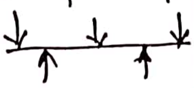
UNIT-II – Shear Force Diagram, Bending moment diagram

Theory of simple bending.

Beam: A structural member that is designed to resist forces acting in the transverse direction is called a beam.

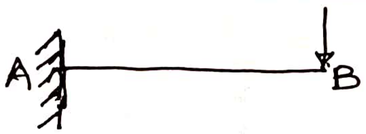
Determinate Beams : cantilever beam 
Simply supported beam 
overhanging Beam 

Indeterminate Beams : Propped cantilever beam
fixed-fixed Beam
Continuous Beam.

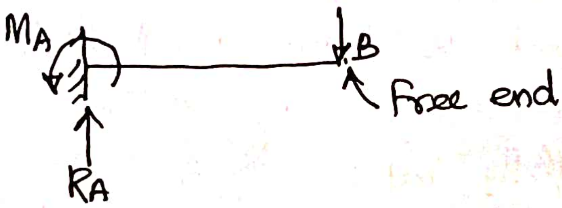
A determinate Beam is a beam in which the support reactions can be found using only the static equations of equilibrium.

Support reactions < Reaction forces / Reaction moments.

Cantilever Beam

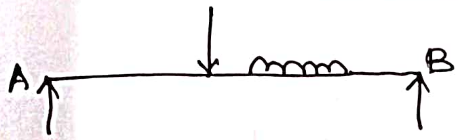


R_A = Support Reaction force
M_A = Support reaction moment



Fixed end: or Built-in end.
slope = 0
deflection = 0

Simply Supported Beam

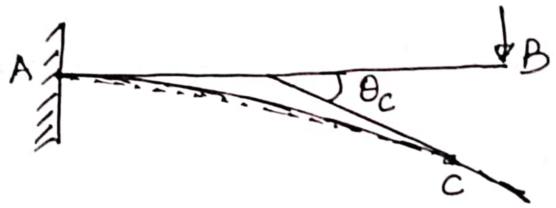


R_A, R_B = support reaction forces at A & B respectively.

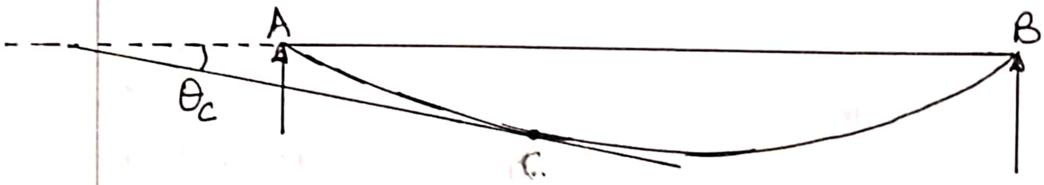
In a SSB, support reaction moments are zero.

Simply supported end:
deflection = 0
Slope is not equal to zero.

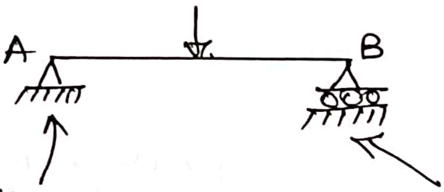
What is slope at a point?



Slope is an angle.
Slope is denoted by θ.
θ_c - slope at C.



Consider a cantilever beam and a simply supported beam. Slope at the point C in both beams are to be found. To do so, draw a tangent at the point C to the deflection curve. Extend the tangent to meet the undeflected beam position. The angle between the tangent and the original beam is the slope at point C.



What are the types of supports in a simply supported beam? Why?

Hinged Support
or
pinned Support
or
pivoted Support.

Roller Support

* A Hinged support can not move in x-direction or y-direction. Hence, in a simply supported Beam, if both the ends are hinged, the beam cannot bend.
* If the beam has to bend, then the length of the beam will decrease slightly and one of the supports should be able to move in the horizontal direction.
* If both the supports are roller supports, then the simply supported beam becomes unstable.
* Hence, in a simply supported beam, one end should be hinged and the other end is a roller support.

* The pin support or hinged support restrains the beam from translating both horizontally and vertically but it does not prevent rotation.

* A Roller Support can resist a vertical force but not a horizontal force.

Concentrated loads - P KN.

Uniformly distributed Load (UDL)

$q \frac{KN}{m}$.

Moment

Shear force at a point.

If a Shear force at a point is required to be found, add all the forces acting at that point and acting to the right side of that point. The sum of these forces gives the Shear force at that point.

Bending moment at a point:

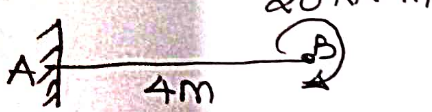
Find the moments produced by all the forces and moment acting at that point and to the right hand side of that point. The total moment moment obtained gives the bending moment at that point.

*. There cannot be a moment for a moment.

i.e. Do not multiply a moment with distance (or moment arm).

Bending moment at A = 10x5

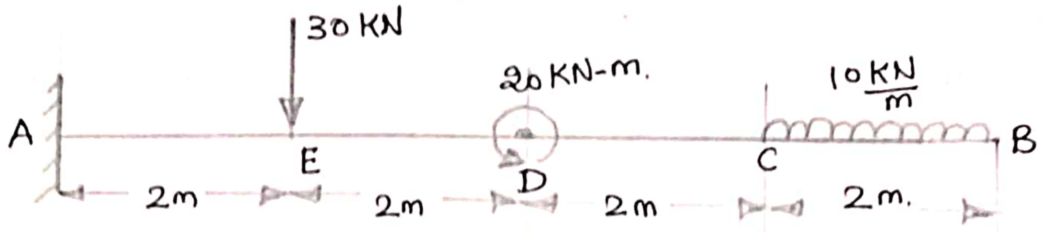
= 50 KN-m Clockwise



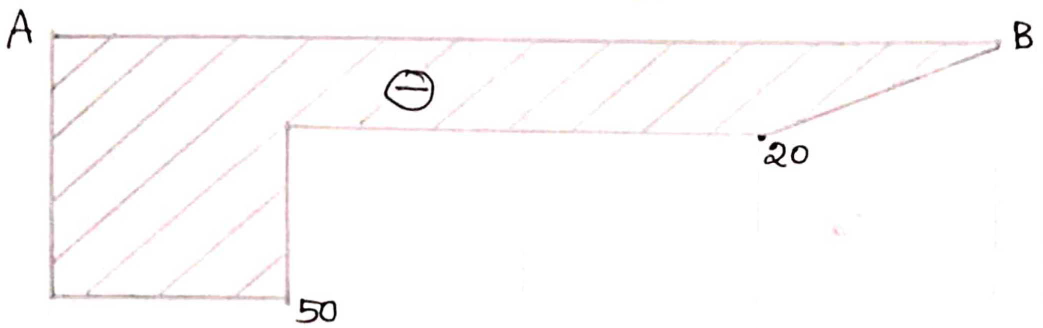
Bending moment at A = 20 KN-m only.

Do not multiply 20 KN-m with 4m moment arm.

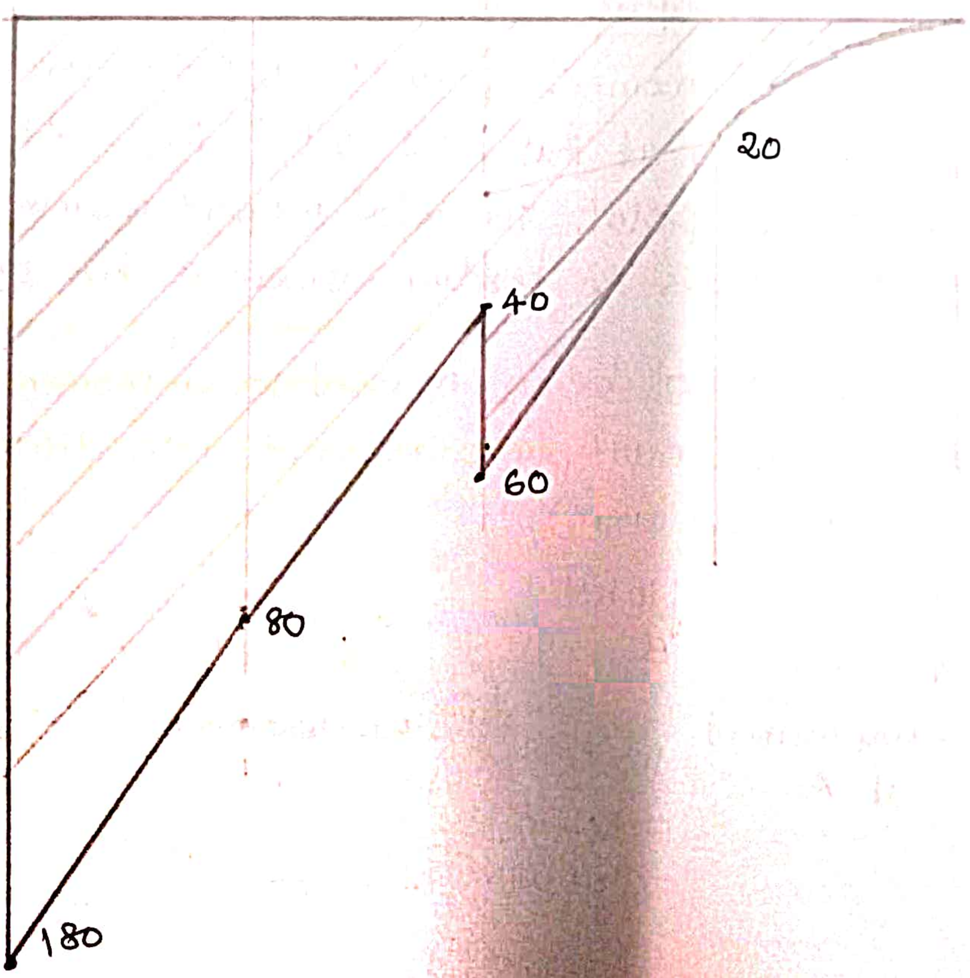
2-4



Shear Force Diagram in KN.



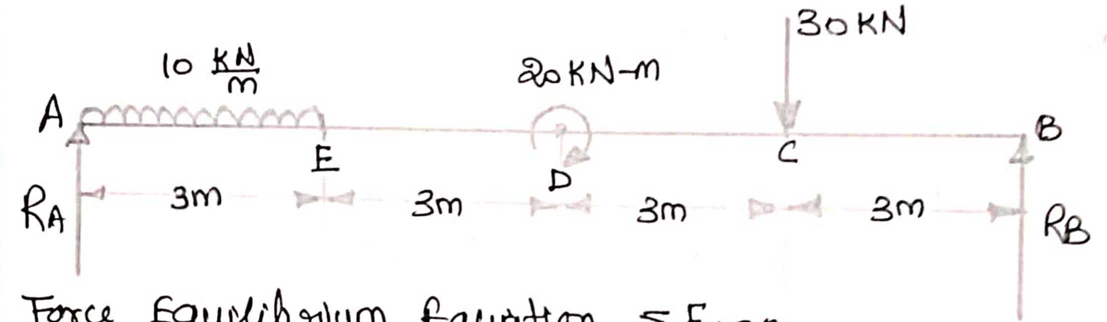
Bending Moment Diagram in KN-m



At
* The point where the shear force changes its sign, the bending moment is maximum.

* the point where the bending moment changes its sign is called point of contra-flexure.
(point of inflexion or a virtual hinge)

contra → opposite, flexure → bending.



Force Equilibrium Equation $\Sigma F_y = 0$

$$R_A + R_B = (10 \times 3) + 30 = 60 \text{ KN.}$$

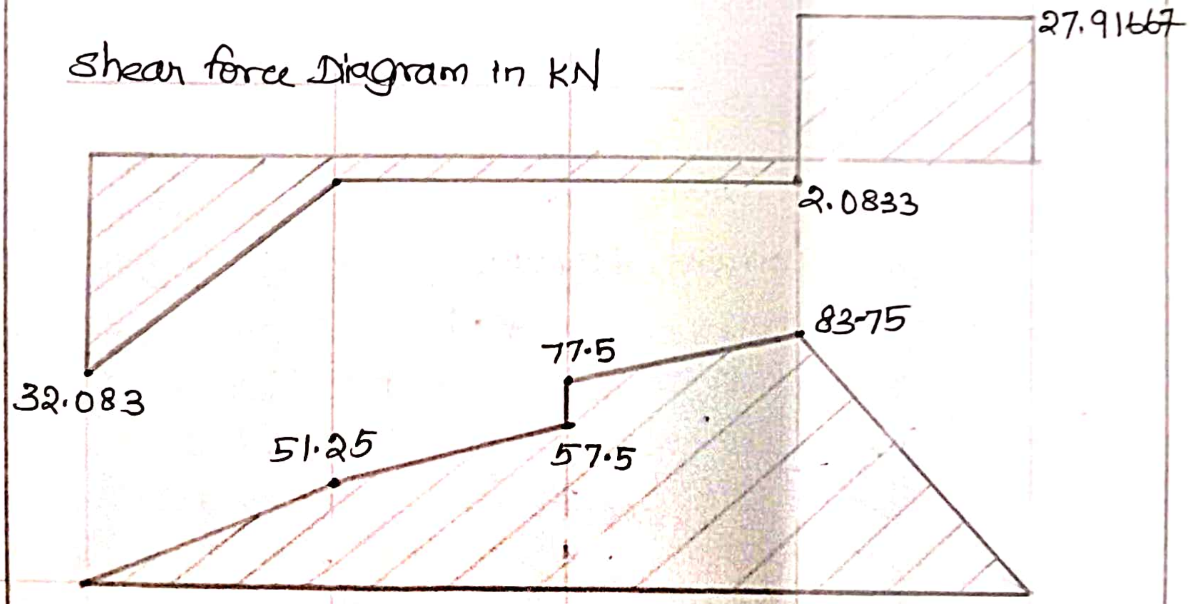
Taking moments about A

$$R_B \times 12 = (10 \times 3 \times 1.5) + 20 + (30 \times 9) \Rightarrow R_B = 27.91667 \text{ KN}$$

Taking moments about B

$$R_A \times 12 = (30 \times 3) - 20 + (10 \times 3 \times 10.5) \Rightarrow R_A = 32.083 \text{ KN}$$

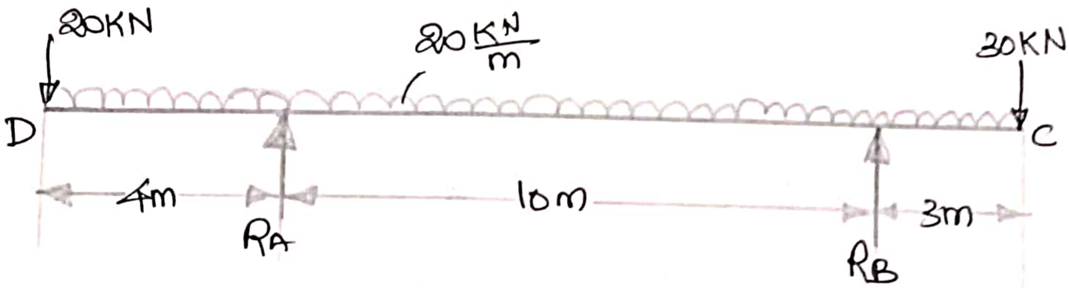
Shear force Diagram in KN



Bending Moment Diagram in KN-m.

On one side of the point of contraflexure, there will be convex bending and on the other side, there will be concave bending.

2-6



Taking moments about A

$$(R_B \times 10) + (20 \times 4) + (20 \times 4 \times 2) = (20 \times 13 \times 6.5) + (30 \times 13)$$

$$\Rightarrow R_B = 184\ KN$$

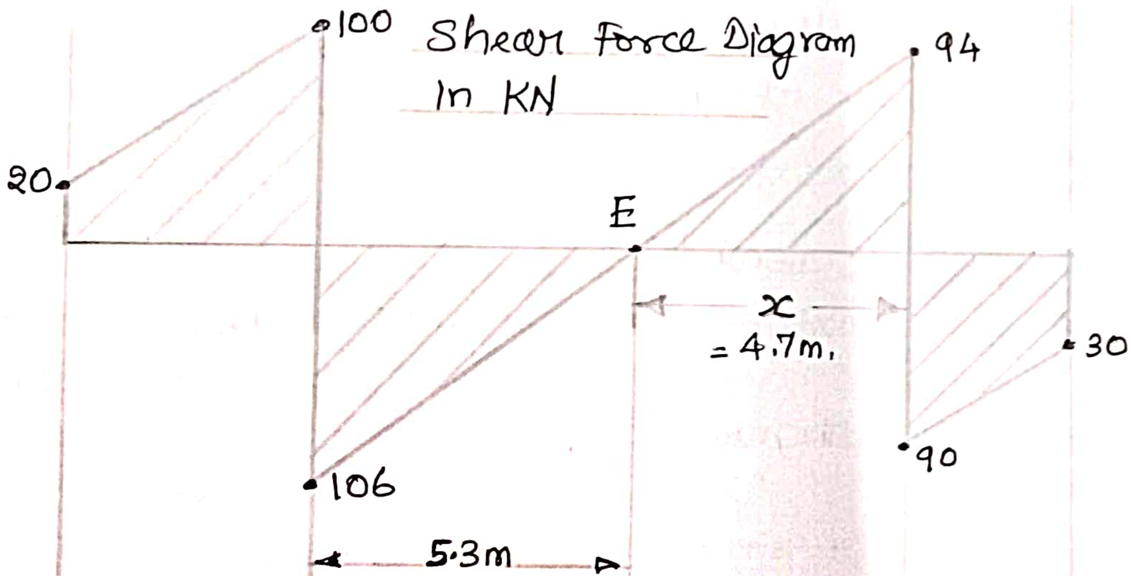
Taking moments about B

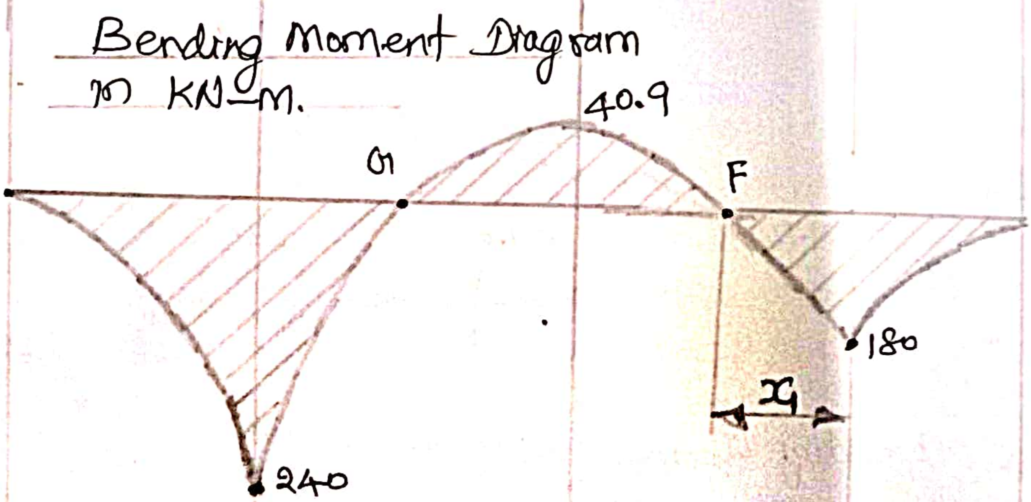
$$(R_A \times 10) + (30 \times 3) + (20 \times 3 \times 1.5) = (20 \times 14 \times 7) + (20 \times 14)$$

$$\Rightarrow R_A = 206$$

Force Equilibrium Equation $\Rightarrow \Sigma F_y = 0$

$$R_A + R_B = 20 + 30 + (20 \times 17) = 390\ KN.$$





Points F and G - Points of contraflexure.

To find F, Equate the bending moment to zero at F.

$$-30(3+x_1) - 20 \times \frac{(3+x_1)^2}{2} + 184x_1 = 0 \Rightarrow x_1 = 2.6776m.$$