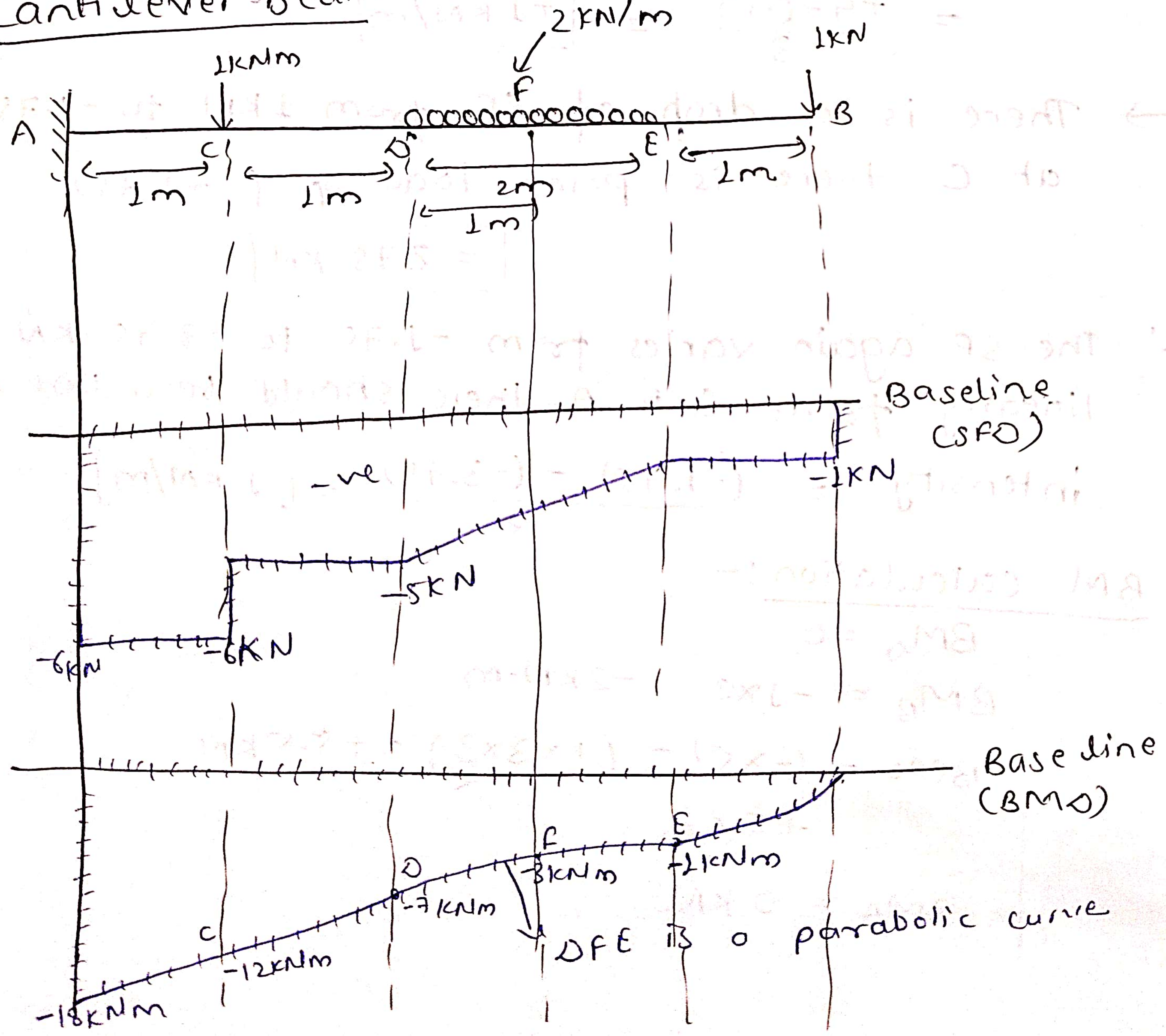
$$x^2 - 8x + 4 = 0 \longrightarrow x = \frac{8\pm\sqrt{64-16}}{2} = \frac{8\pm4\sqrt{3}}{2}$$

$$\boxed{x = 4\pm2\sqrt{3}}$$

$$x = 4-2\sqrt{3}$$

$$\boxed{x = 0.54\,m}$$

Cantilever Beam :-



→ **SF calculation** :- [from right side — ↑ +ve]

$SF_B = -1KN$

$SF_E = -1KN$

$SF_D = -1-2\times2 = -5KN$

$SF_C = -1-2\times2 -1 = -6KN$

$SF_A = -6KN$

BM Calculation :- [from right side → ↻ +ve]

$BM_B = 0$

$BM_E = -1\times1 = -1KNm$

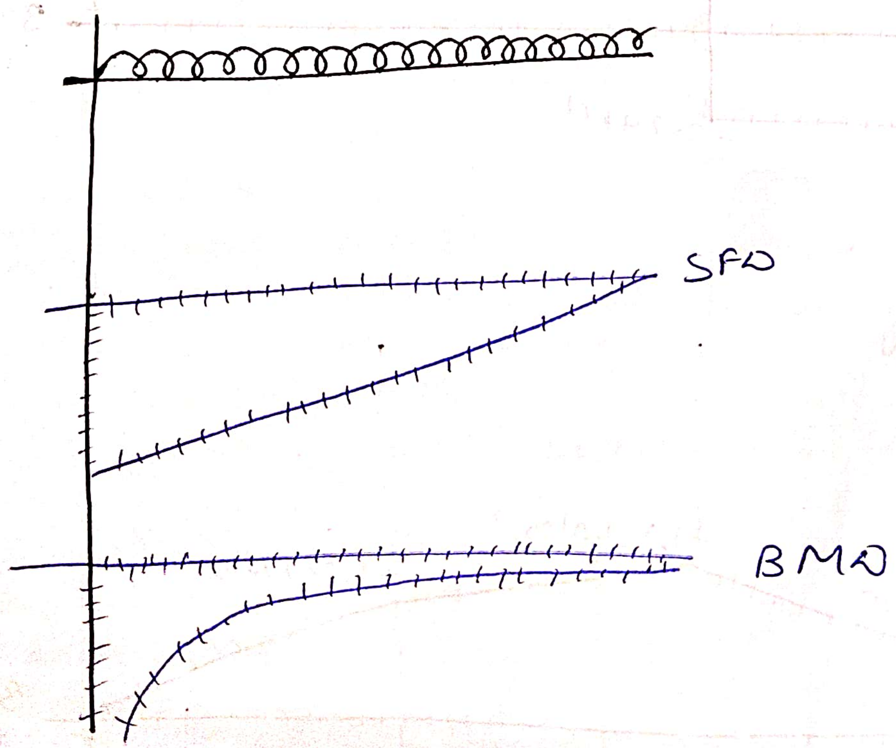
$BM_D = -1\times3 - 2\times2\times\frac{2}{2} = -7KNM$

$BM_C = -1\times4 - 2\times2\times\left(1+\frac{2}{2}\right) = -12\ KNm$

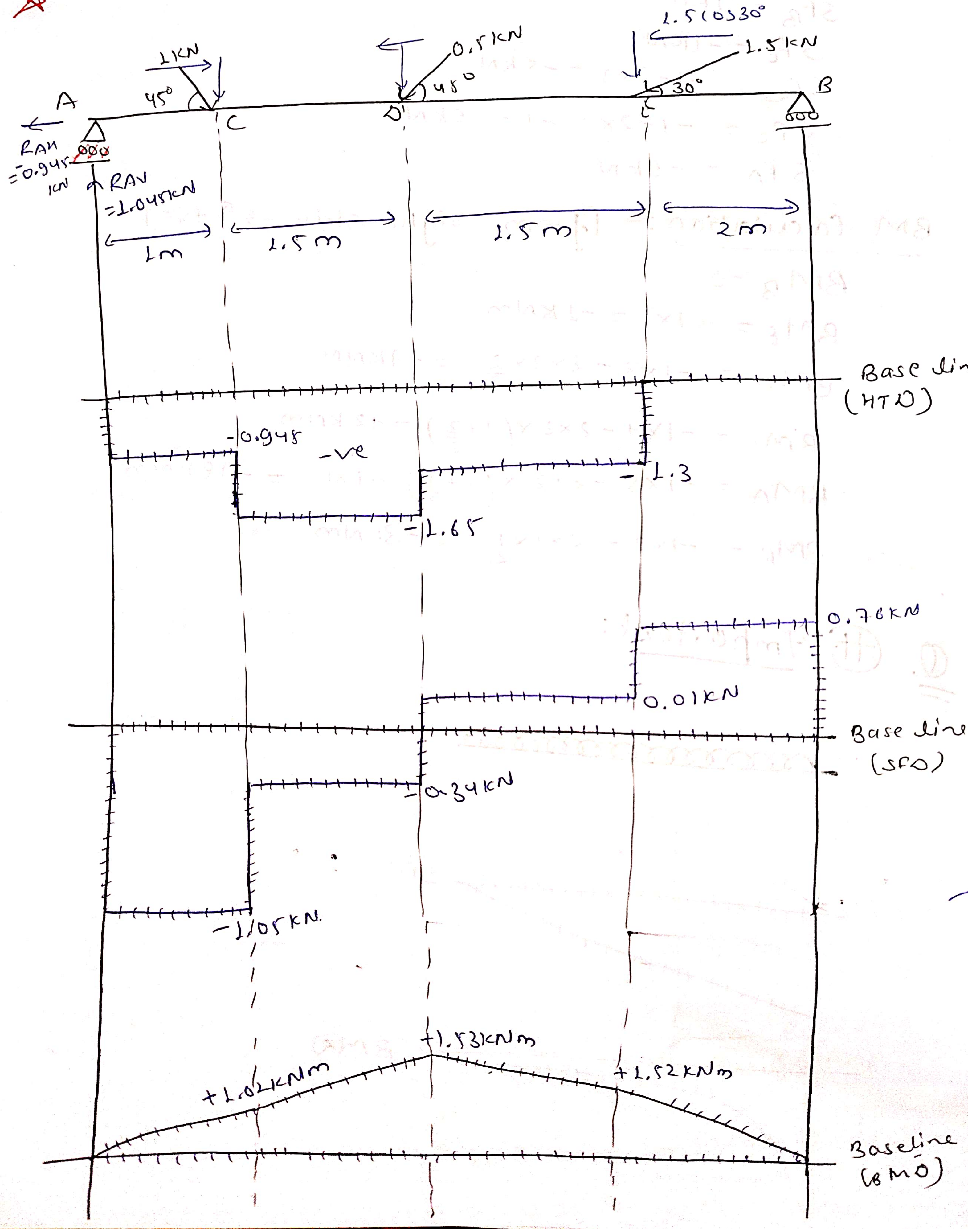
$BM_A = -1\times5 - 2\times2\times\left(2+\frac{2}{2}\right) - 1\times1 = -18\ KNm$

$BM_F = -1\times2 - 2\times1\times\frac{1}{2} = -3KNm$

Q # **Important** :-



HTD : Horizontal Thrust Diagram :-



→ Let R_{AV} & R_{AH} be reaction at A.

Let R_B be the reaction at B.

Taking moment about A.

$$\Sigma M_A = 0 \quad [\circlearrowright +ve, \circlearrowleft -ve]$$

$$\Rightarrow R_B \times 6 - 1.5 \sin 30^\circ \times 4 - 0.5 \sin 45^\circ \times 2.5 - 1 \cos 45^\circ \times 1 = 0$$

$$\Rightarrow 6R_B - 3 - 0.88 - 0.70 = 0$$

$$\boxed{R_B = 0.76\,KN}$$

Consider vertical equilibrium,

$$\Sigma V = 0 \quad [\uparrow +ve, \downarrow -ve]$$

$$+R_A + R_B - 1.5 \sin 30^\circ - 0.5 \sin 45^\circ - 1 \sin 45^\circ$$

$$R_A = 0.353 + 0.707 + 0.75 - 0.76$$

$$\boxed{R_{AV} = 1.045\ KN}$$

Consider horizontal equilibrium,

$$\Sigma H = 0 \quad [\rightarrow (+ve), \leftarrow (-ve)]$$

$$-1.5 \cos 30^\circ - 0.5 \cos 45^\circ + 1 \cos 45^\circ - R_{AH} = 0$$

$$\boxed{R_{AH} = -0.945\ KN}$$

- HTD Calculation:-

[from right side → (+ve)]

$HT_B = 0\,KN$

$HT_E = -1.5 \cos 30^\circ = -1.3\,KN$

$HT_D = -1.5 \cos 30^\circ - 0.5 \cos 45^\circ = -1.65\,KN$

$HT_C = -1.5 \cos 30^\circ - 0.5 \cos 45^\circ + 1 \cos 45^\circ$

$= -0.945\ KN$

$HT_A = -0.945\ KN$

- SF calculation:-

[from right side → ↑ +ve]

$SF_B = +0.76\,KN$

$SF_E = +0.76 - 1.5 \sin 30^\circ$

$= 0.01\,KN$

$SF_D = 0.76 - 0.75 - 0.5 \sin 45^\circ$

$= -0.34\ KN$

$SF_C = 0.76 - 0.75 - 0.5 \sin 45^\circ - 1 \sin 45^\circ = \cancel{10}$

$\boxed{-1.05\,KN}$

- BM calculation :- (from right side ...)

$BM_B = 0$

$BM_E = R_B \times 2 = 0.76 \times 2 = +1.52$ KNm

$BM_D = 0.76 \times 3.5 - 1.5 \sin 30° \times 1.5 = 2.66 - 1.125$

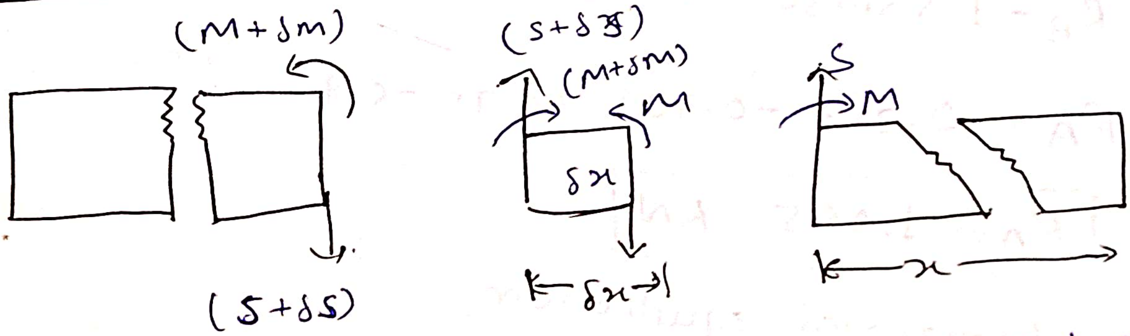
$= +1.535$ KNm

$BM_C = 0.76 \times 5 - 1.5 \sin 30° \times 3 - 0.5 \sin 45° \times 1.5$

$= 3.8 - 2.25 - 0.53 = 1.02$ KN

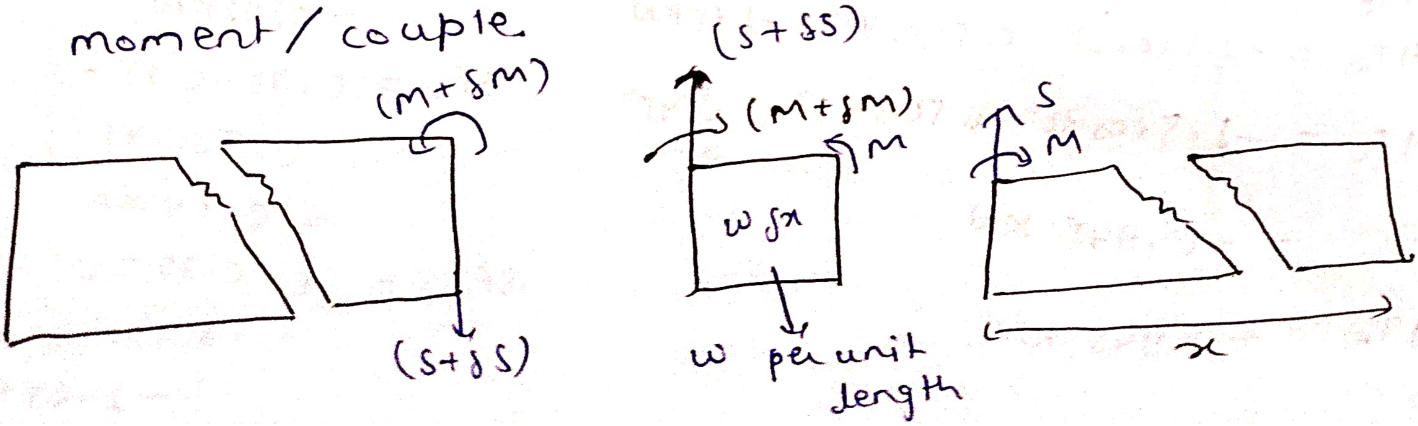
$BM_A = 0.$

- Relation between shear force & Bending moment :-



Consider a short length δx of a beam at a distance x from some origin. Let the load over the short length be w per unit length acting vertically downward.

Then, the shearing forces over this short length will increase from S to $S + \delta S$ while the BM increases from M to $M + \delta M$. This short length is in equilibrium under both vertical forces & moment / couple.



Vertical forces :- $(S+\delta S) - S = w\delta x$

$$\frac{\delta S}{\delta x} = w \quad \text{or} \quad \boxed{\frac{dS}{dx} = w} \quad \text{—} ①$$

Moments / Couples :- $(M-(M+\delta M)) = -S\delta x - w\delta x\left(\frac{\delta x}{2}\right)$

$$\Rightarrow -\delta M = -S\delta x - \frac{w}{2}\cancel{(\delta x)^2}^{\,0}$$

$\because (\delta x)^2$ is very small quantity of 2nd order, so it can be taken as zero.

$$\Rightarrow -\delta M = -S\delta x$$

$$\Rightarrow \boxed{\frac{\delta M}{\delta x} = S = \frac{dM}{dx}} \quad \text{—} ②$$

In the integral form, we get,

$$S = \int w\,dx \quad \text{—} ③.$$

$$M = \int S\,dx \quad \text{—} ④.$$

Conclusion :-

① . from eq. ① . It is concluded that rate of change of shear force at any section represents the ~~rate of~~ ~~rate of~~ loading at that section.

② . from eq. ② , we can conclude that rate of change of bending moment at any section represent the shear force at that section.