



The Shirpur Education Society's

**R. C. Patel College of Engineering and  
Polytechnic, Shirpur**

Department of Mechanical Engineering

**NAME OF COURSE:** - Strength of Materials

**CODE OF COURSE:** - 313308

**SEMESTER:** - SYME-3K

**SUBJECT TEACHER:** - Mr. Laxmikant Y.Borse



The Shirpur Education Society's  
**R. C. Patel College of Engineering and Polytechnic, Shirpur**

**QUESTION BANK**

**CHAPTER 3. Shear force and Bending Moments**

Program Name: Mechanical Engineering

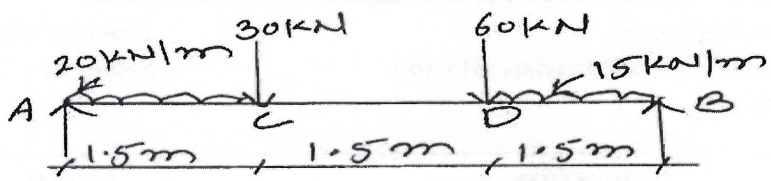
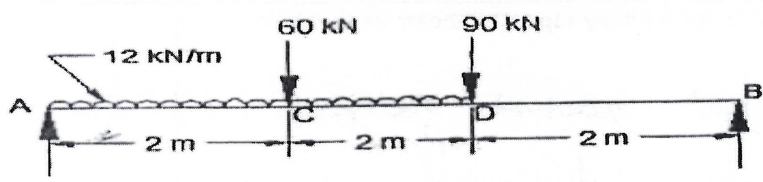
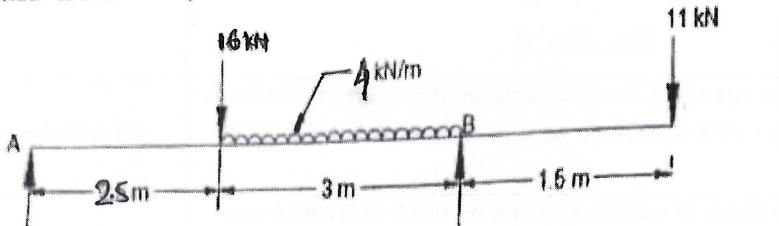
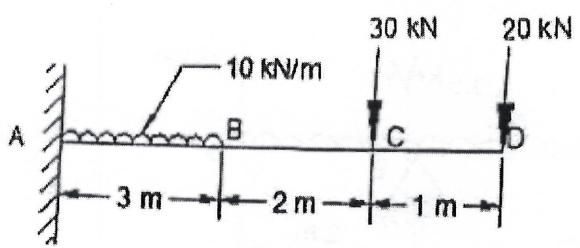
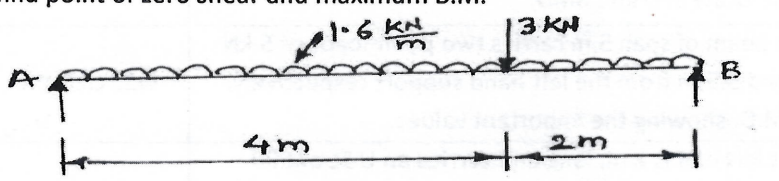
Name of Subject & Code : Strength of Materials (313308)

Date & Time Slot: 08/06/2026 ;

Program Code: ME3k

Semester : Third

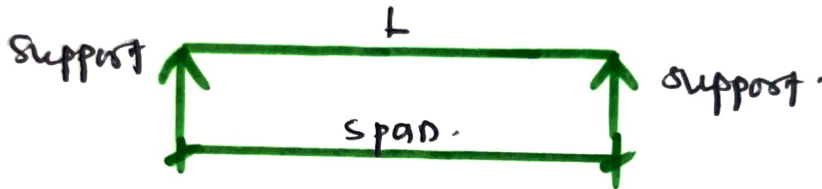
Q. NO.	QUESTION	DETAIL	MAPPING
1	State relation between shear force and bending moment.	S25 Q1f 2M	CO 3.3R
2	Define shear force and bending moment.	W25 Q1c2M	CO 3.3 U
3	Define point of contra flexure and point of contra shear	W24 Q1D 2M	CO 3.5 R
4	<p>Draw S.F.D. and B.M.D. for a simply supported beam as shown in Figure No. 3.</p> <p style="text-align: center;"><b>Fig. No. 3</b></p>	W24 Q4A 4M	CO 3.4 A
5	A cantilever beam of span 3 m carries a point load of 5 kN at 2 m from the support and u.d.l. of 4 kN/m over the entire span. Draw S.F. and B.M. diagrams.	S25 Q2D 4M	CO 3.4 A
6	A simply supported beam of span 7 m carries an u.d.l. of 2 kN/m over 4 m length from left hand support and a point load of 5 kN at 2 m from right hand support. Draw S.F. and B.M. diagram.	S25 Q3C 4M	CO 3.4 A
7	<p>Draw shear force and bending moment diagram for the beam as shown in Fig. No. 1</p> <p style="text-align: center;"><b>Fig. No. 1</b></p>	S24 Q4A 4M	CO 3.4 A
8	A simply supported beam of span 'L' carrying an udl of w/unit length over the entire span. Draw SFD and BMD.	S25 Q4E 4M	CO 3.4 A
9	A simply supported beam of span 5 m carries two point loads of 5 kN and 7 kN at 1.5 m and 3.5 m from the left hand support respectively. Draw S.F.D. and B.M.D. showing the important values.	W25 Q2C 4M	CO 3.5 A
10	A cantilever fixed at left end is 2 m. long and carries an UDL of 500 N/m. A point load of 800 N and 600 N act at 1 m and 2 m from fixed end respectively. Draw SF and BM Diagram.	W24 Q5A 6M	CO 3.4 A

<p style="text-align: center;">11</p>	<p>Draw the shear force and bending moment diagrams for the beam as shown in Figure No. 4.</p>  <p style="text-align: center;"><b>Fig. No. 4</b></p>	<p style="text-align: center;">W24 Q5B 6M</p>	<p style="text-align: center;">CO 3.4 A</p>
<p style="text-align: center;">12</p>	<p>Draw SFD and BMD diagram for a simply supported beam as shown in Fig. No. 2. Also find maximum shear force and bending moment locate point of zero shears.</p>  <p style="text-align: center;"><b>Fig. No. 2</b></p>	<p style="text-align: center;">S26 Q5A 6M</p>	<p style="text-align: center;">CO 3.5 A</p>
<p style="text-align: center;">13</p>	<p>Draw SF and B.M. diagram for the beam as shown in Figure. No. 3. Also Locate the point of contraflexure.</p>  <p style="text-align: center;"><b>Fig. No. 3</b></p>	<p style="text-align: center;">S26 Q5B 6M</p>	<p style="text-align: center;">CO 3.5 A</p>
<p style="text-align: center;">14</p>	<p>A cantilever beam is loaded as shown in fig.No.4. Draw the SFD and BMD</p>  <p style="text-align: center;"><b>Fig. No. 4</b></p>	<p style="text-align: center;">S26 Q5C 6M</p>	<p style="text-align: center;">CO 3.5 A</p>
<p style="text-align: center;">15</p>	<p>Draw SF and BM diagram for the beam as shown in Fig. No. 3. Also find point of zero shear and maximum B.M.</p>  <p style="text-align: center;"><b>Fig. No. 3</b></p>	<p style="text-align: center;">S24 Q5C 6M</p>	<p style="text-align: center;">CO 3.4 A</p>

**SHEAR FORCE AND BENDING MOMENT**

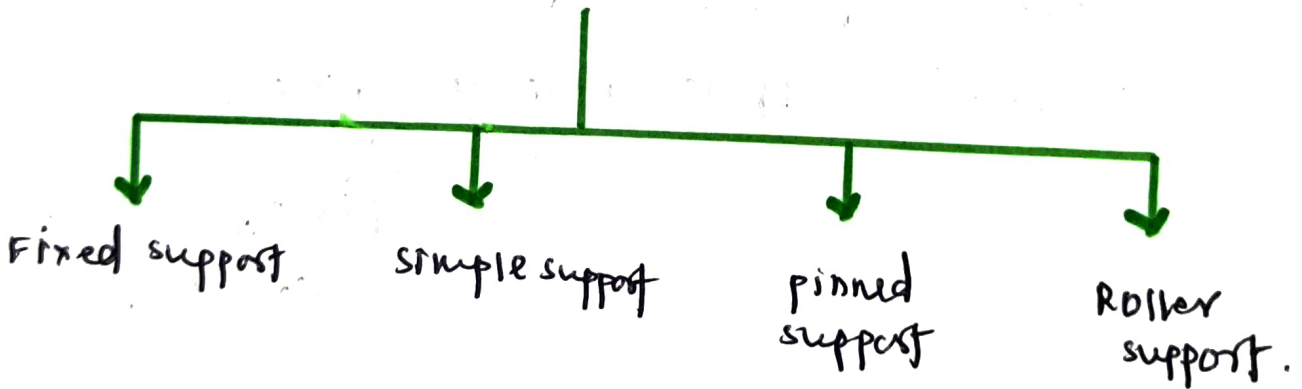
3.1  
Beam - It is a horizontal or inclined structural member having a span bet<sup>n</sup> one or more supports and carrying a vertical loads across its longitudinal axis.

Span:- it is the distance bet<sup>n</sup> two intermediate support of a structure.



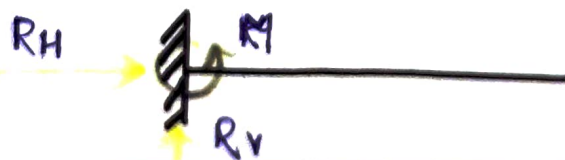
3.2

\* TYPES OF SUPPORTS



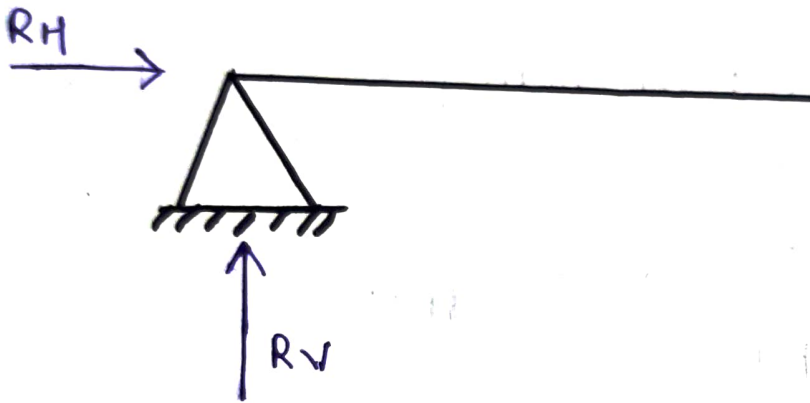
① Fixed support -

- A fixed support is the most rigid type of support
- It cannot move or rotate in any directions.
- it is widely used as only support for cantilever.



② pinned support:- it is also called Hinged support.

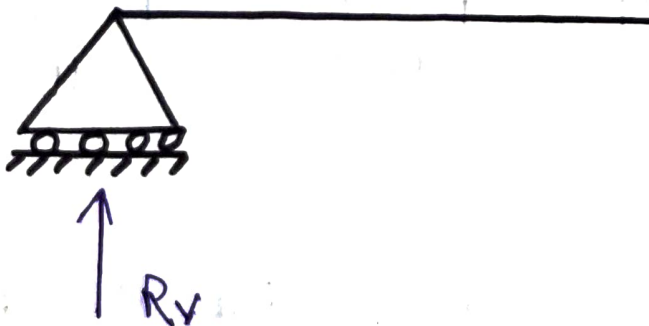
- it is very common type of support
- it resist vertical and horizontal forces but not a moment.
- pinned support can be used in trusses.



Fixity code:-  
Horizontal and vertical.

③ Roller support:- Roller support can resist the vertical force.

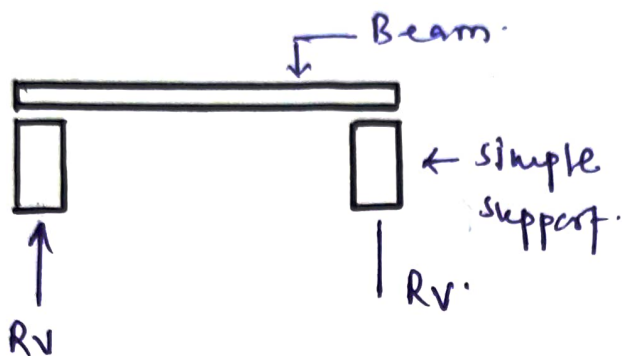
- This support rest on rollers.



Fixity code:-  
Vertical

④ Roller support! - A roller support basically used where the member rests on external structure.

- They are quite similar to roller support. In the sense they are able to resist vertical forces.



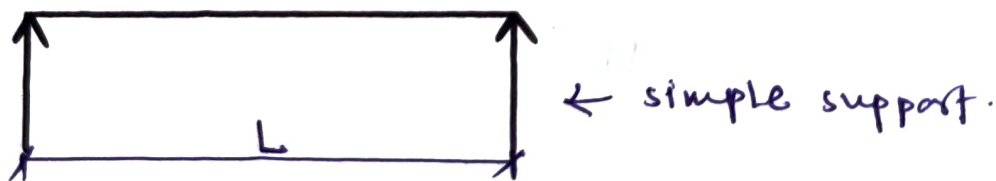
Fixity code: - vertical.
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3.3

## \* TYPES OF BEAMS

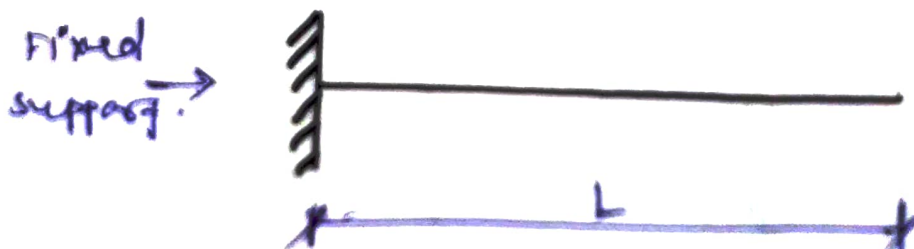
① Simply supported beam :-

- simply supported beams are defined as having two supports at either end.



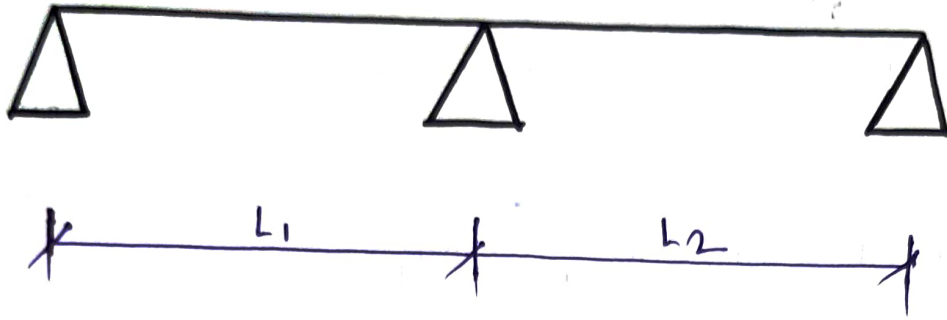
② cantilever beam :-

cantilever beams are supported from one end, using a fixed support.



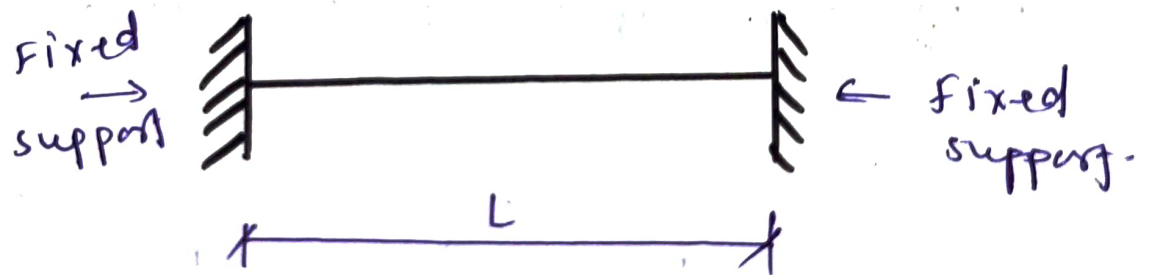
### ③ Continuous Beam:-

- Continuous beams are multi spanned beams that have multiple supports i.e more than two. Support across it's span.

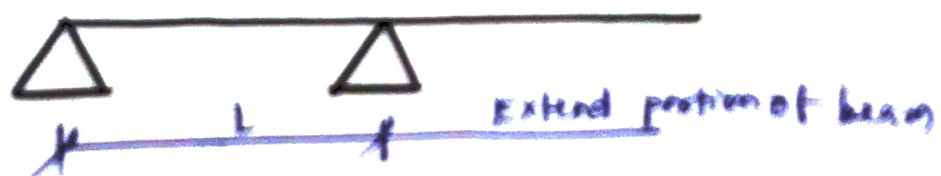


### ④ Fixed Beam:-

- Fixed beams have Fixed supports at either end.  
- This type of beam used when we to control the deflection at mid span because two fixed support prevent rotation.



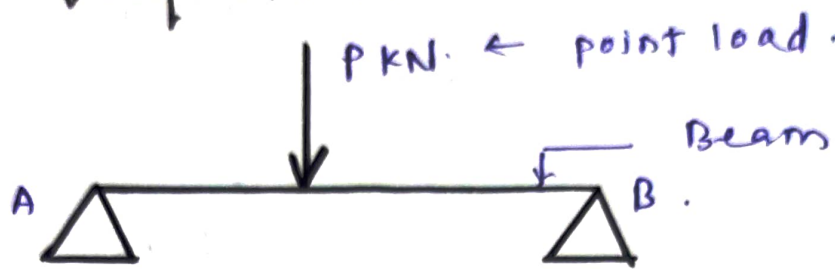
⑤ Over hang Beam:- A beam in which some portion of beam extends beyond the support is called overhang beam.



### 3.2 TYPES OF LOADS:-

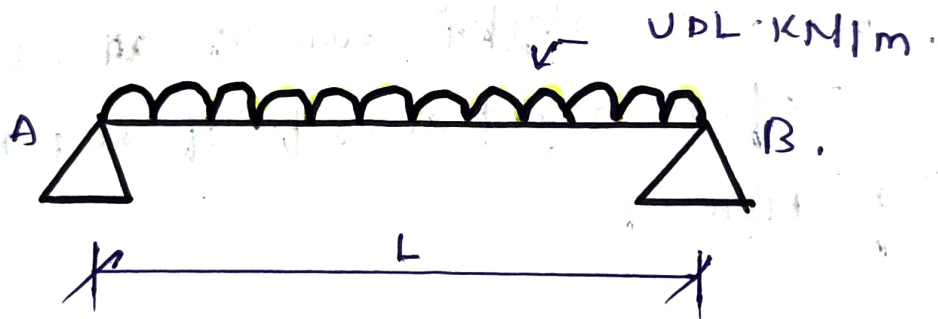
#### ① point load or concentrated load:-

A point load is a concentrated action or load on a structural element which acts only on a very small area i.e. on point.



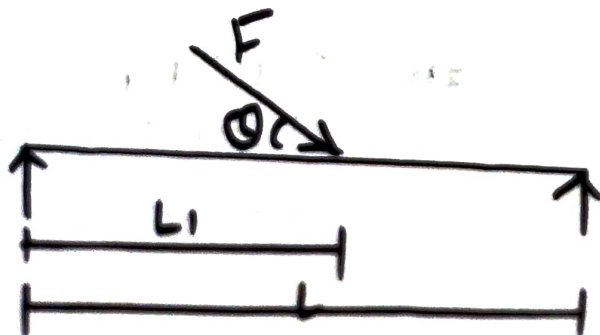
#### ② Uniformly Distributed load:-

it is a load that is distributed across the whole span of structural member



#### ③ Inclined point load:-

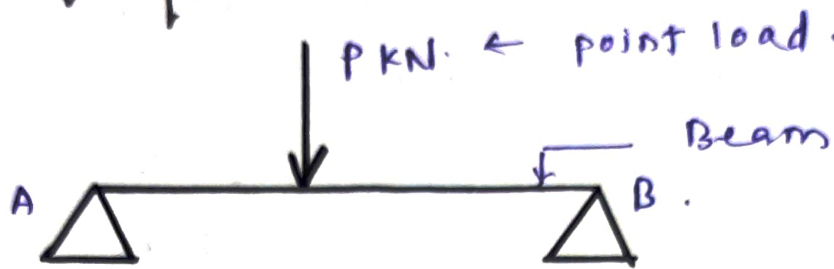
- When a line of action of a load is not vertical but makes angle with axis of beam, then it's called as inclined load.



### 3.2 TYPES OF LOADS:-

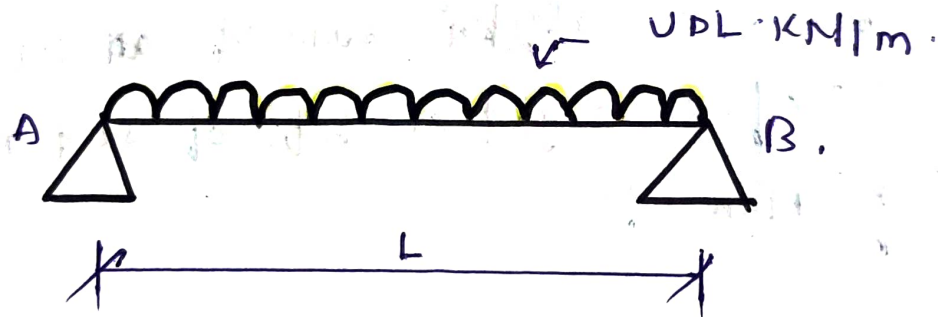
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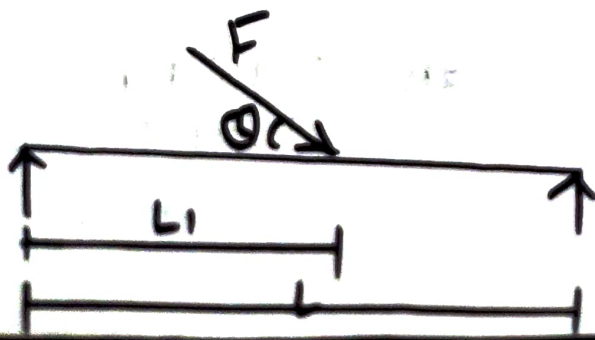
#### ② Uniformly Distributed load:-

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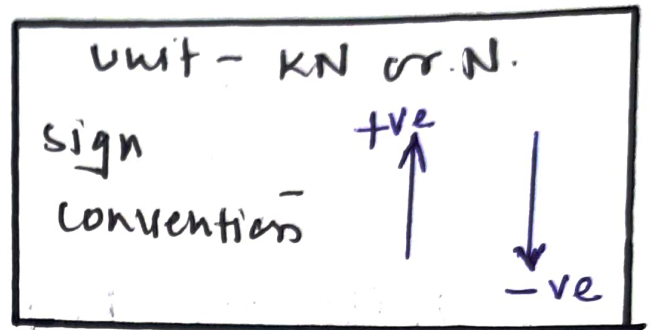
#### ③ Inclined point load:-

- When a line of action of a load is not vertical but makes angle with axis of beam, then it's called as inclined load.



\* Shear force - it is an internal force that acts parallel to the cross-section of structural member  
or

Shear force at any US of the beam is the algebraic sum of all vertical forces on the beam acting on left or right side of the section is called shear force.



Bending Moment: - Bending moment at any US of the beam is algebraic sum of all moments of all forces acting on right or left of section is called Bending Moment.

\* Relation bet<sup>n</sup> S.F and B.M at a section:

The shearing force is the rate of change of Bending moment at any section is equal to shear force at that section w.r to distance

$$\therefore \frac{dM}{dx} = V$$

dM - finite B.M.

dx - finite distance.

V - shear force.

\* point of contra shear: - it is the point at which shear force dia. changes the sign from positive to negative or negative to positive w.r. to. base line is called as point of contra shear.

At the point of contra shear  
B.M. will be maximum.

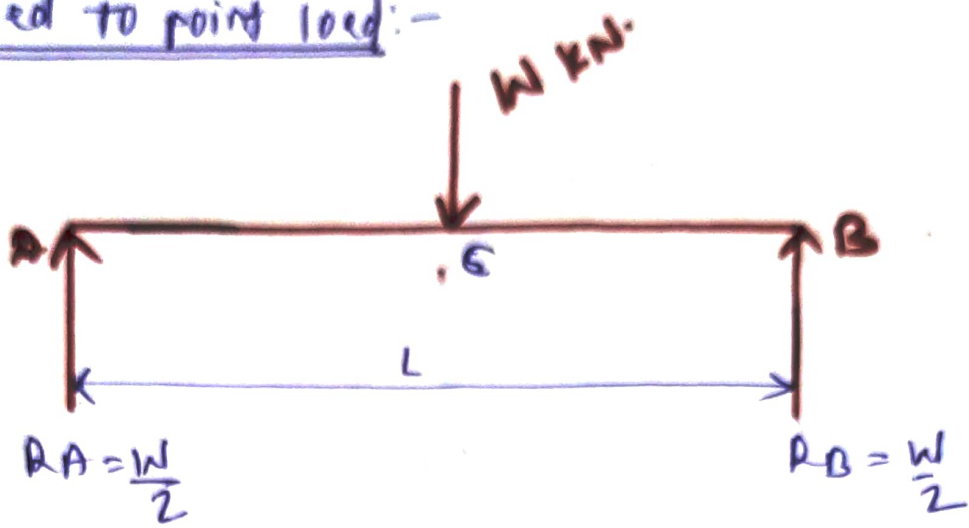


\* point of contra flexure: - it is the point at which B.M.D changes the sign from +ve to -ve or -ve to +ve w.r. to base line is called point of contra flexure.

At the point of contra flexure  
B.M. will be zero

# SFD and BMD FOR SIMPLY SUPPORTED BEAM

SSB subjected to point load:-



### Reactions

$$M_A = -R_B \times L + W \times \frac{L}{2} = 0$$

$$\therefore R_B L = \frac{WL}{2}$$

$$\therefore R_B = \frac{WK}{2}$$

$$R_B = \frac{W}{2} \text{ KN}$$

$$\therefore R_A + R_B = W$$

$$\therefore R_A = W - \frac{W}{2}$$

$$R_A = \frac{W}{2}$$

### Step ① S.F. calculations

S.F @ left of A = 0 KN

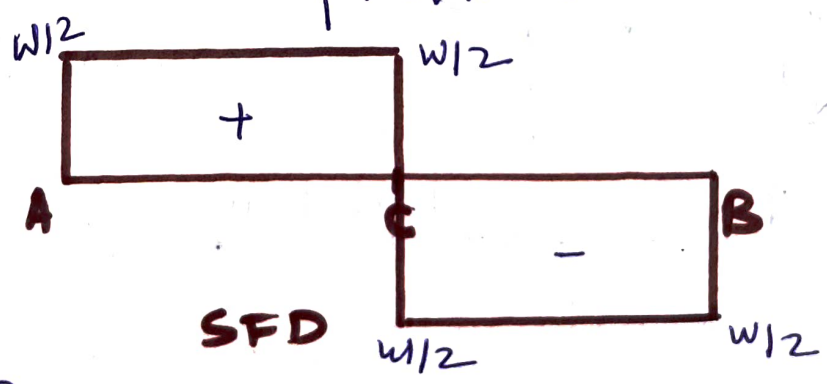
S.F @ right of A =  $\frac{W}{2}$

S.F @ left of C =  $\frac{W}{2}$

S.F @ right of C =  $\frac{W}{2} - W$   
 $= -\frac{W}{2}$

S.F @ left of B =  $-\frac{W}{2}$

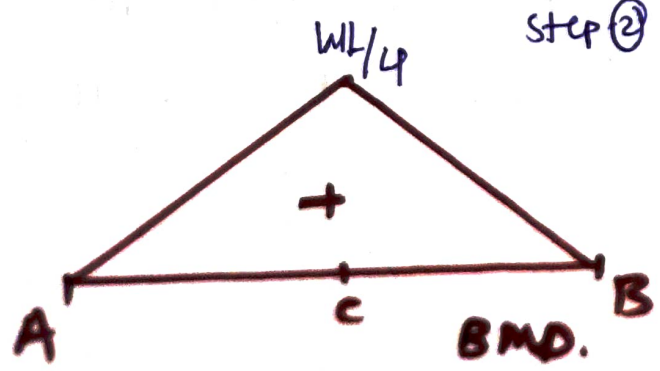
S.F @ right of B = 0 KN



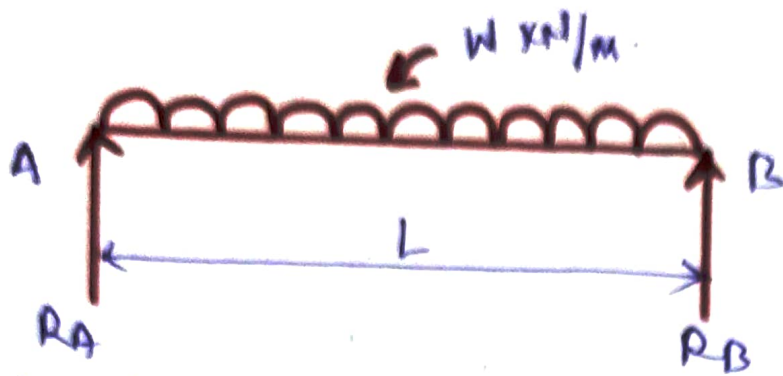
### Step ② B.M. calculations

$$M_A = 0, M_B = 0$$

$$M_C = \frac{W}{2} \times \frac{L}{2} = \frac{WL}{4} \text{ KN-m}$$



↓ SFB subjected to UDL



Reactions :-

$$R_A + R_B = WL \quad \text{--- (1)}$$

$$M_A = \frac{WL^2}{2} - R_B L$$

$$\therefore R_B = \frac{WL^2}{2L}$$

$$R_B = \frac{WL}{2}$$

$$R_A = WL - \frac{WL}{2}$$

$$R_A = \frac{WL}{2}$$

Step (2) S.F. calculations

S.F @ left of A = 0

S.F @ Right of A =  $\frac{WL}{2}$

S.F @ left of B =  $\frac{WL}{2} - WL$   
 $= -\frac{WL}{2}$

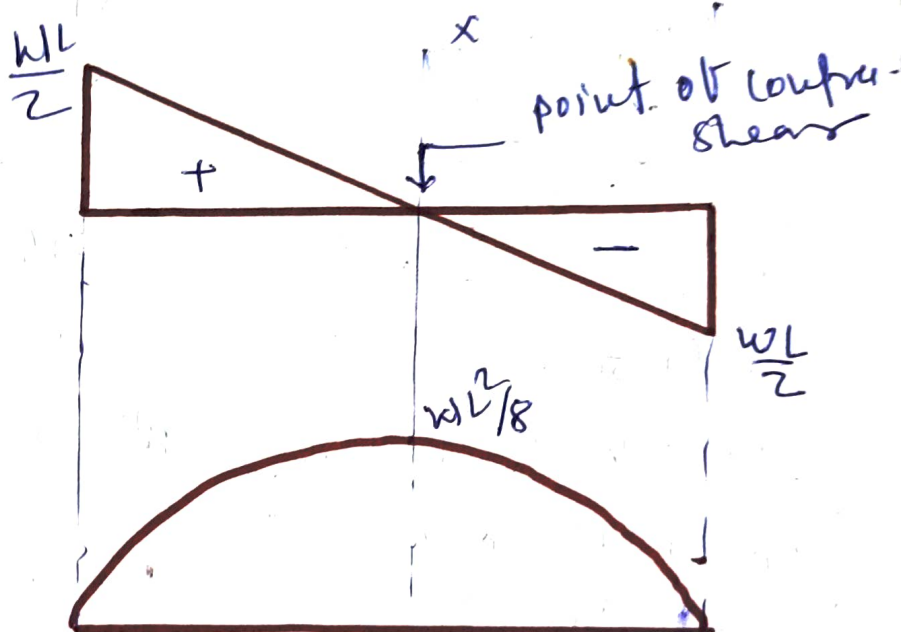
S.F @ right of B = 0

Step (3)

B.M. calculations

B.M @ A = 0

B.M @ B = 0



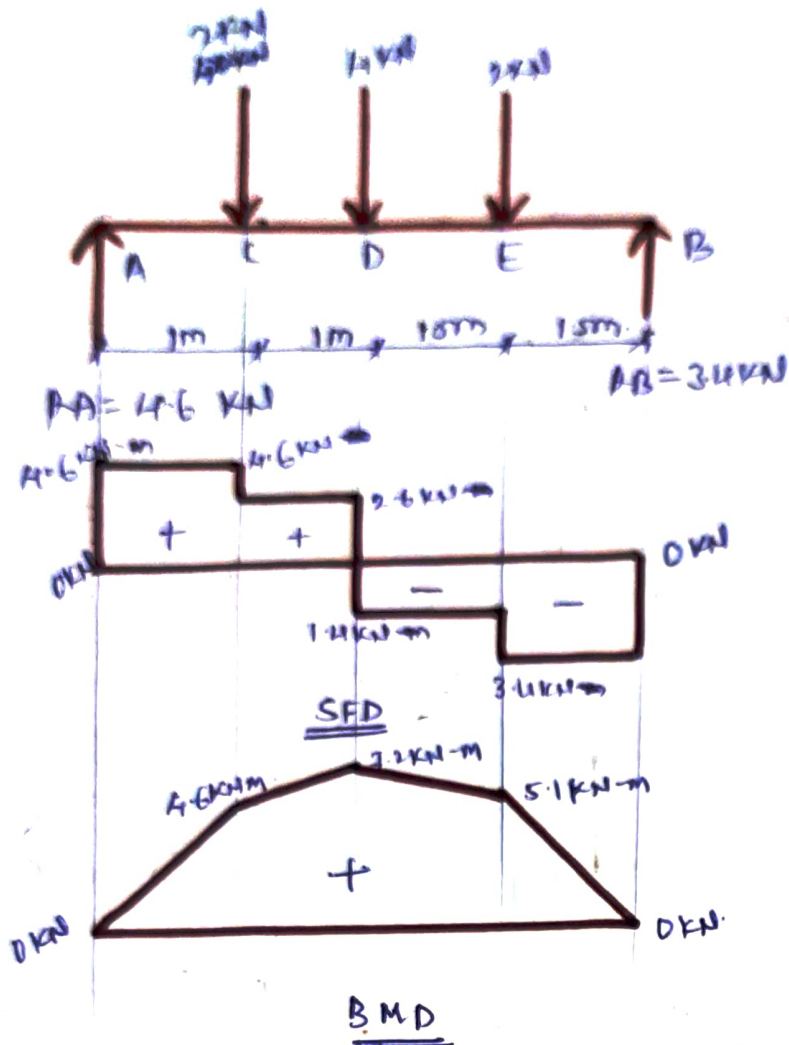
@ point of contra-shear  
 B.M. will be maximum.

$$\therefore B.M_{xx} = R_A \times \frac{L}{2} - W \times \frac{L}{2} \times \frac{L}{4}$$

$$= \frac{WL^2}{4} - \frac{WL^2}{8}$$

$$B.M_{xx} = \frac{WL^2}{8}$$

Draw SFD and BMD



Reactions:-

$$R_A = (2 \times 1) + (4 \times 2) + (2 \times 3) = 14 \text{ kN}$$

$$R_B \times 5 = 0$$

$$R_A + R_B = 2 + 4 + 2 = 8 \text{ kN}$$

$$R_A + R_B = 8 \text{ kN} \quad \text{--- (1)}$$

$$R_B = 3.4 \text{ kN}$$

$$R_A = 4.6 \text{ kN}$$

Step 1) S.F. calculations

$$\text{S.F. @ left of B} = -3.4 \text{ kN}$$

$$\text{S.F. @ right of B} = 0 \text{ kN}$$

Step 2) B.M. calculations

$$M_A = 0 \text{ kN-m}$$

$$M_B = 0 \text{ kN-m}$$

$$M_C = 4.6 \times 1 = 4.6 \text{ kN-m}$$

$$M_D = (4.6 \times 2) - (2 \times 1)$$

$$M_D = 7.2 \text{ kN-m}$$

$$M_E = 3.4 \times 1.5 = 5.1 \text{ kN-m}$$

$$\text{S.F. @ left of A} = 0$$

$$\text{S.F. @ right of A} = 4.6 \text{ kN}$$

$$\text{S.F. @ left of C} = 4.6 \text{ kN}$$

$$\text{S.F. @ right of C} = 4.6 - 2 = 2.6 \text{ kN}$$

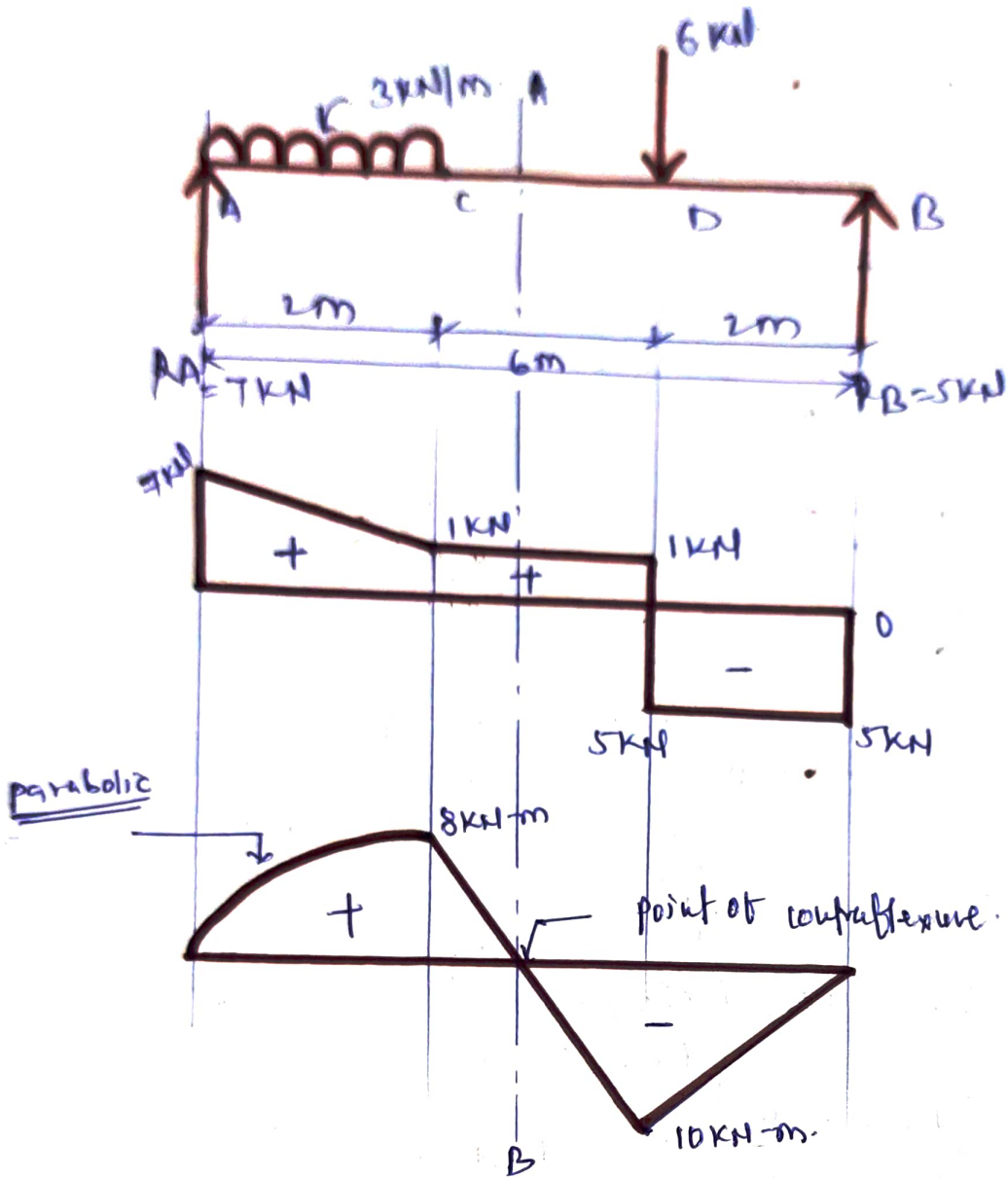
$$\text{S.F. @ left of D} = 2.6 \text{ kN}$$

$$\text{S.F. @ right of D} = 2.6 - 4 = -1.4 \text{ kN}$$

$$\text{S.F. @ left of E} = -1.4 \text{ kN}$$

$$\text{S.F. @ right of E} = -1.4 - 2 = -3.4 \text{ kN}$$

\* Draw SFD and BMD FOR IFR as shown in fig.



Step ③  
To locate point of contraflexure.

$$M_{AB} = 6 \times (x-2) - 5 \times x$$

$$6x - 12 - 5x = 0 = 0$$

$$1x = 12$$

$$x = 12$$

Reactions

$$R_A + R_B = (3 \times 2) + 6$$

$$R_A + R_B = 12 \text{ kN} \quad \text{①}$$

$$M_A = \frac{3 \times 2^2}{2} + (6 \times 4) - R_B \times 6$$

$$0 = 6 + 24 - R_B \times 6$$

$$0 = 30 - R_B \times 6$$

$$\therefore R_B = 5 \text{ kN}$$

$$R_A = 7 \text{ kN}$$

Step ① S.F. calculations

S.F @ left of A = 0 kN.

S.F @ Right of A = 7 kN.

S.F @ left of C =  $7 - 6 = 1 \text{ kN}$ .

S.F at Right of C = 1 kN.

S.F @ left of D = 1 kN.

S.F @ Right of D =  $1 - 6 = -5 \text{ kN}$ .

S.F @ left of B = -5 kN.

S.F @ Right of B = 0 kN. +

Step ② B.M. calculations

$M_A = 0$

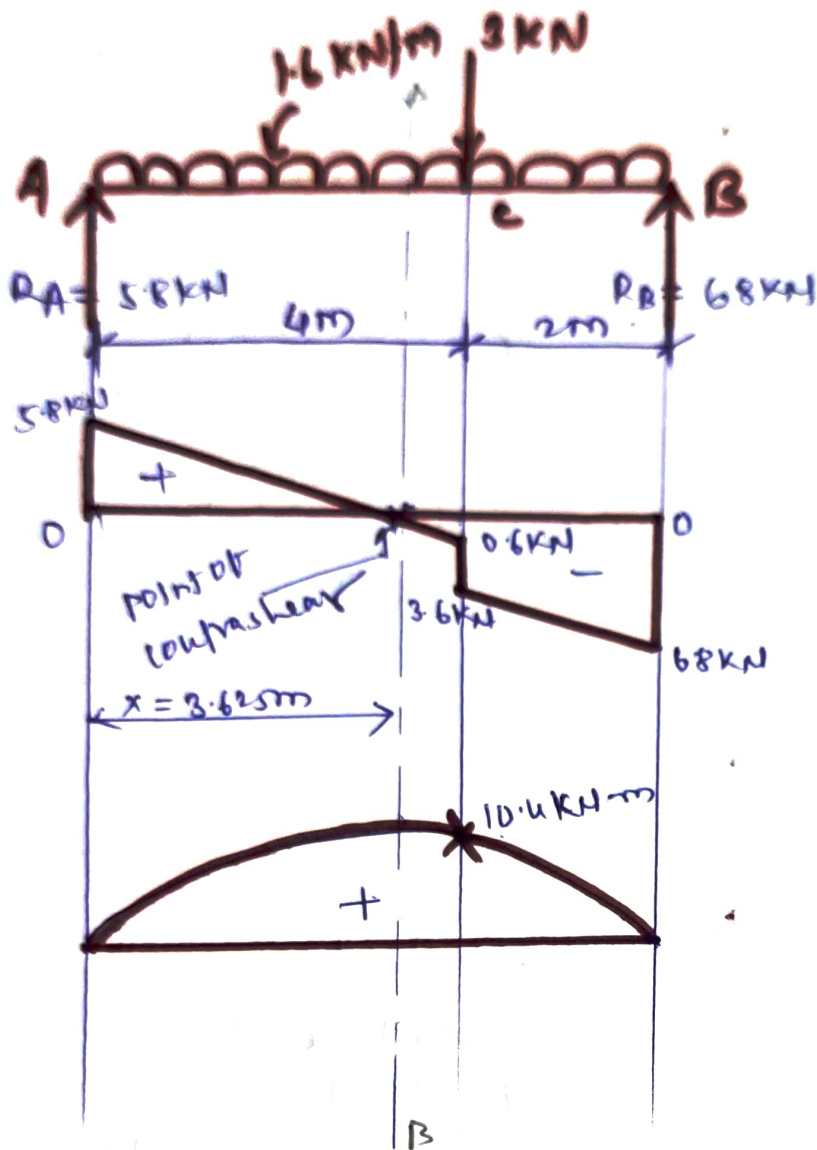
$M_B = 0$

$M_C = (7 \times 2) - (3 \times 2 \times \frac{2}{2})$   
 $= 14 - 6$

$M_C = 8 \text{ kN-m}$

$M_D = -5 \times 2$   
 $= -10 \text{ kN-m}$

\* Draw SFD and BMD for the given beam as shown in fig  
 also find point of zero shear and maximum B.M



Reactions:-

$$R_A + R_B = (1.6 \times 6) + 3$$

$$= 9.6 + 3$$

$$R_A + R_B = 12.6 \text{ kN.}$$

$$M_A = 1.6 \times 6 \times \frac{6}{2} + (3 \times 4) - R_B \times 6$$

$$R_B = 6.8 \text{ kN}$$

$$R_A = 5.8 \text{ kN}$$

Step-1

S.F. Calculations

S.F @ left of A = 0

S.F @ right of A = 5.8 kN

S.F @ left of C =  $5.8 - 6.4$   
 $= -0.6 \text{ kN.}$

S.F @ right of C =  $5.8 - 6.4 - 3$   
 $= -3.6 \text{ kN.}$

S.F @ left of B =  $5.8 - 9.6 - 3$   
 $= -6.8 \text{ kN}$

S.F @ right of B = 0 kN.

Step-2

B.M calculations

$$M_A = 0$$

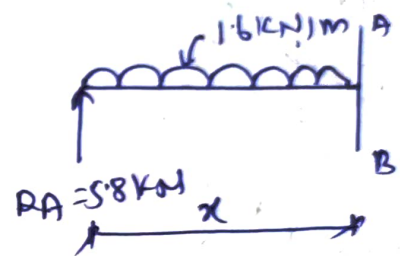
$$M_B = 0$$

$$M_C = (5.8 \times 4) - \left( \frac{1.6 \times 4^2}{2} \right)$$

$$M_C = 10.4 \text{ kN-m}$$

Step-3 - Locate point of

contra-shear



$$M_{AB} = (3 \times x) + (1.6 \times x \times \frac{x}{2})$$

$$(5.8 \times x) - (1.6 \times x \times \frac{x}{2})$$

$$5.8x - 0.8x^2$$

$$0.8x^2 - 5.8x$$

$$x = 3.625 \text{ m}$$

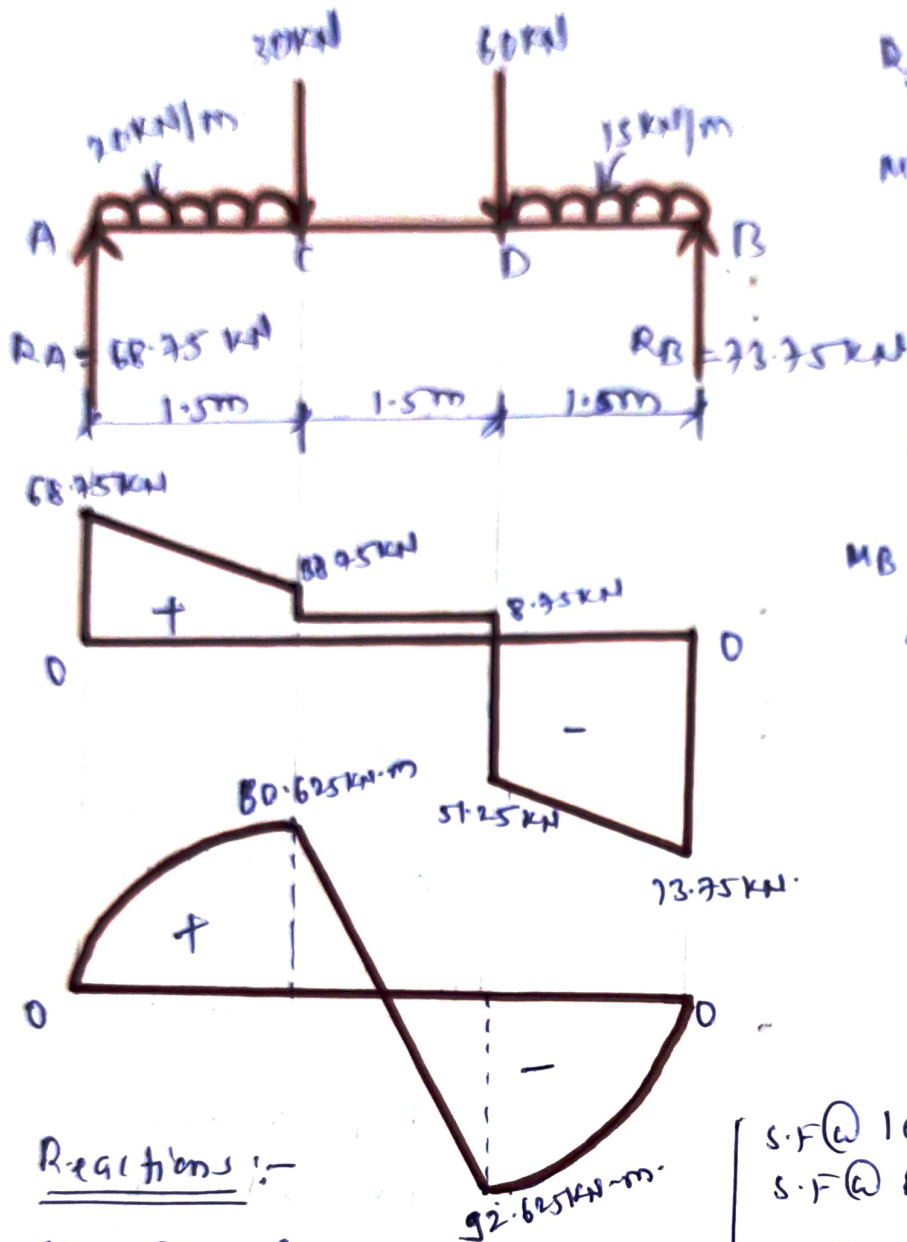
$B_{max} =$

$$(5.8 \times 3.625) - \left( \frac{1.6 \times 3.625^2}{2} \right)$$

$$= 10.5125$$

kN-m

$$B_{max} = 10.5125 \text{ kN-m}$$



Reactions

$$M_A = \left[ \frac{20 \times 1.5^2}{2} \right] + [30 \times 1.5] + [60 \times 3] + \left[ \frac{15 \times 1.5^2}{2} \right] - R_B \times 4.5 = 0$$

$$R_A = 58.75 \text{ kN}$$

$$M_B = - \left[ \frac{15 \times 1.5^2}{2} \right] - [60 \times 1.5] - [30 \times 3] - [20 \times$$

Reactions :-

$$M_A = \left[ \frac{20 \times 1.5^2}{2} \right] + [30 \times 1.5] + [60 \times 3] + [15 \times 1.5 \times 3.75] - R_B \times 4.5 = 0$$

$R_B = 73.75 \text{ kN}$

$R_A = 68.75 \text{ kN}$

Step ① S.F. Calculations -

- s.f @ left of A = 0
- s.f @ right of A = 68.75 kN
- s.f @ left of C = 68.75 - 30 = 38.75 kN
- s.f @ right of C = 38.75 - 30 = 8.75 kN

s.f @ left of D = 8.75 kN

s.f @ right of D = 8.75 - 60 = -51.25 kN

s.f @ left of B = -51.25 - 22.5 = 73.75 kN

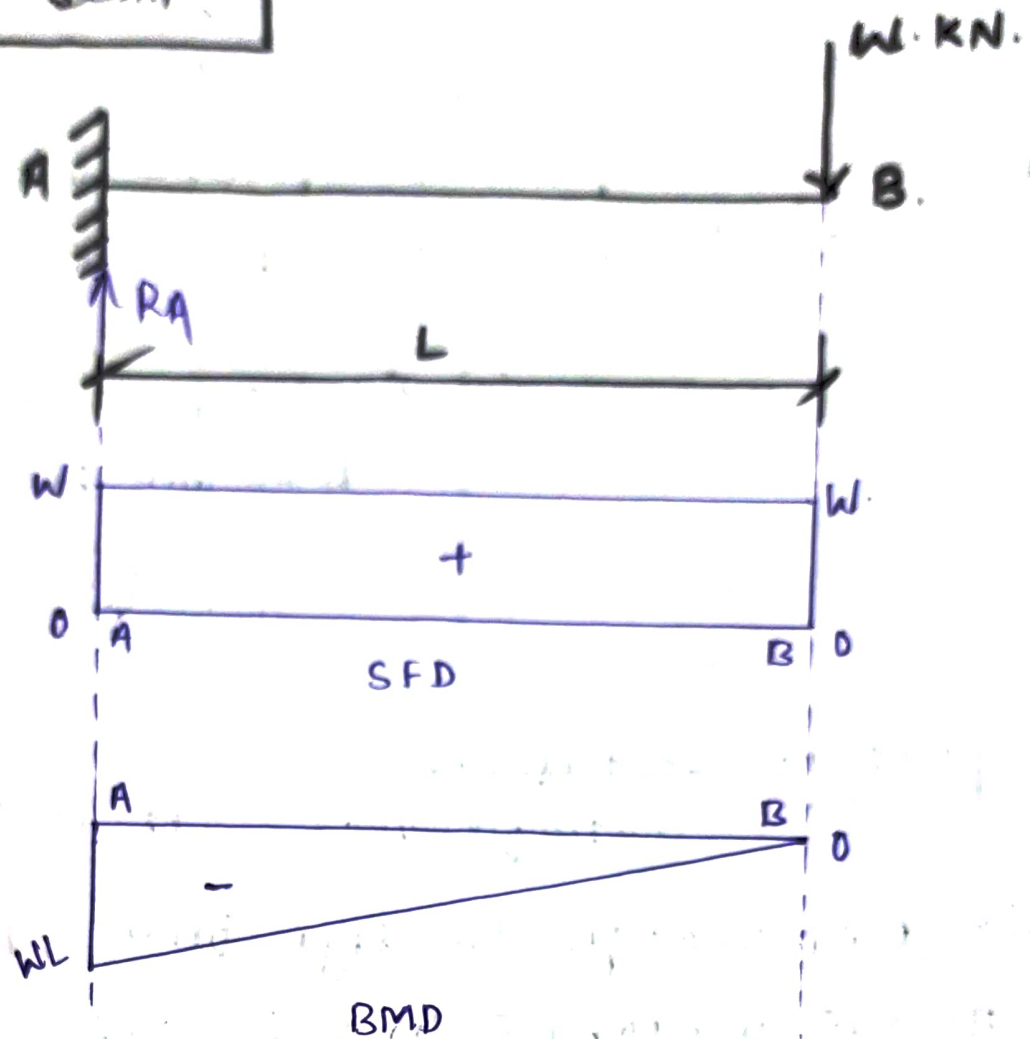
Step ② B.M. Calculations -

$M_A = 0, M_B = 0$

$M_C = (68.75 \times 1.5) - \left( \frac{20 \times 1.5^2}{2} \right)$   
 $M_C = 80.625 \text{ kN-m}$

$M_D = -(3 \times 1.5) + \left( \frac{15 \times 1.5^2}{2} \right)$   
 $M_D = -92.625 \text{ kN-m}$

## ↓ Cantilever Beam :-



Reactions :-

$$\sum F_y = 0$$

$$\therefore R_A - W = 0$$

$$\therefore R_A = W \text{ KN.}$$

Step ① S.F. calculations.

$$\text{S.F. @ B} = 0$$

$$\text{S.F. @ A} = \cancel{R_A} = -W$$

$$\text{S.F. @ B} = W$$

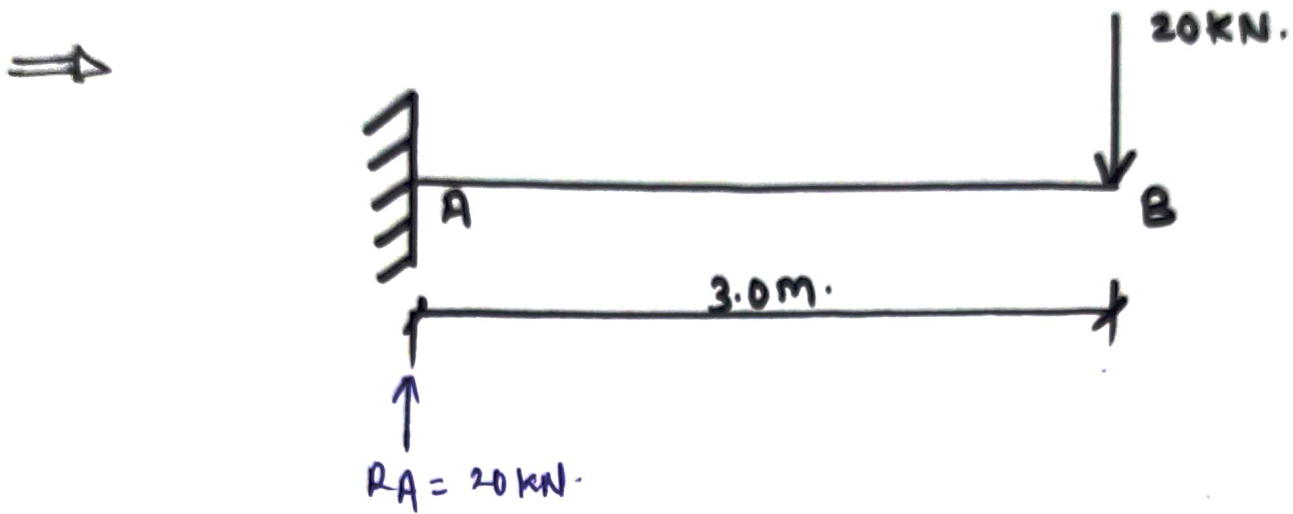
Step ② B.M. calculations

$$\text{B.M. @ B} = 0$$

$$\text{B.M. @ A} = -W \times L \\ = -WL$$

① Determine maximum shear force and maximum bending moment for a cantilever beam having 3.0m span carrying point load of 20kN at free end.

—S-23.



Reactions:-

$$\sum F_y = 0$$

$$R_A - 20 = 0$$

$$R_A = 20 \text{ kN}$$

Step-① - S.F. calculations

$$\text{S.F. @ left of A} = 0 \text{ kN}$$

$$\text{S.F. @ Right of A} = 20 \text{ kN}$$

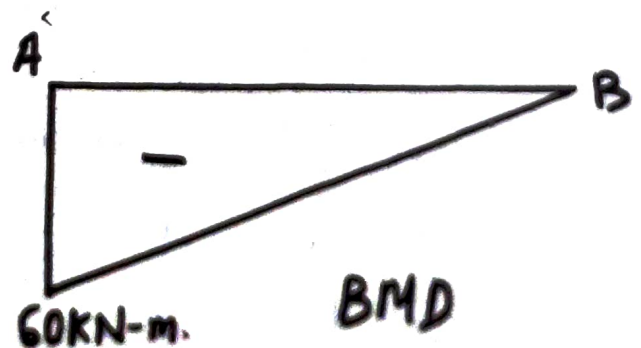
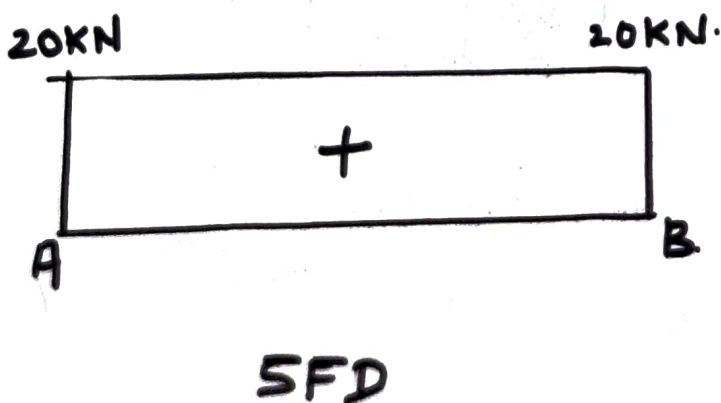
$$\text{S.F. @ left of B} = 20 \text{ kN}$$

$$\text{S.F. @ Right of B} = 0 \text{ kN}$$

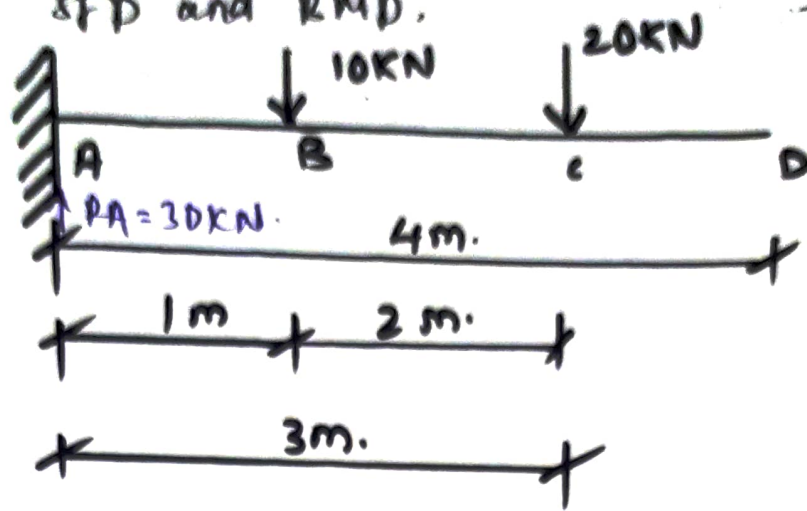
Step-② B.M. calculations

$$\text{B.M. @ A} = -20 \times 3 = -60 \text{ kN-m}$$

$$\text{B.M. @ B} = 0 \text{ kN-m}$$



\* A cantilever beam of span 4m carries two point loads 10kN and 20kN at 1m and 3m from Fixed end resp. draw SFD and BMD. -W-22



→ Reactions :-

$$\sum F_y = 0$$

$$R_A - 10 - 20 = 0$$

$$\boxed{R_A = 30\text{ kN}}$$

Step-1 S.F. calculations

$$\text{S.F. @ left of A} = 0$$

$$\text{S.F. @ right of A} = 30\text{ kN}$$

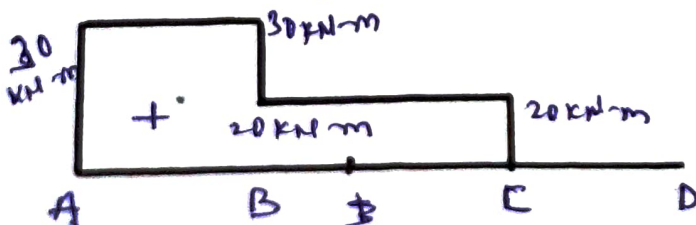
$$\text{S.F. @ left of B} = 30\text{ kN}$$

$$\text{S.F. @ right of B} = 30 - 10 = 20\text{ kN}$$

$$\text{S.F. @ left of C} = 20\text{ kN}$$

$$\text{S.F. @ right of C} = 30 - 10 - 20 = 0\text{ kN}$$

$$\text{S.F. @ D} = 0$$



SFD

Step-2 B.M. calculations

$$\text{B.M. @ A} = [10 \times 1] + [-20 \times 3]$$

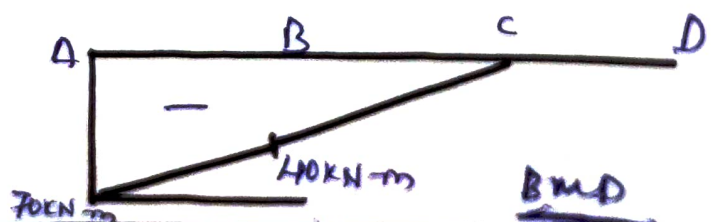
$$= -10 - 60$$

$$= -70\text{ kN-m}$$

$$\text{B.M. @ B} = -20 \times 2$$

$$= -40\text{ kN-m}$$

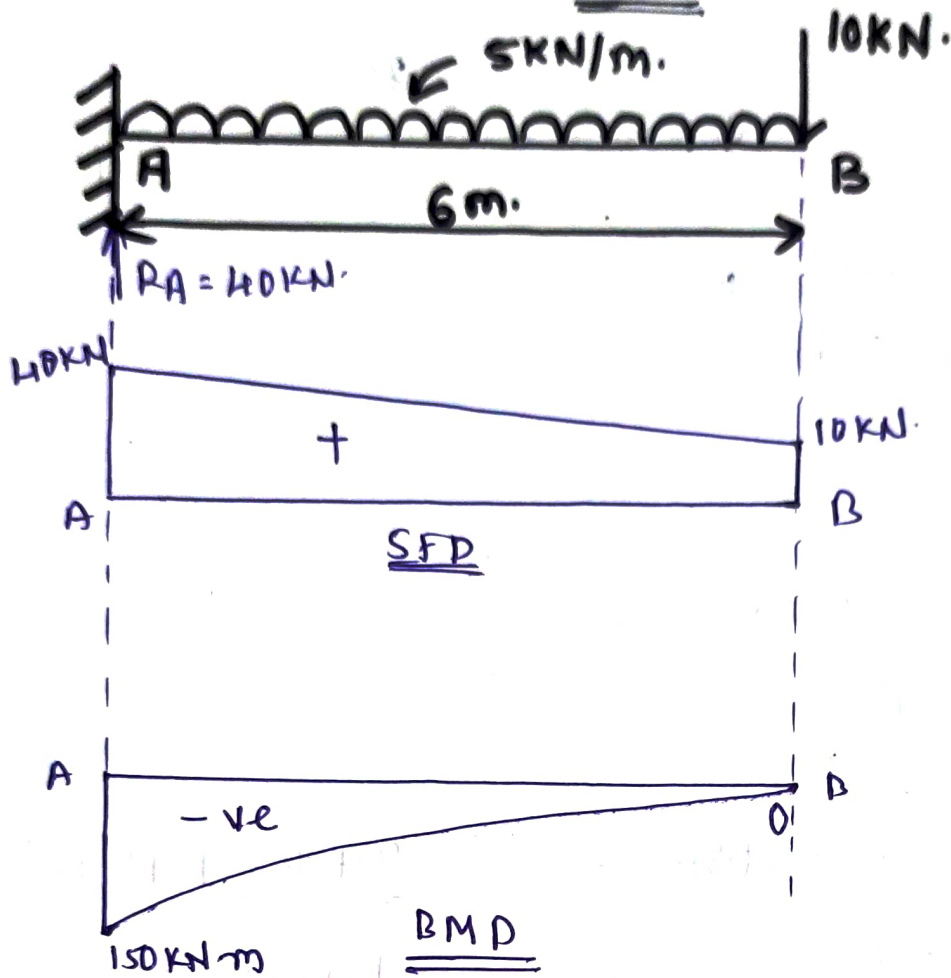
$$\text{B.M. @ C, D} = 0\text{ kN-m}$$



BMD

\* Draw SFD and BMD.

— S-23



Reactions

$\sum F_V = 0$

$R_A - (5 \times 6) - 10 = 0$

$R_A = 30 + 10$

$R_A = 40 \text{ kN}$

Step-2 B.M. calculations

B.M. @ A =  $-\frac{5 \times 6^2}{2}$   
 $= -150 \text{ kNm}$

B.M. @ B = 0 kNm

B.M. @ free end = 0

Step-1 s.f. calculations -

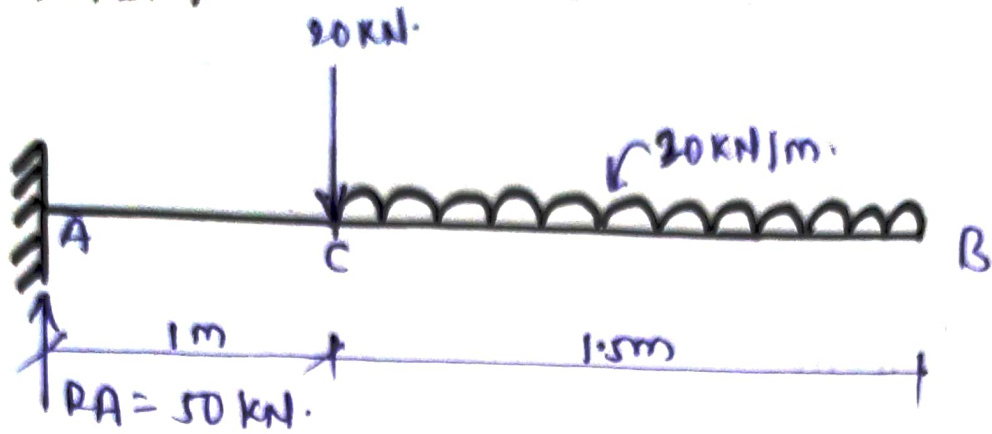
s.f. @ left of A = 0

s.f. @ right of A = 40 kN

s.f. @ left of B =  $40 - (5 \times 6)$   
 $= 10 \text{ kN}$

s.f. @ right of B =  $40 - 30 - 10$   
 $= 0 \text{ kN}$

\* DRAW SFD, BMD



⇒ Reactions! -

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

$$R_A = 50 \text{ kN.}$$

Step-① - S.F. calculations -

$$\text{S.F. @ left of A} = 0$$

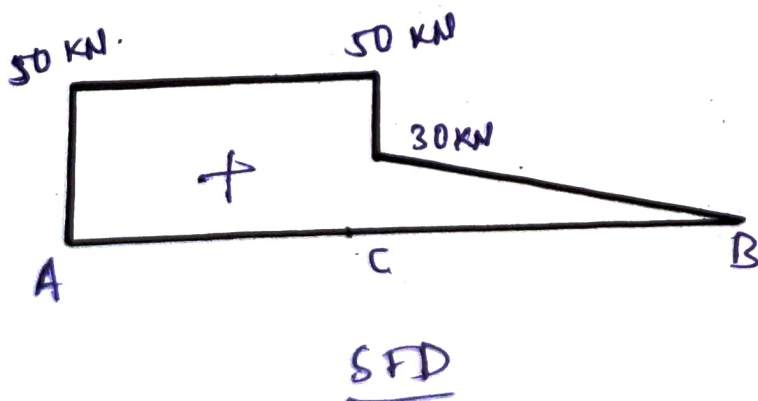
$$\text{S.F. @ Right of A} = 50 \text{ kN.}$$

$$\text{S.F. @ left of C} = 50 \text{ kN.}$$

$$\begin{aligned} \text{S.F. @ Right of C} &= 50 - 20 \\ &= 30 \text{ kN.} \end{aligned}$$

$$\begin{aligned} \text{S.F. @ left of B} &= 50 - 20 - (20 \times 1.5) \\ &= 50 - 20 - 30 \\ &= \cancel{15} \text{ kN. } 0 \text{ kN.} \end{aligned}$$

$$\text{S.F. @ Right of B} = 0 \text{ kN.}$$

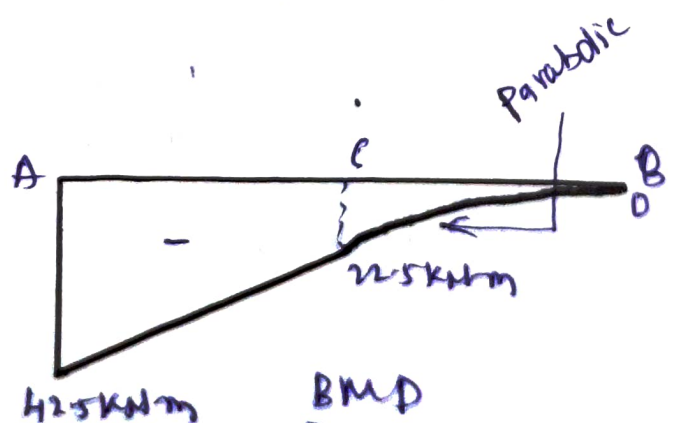


Step-② - B.M. calculations

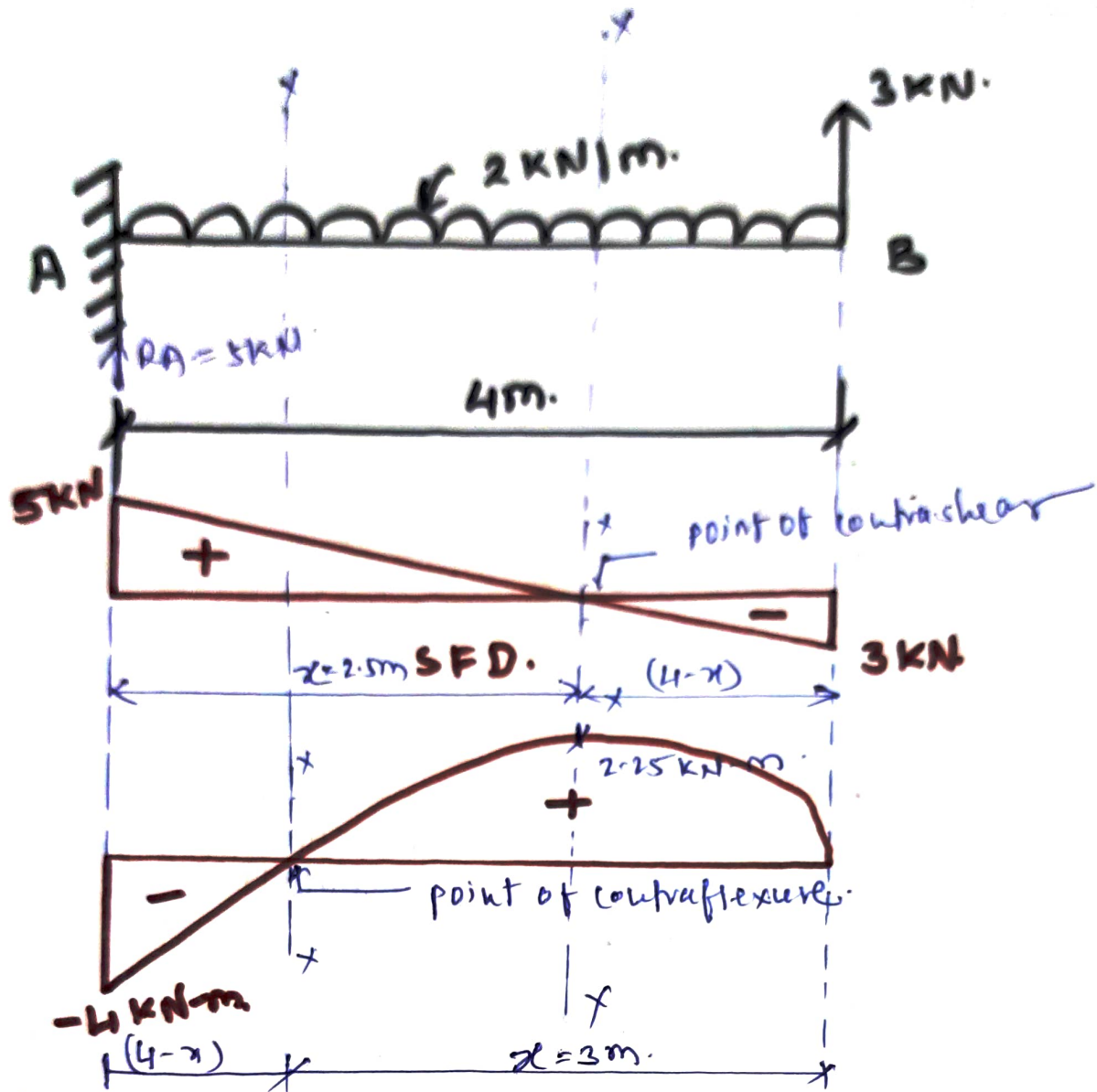
$$\begin{aligned} \text{B.M. @ A} &= (20 \times 1) - \\ &\quad \left( \frac{20 \times 1.5^2}{2} \right) \\ &= -42.5 \text{ kN.m.} \end{aligned}$$

$$\begin{aligned} \text{B.M. @ C} &= \frac{20 \times 1.5^2}{2} \\ &= -22.5 \text{ kN.m.} \end{aligned}$$

$$\text{B.M. @ B} = 0 \text{ kN.m.}$$



\* Draw SFD and BMD :-



Reactions

$$R_A - 8 + 3 = 0$$

$$R_A = 5 \text{ kN}$$

$$B.M. @ B = 0$$

point of contra-shear

to find  $x$

$$\frac{5}{1} = \frac{3}{4-x}$$

$$\therefore x = 2.5 \text{ m from A.}$$

$$B.M. \text{ max } @ xx = 3 \times 1.5 - (2 \times 1.5^2)$$

$$B.M. \text{ max } = 2.25 \text{ kNm}$$

point of contraflexure.

$$B.M. @ xx = 0$$

$$3 \times x - \frac{2 \times x^2}{2} = 0$$

$$x = 3 \text{ m}$$

Step 1 S.F. calculations

$$S.F. @ \text{ left of A} = 0$$

$$S.F. @ \text{ right of A} = 5 \text{ kN}$$

$$S.F. @ \text{ left of B} = 5 - 8 = -3 \text{ kN}$$

$$S.F. @ \text{ right of B} = 0$$

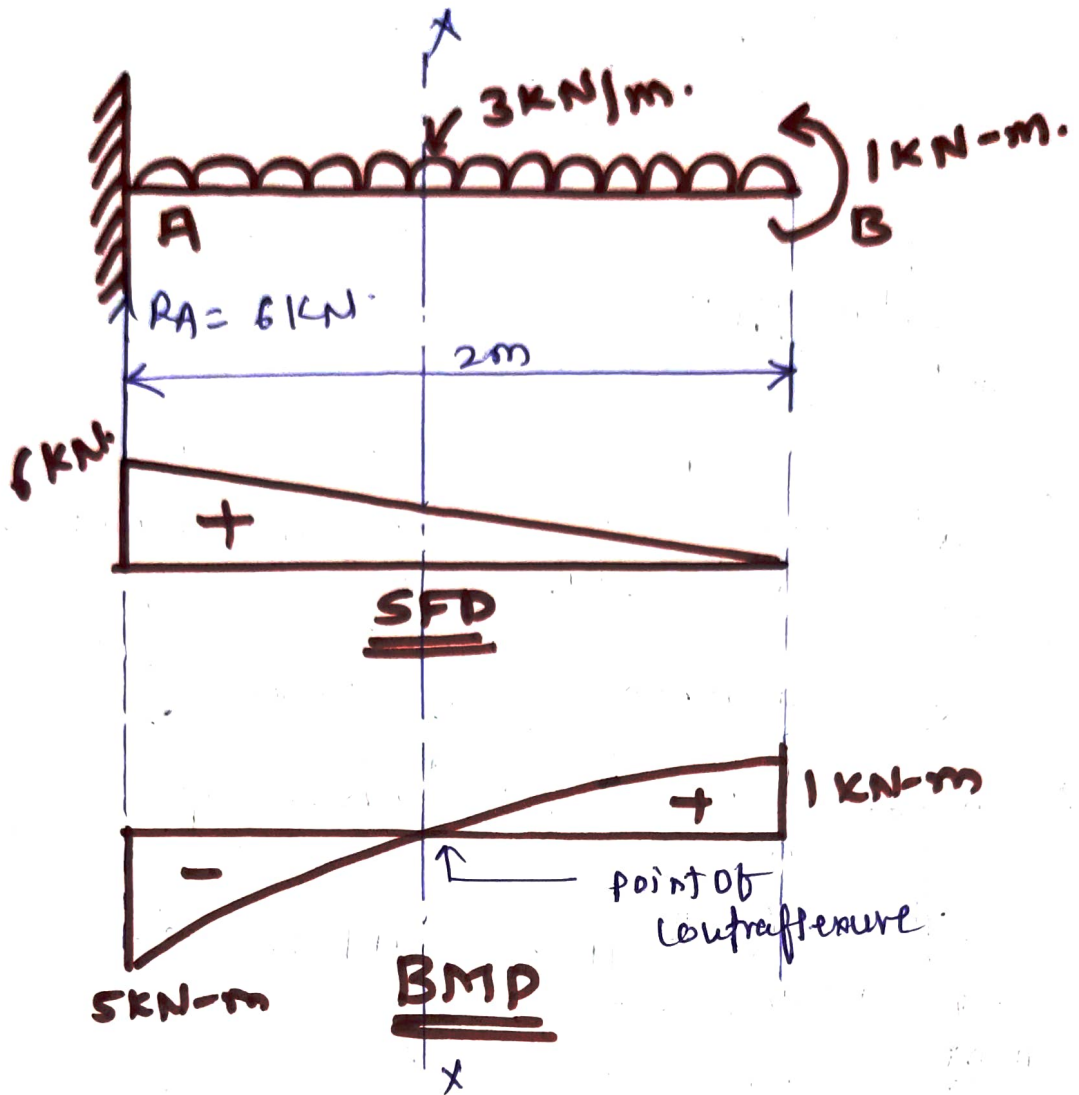
Step 2 B.M. calculations

$$B.M. @ A = -\frac{2 \times 4^2}{2} + 3 \times 4$$

$$= -16 + 12$$

$$= -4 \text{ kNm}$$

\* draw SFD & BMD



Reactions

$$R_A = (3 \times 2) = 0$$

$$R_A = 0 \text{ kN}$$

$$\begin{aligned} \text{B.M. left of B} &= \\ &= (6 \times 2) - \left( \frac{3 \times 2^2}{2} \right) \\ &= 1 \text{ kN} \end{aligned}$$

Step 1 to cal. S.F.

$$\text{S.F. @ left of A} = 0$$

$$\text{S.F. @ right of A} = 6 \text{ kN}$$

$$\begin{aligned} \text{S.F. @ left of B} &= \\ &= 6 - (3 \times 2) \\ &= 0 \text{ kN} \end{aligned}$$

$$\text{S.F. @ right of B} = 0 \text{ kN}$$

Step 2 B.M. calculations

$$\text{B.M.A} = 1 - \left( \frac{3 \times 2^2}{2} \right) = -5 \text{ kN-m}$$

Point of contraflexure -



Now.

$$\text{B.M. @ } xx = -3 \times x \times \frac{x}{2} + 1 = 0$$

$$\frac{3x^2}{2} = 1$$

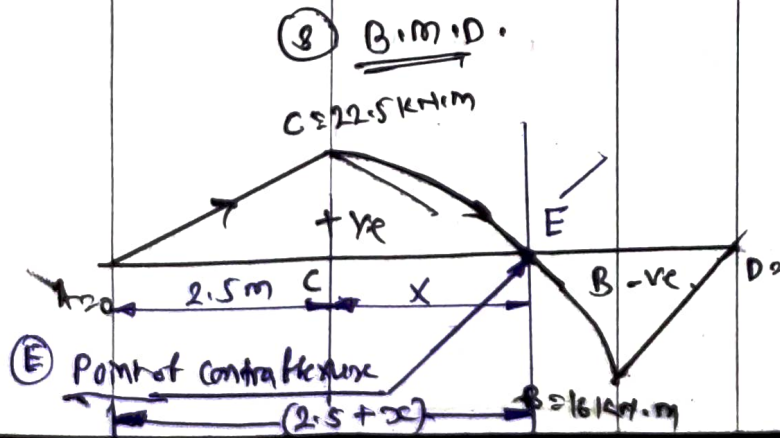
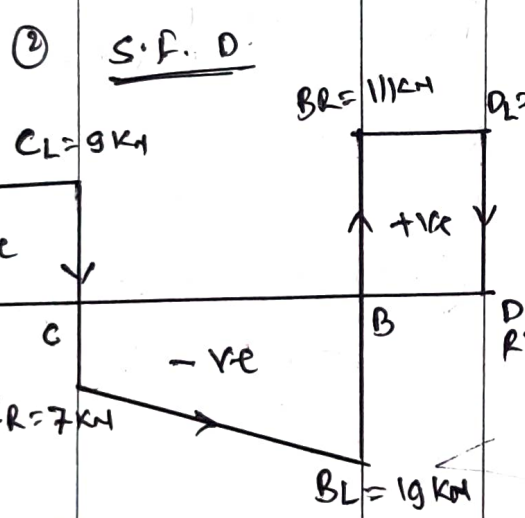
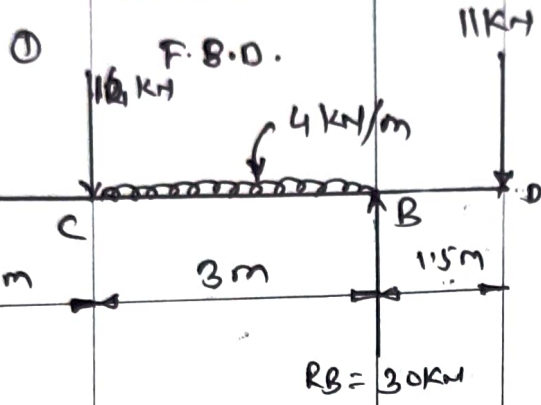
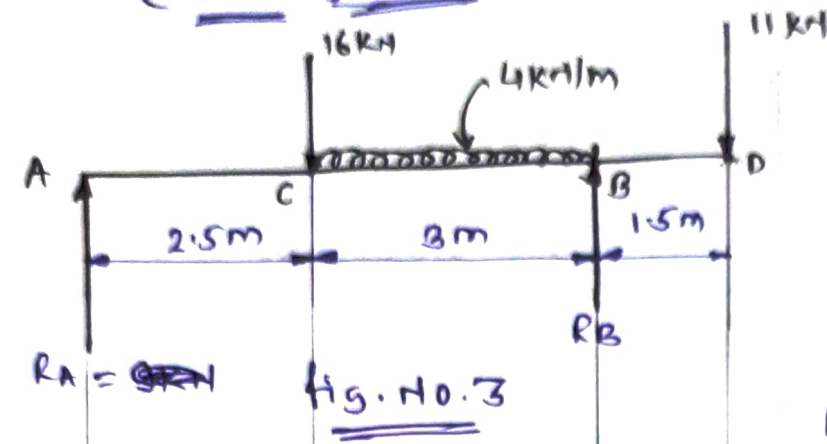
$$\therefore 1.5x^2 = 1$$

$$x^2 = \frac{1}{1.5}$$

$$x = 0.667 \text{ m}$$

### (X) 3.5 Examples Based on Overhanging Beam

① Draw SF and BM diagram for the beam as shown in figure no. 3. Also locate the point of contraflexure.  
(5-26 Q.5 B. 6 marks)



Soln.

Step 1: ① To find out support reaction.

$$\sum F_y = 0 \quad \begin{matrix} \uparrow +ve \\ \downarrow -ve \end{matrix}$$

$$R_A + R_B = 16 - (4 \times 3) - 11 = 0$$

$$\therefore R_A + R_B = 39 \text{ kN} \quad \text{--- (1)}$$

\(\therefore\) Applying moment at point 'A'.

$$\sum M_A = 0 \quad \begin{matrix} \curvearrowright +ve \\ \curvearrowleft -ve \end{matrix}$$

$$16 \times 2.5 + (4 \times 3) \times (2.5 + \frac{3}{2}) - R_B \times 5.5 + 11 \times 7 = 0$$

$$\therefore R_B = \frac{165}{5.5} = 30 \text{ kN}$$

from eqn (1) becomes,

$$\therefore R_A = 39 - 30 = 9 \text{ kN.}$$

so  $R_A = 9 \text{ kN}$  and  $R_B = 30 \text{ kN}$

Step 2: ② To find Shear force calculation i.e SF calculation.

- ①  $A_L = 0$
- ②  $A_R = 9 \text{ kN}$
- ③  $C_L = 9 \text{ kN}$
- ④  $C_R = 9 - 16 = -7 \text{ kN}$
- ⑤  $B_L = 9 - 16 - 4 \times 3 = -19 \text{ kN}$

## S.F. calculation Example No. ①

⑥  $B_R = 9 - 16 - 4 \times 3 + 30 = 11 \text{ kN}$

⑦  $D_L = 11 \text{ kN}$

⑧  $D_R = 11 - 11 = 0 \text{ kN}$

## STEP NO. ③ Bending moment calculation or B.M. calculation

Sign convention:  $\downarrow$  +ve  $\rightarrow$  i.e. Clockwise +ve  
 $\curvearrowright$  -ve  $\rightarrow$  i.e. Anticlockwise -ve.

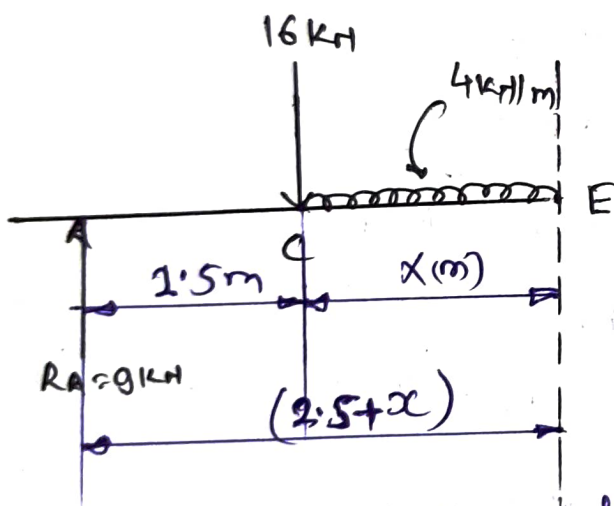
① B.M. at point 'A' & D = 0

② B.M. at point C =  $9 \times 2.5 = \underline{22.5 \text{ kN}\cdot\text{m}}$

③ B.M. at point B =  $9 \times 5.5 - 16 \times 3 - (4 \times 3) \times \left(\frac{3}{2}\right) = \underline{-16.5 \text{ kN}\cdot\text{m}}$

④ B.M. at point D =  $9 \times 7 - 16 \times 4.5 - (4 \times 3) \times (1.5 + 1.5) = 0$   
 $+ 30 \times 1.5$

## ④ To find point of Contraflexure:



⑤ Here, the point of contraflexure from point 'A' to 'E' distance is  $x = 2.5 + 2.033 = \underline{4.533 \text{ m}}$  from point 'A' and  $\underline{0.97 \text{ m}}$  from point 'D'.

Moment at point (E) called point of contraflexure.

$$\sum M_E = 0$$

$$9 \times (2.5 + x) - 16x - 4x \times \left(\frac{x}{2}\right) = 0$$

$$22.5 + 9x - 16x - 2x^2 = 0$$

$$\therefore 22.5 - 7x - 2x^2 = 0$$

or

$$2x^2 + 7x - 22.5 = 0 \quad \text{--- This is a quadratic eqn}$$

Here,

$$a = 2, \quad b = 7 \quad \& \quad c = -22.5$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-7 \pm \sqrt{(7)^2 - 4 \times 2 \times (-22.5)}}{2 \times 2}$$

$$x = \frac{-7 + \sqrt{229}}{4} = \frac{-7 + 15.13}{4}$$

$$\therefore \boxed{x = 2.033 \text{ m}} \quad \text{--- sum}$$