PANA ACADEMY

NEPAL ENGINEERING COUNCIL
LICENSE EXAM PREPARATION COURSE

FOR

CIVIL ENGINEERS

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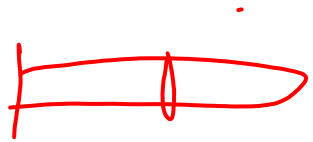
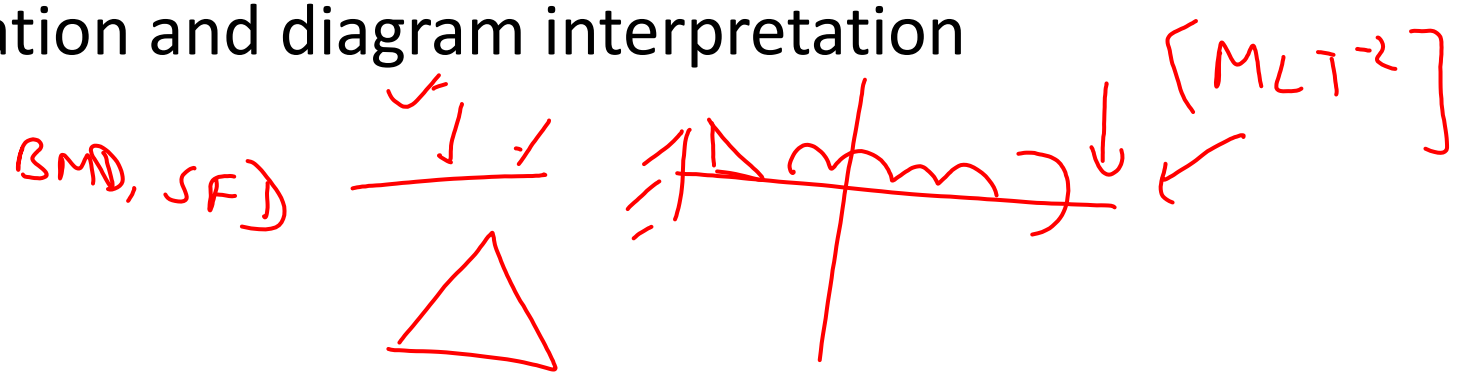
4. Structural Mechanics

4.1 Shear forces and bending moments

Sub topics



- Axial forces
- Shear forces
- Bending moments
- Loads and load superposition
- Relation and diagram interpretation



Types of Load

Point load

- acting at a point

Uniformly distributed load (UDL)

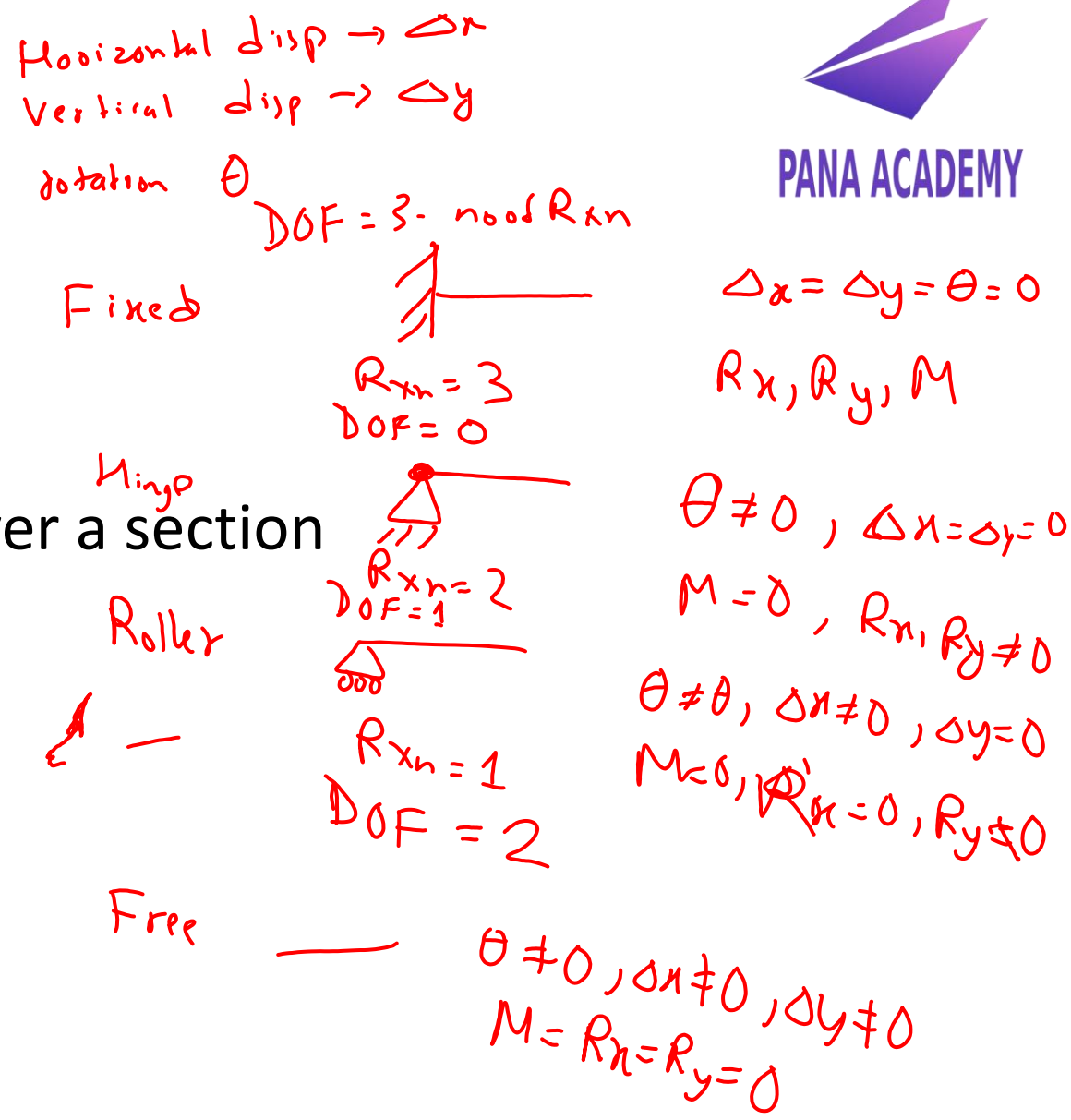
-constant intensity of load over a section

Uniformly varying load (UVL)

-varying intensity

Moment

-bending forces



Axial forces

3 Equation of equilibrium
$\Sigma f_x = 0$, $\Sigma f_y = 0$, $\Sigma M = 0$

R to L

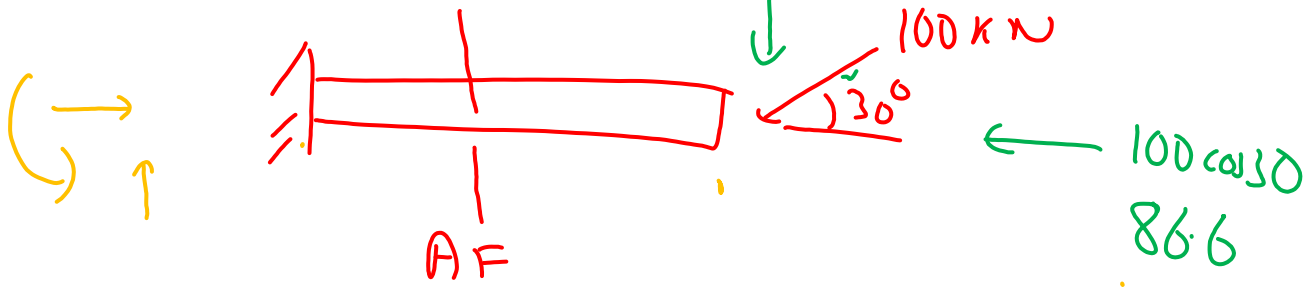
L to R

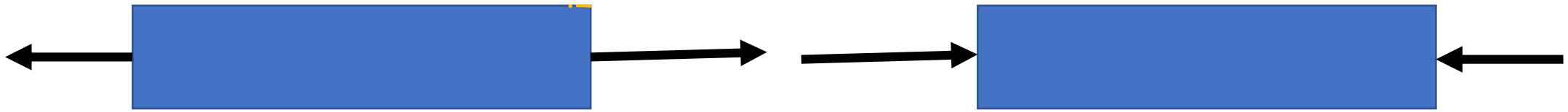
Force acting in direction of axis of a body.

Along the length / perpendicular to cross section.

Tensile or compressive

Unit: N, kN



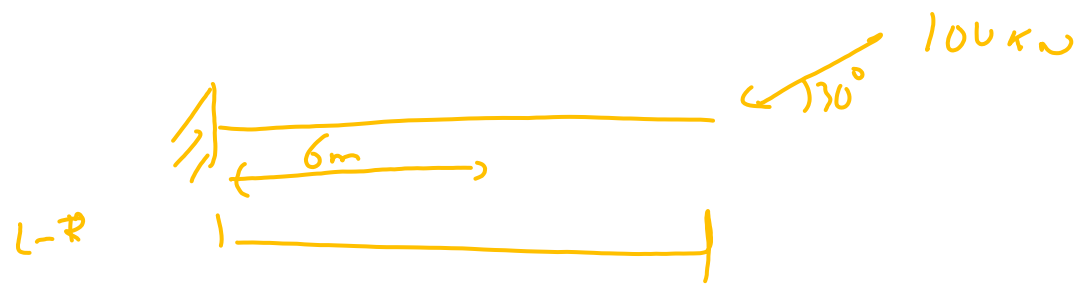


Tension (+ve)

AF = -86.6 kN

Comp (-ve)

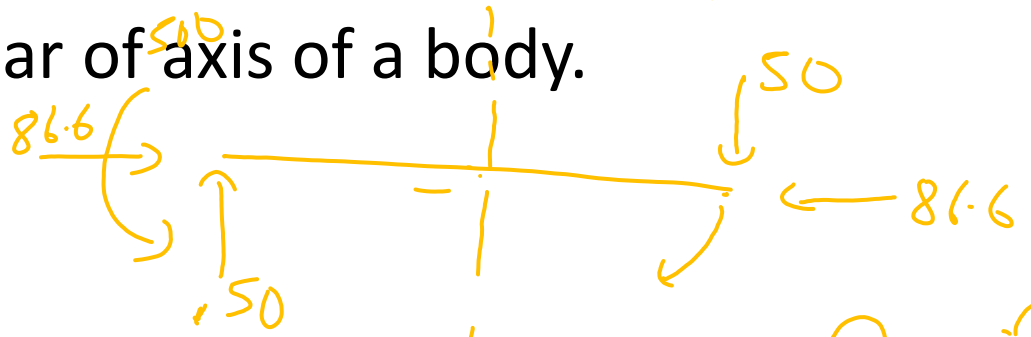
Shear forces



Force acting in perpendicular of axis of a body.

Parallel to cross section.

Unit: N, kN



$\Sigma M_R = 0$

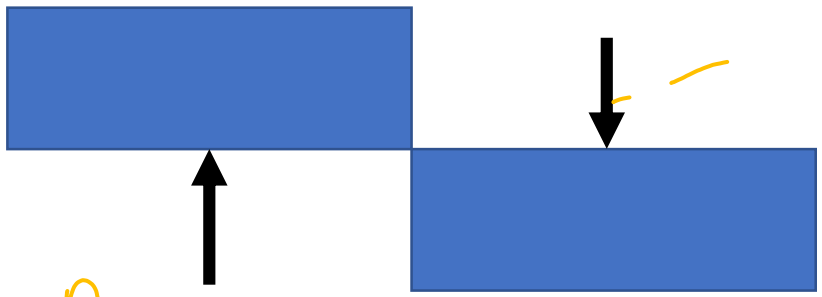
$AF = -86.6$

$SF = -50$

BM =

+ve

-ve



R to L

M = -50 x 4

= -200

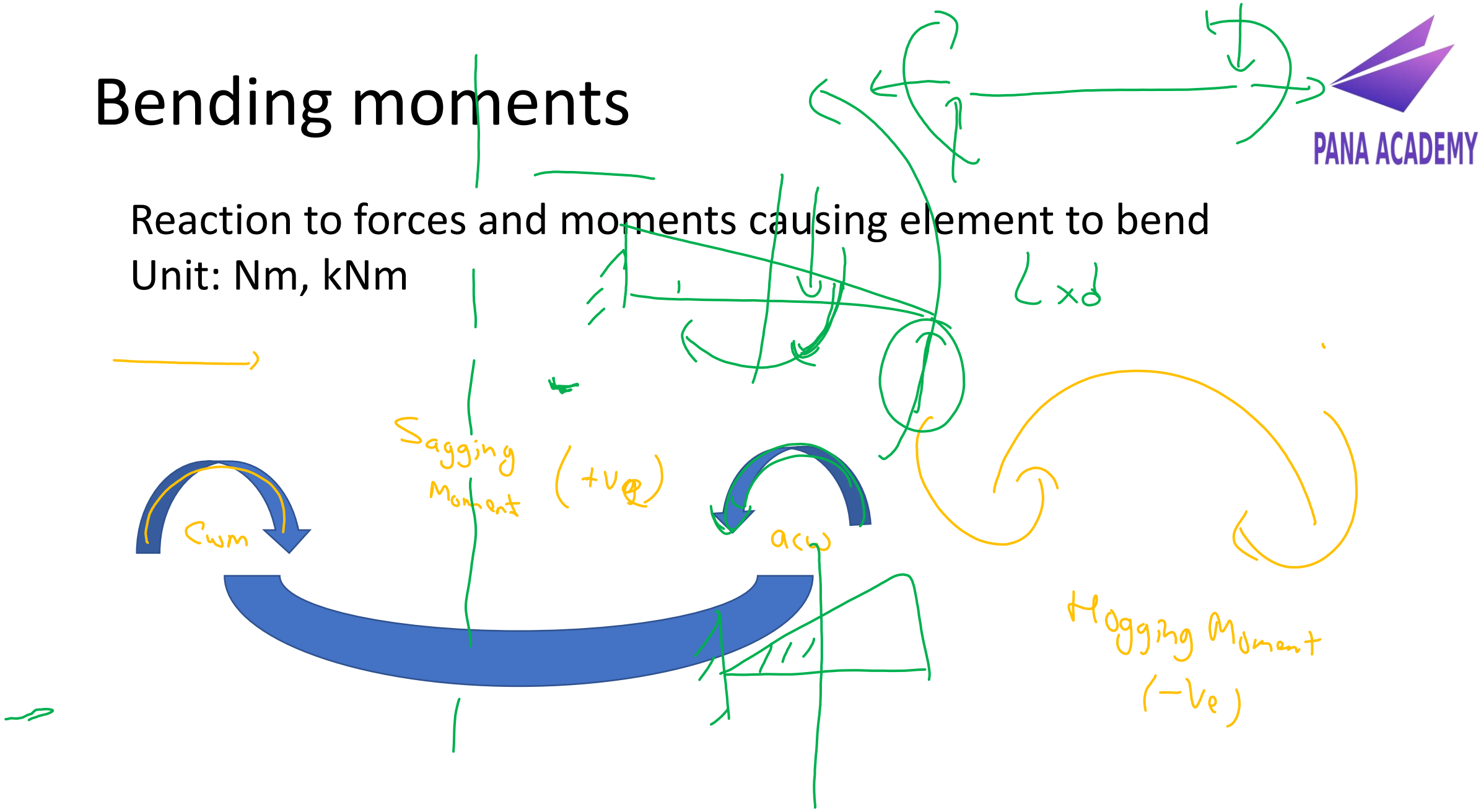
L to R

M = -500 + 50 x 6 = -200

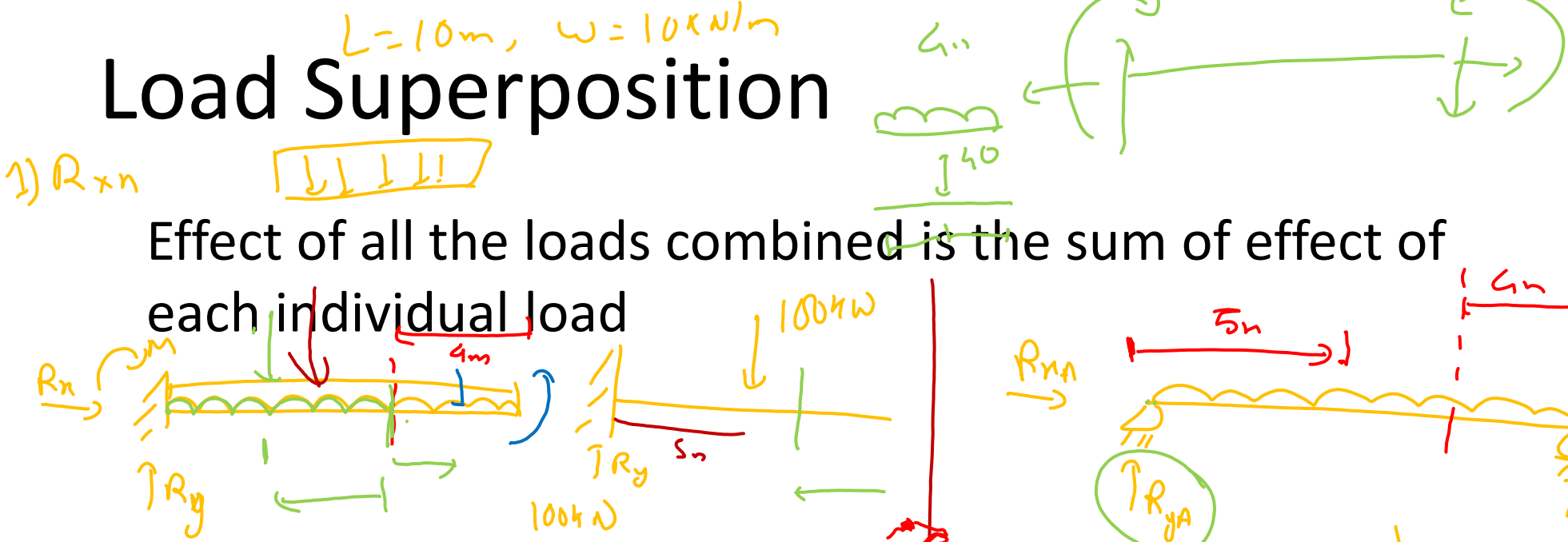
Bending moments

Reaction to forces and moments causing element to bend

Unit: Nm, kNm



Load Superposition



Effect of all the loads combined is the sum of effect of each individual load

$R_x = 0$

$\uparrow \Sigma f_y = 0$

$R_y - 10\times10 = 0$

$R_y = 100$

$AF = 0, SF = 10\times4 = 100 - 10\times6 = 40$

$\circlearrowleft \Sigma M_A = 0$

$M + 100\times5 = 0$

$M = -500$

$BM = -4\times10\times2 = -80$

$= -500 + 100\times6 - 6\times10\times3 = -80$

$R_{xA} = 0$

$\uparrow \Sigma f_y = 0$

$R_{yA} - 10\times10 + R_{yB} = 0$

$R_{yA} = 100 - R_{yB}$

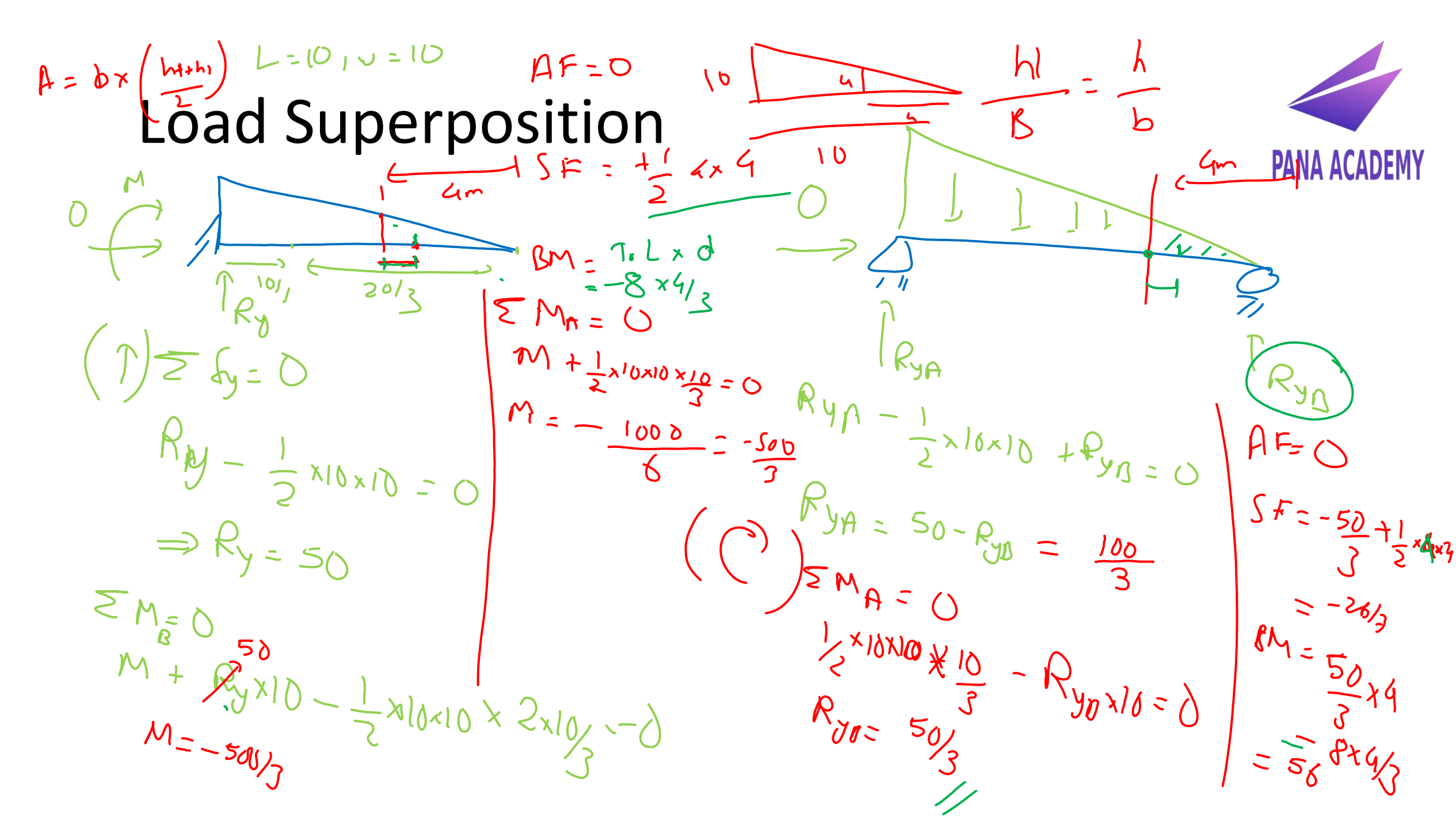
$= 50$

$\circlearrowleft \Sigma M_A = 0$

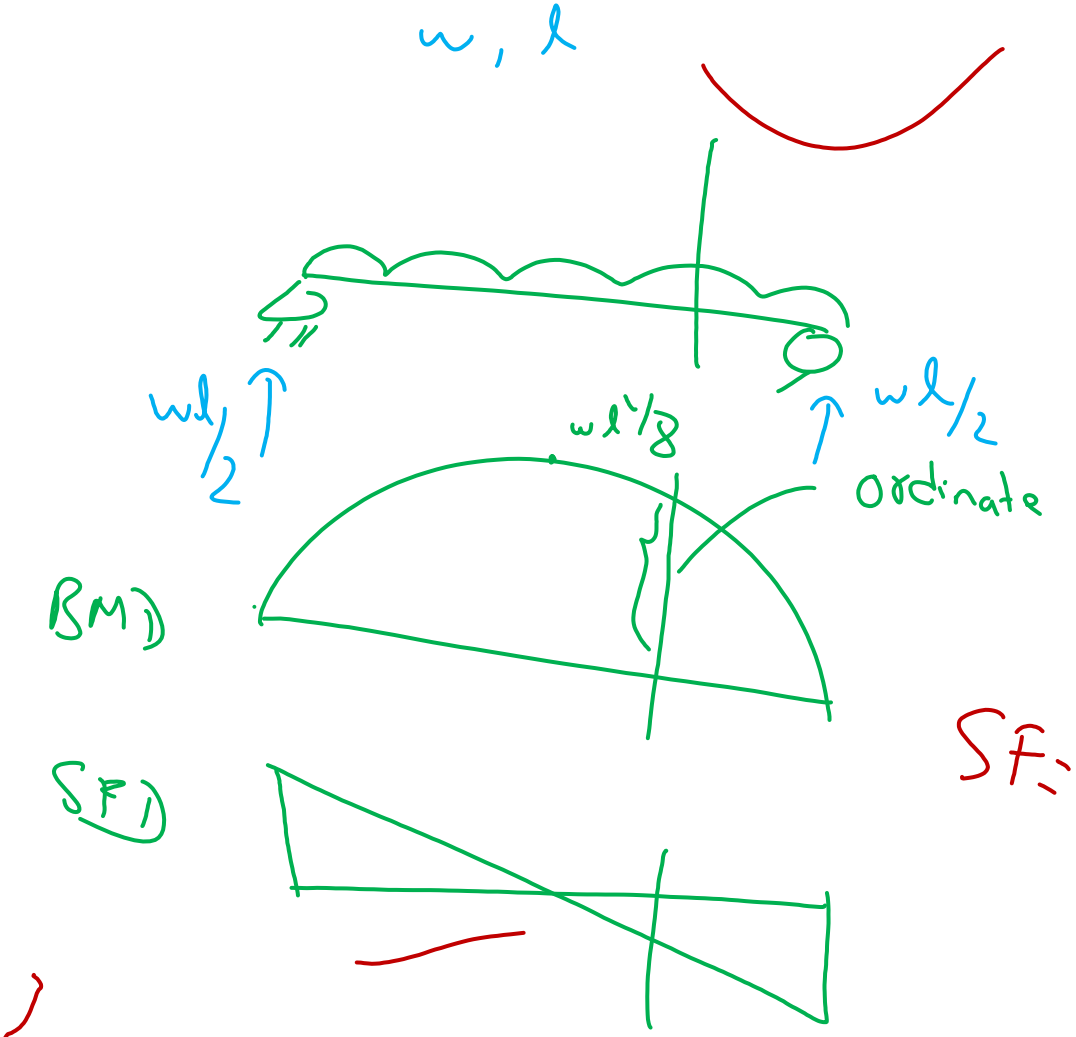
$+ 10\times10\times5 - R_{yB}\times10 = 0$

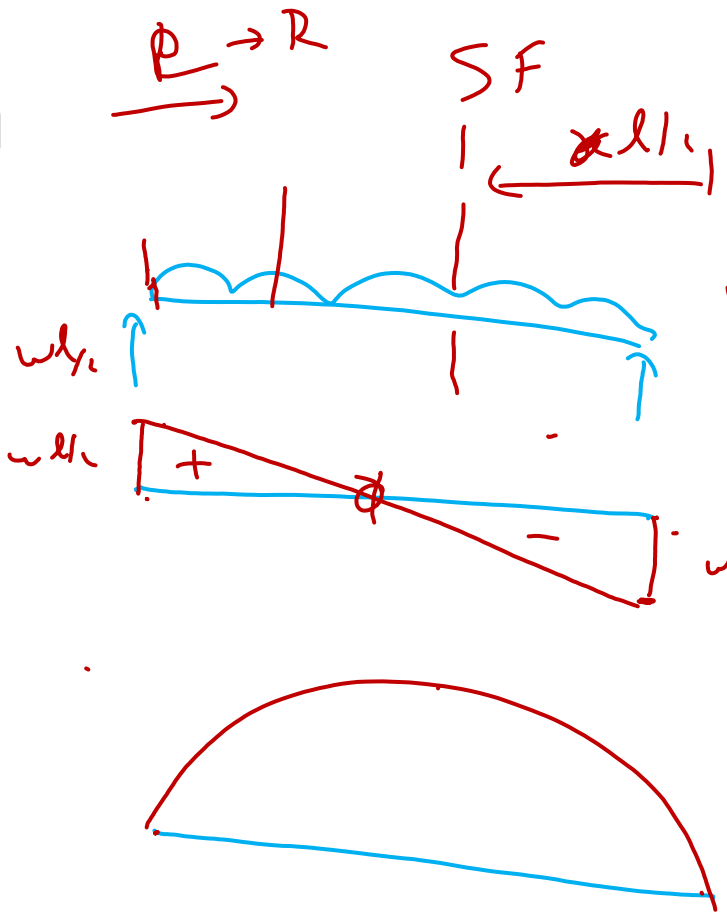
$R_{yB} = 50\,kN$

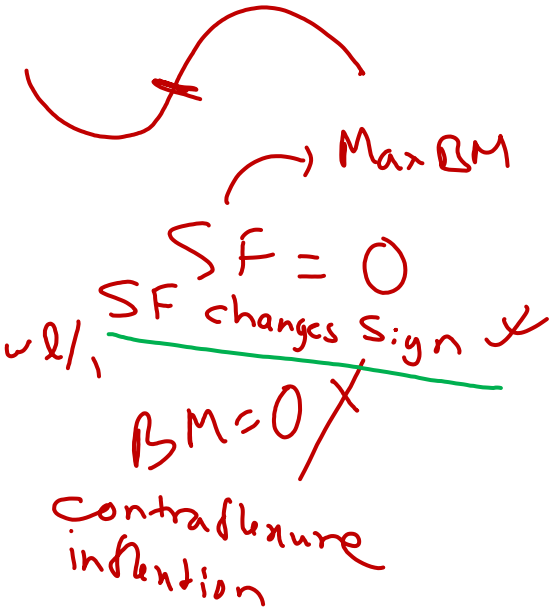
Load Superposition



Load Superposition







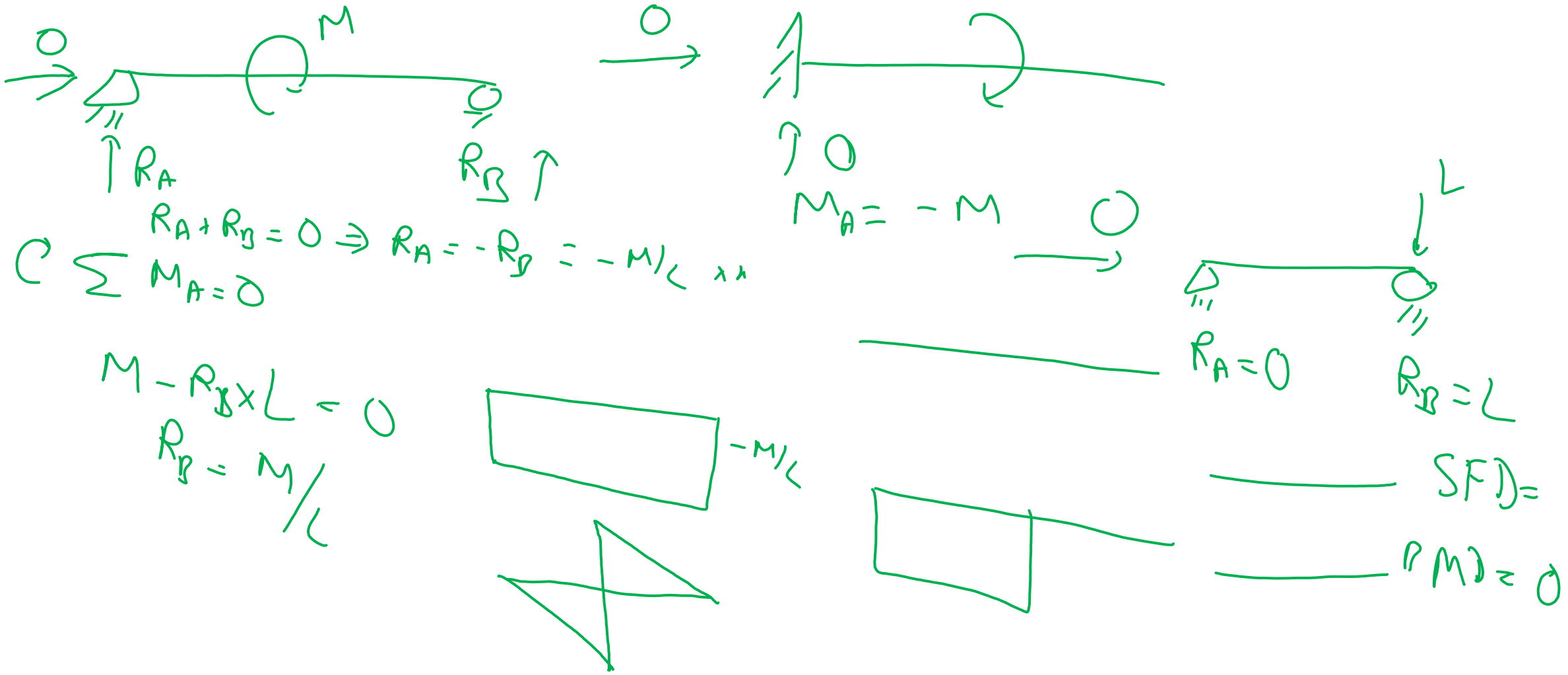
$SF: -wl/2 + wx = 0$

$x = l/2$

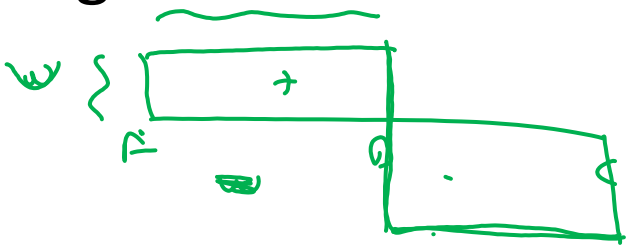
$BM: wl/2 \times l/2 - wl/2 \times l/4 - wx^2/2$

$= wl^2/8$

Load Superposition



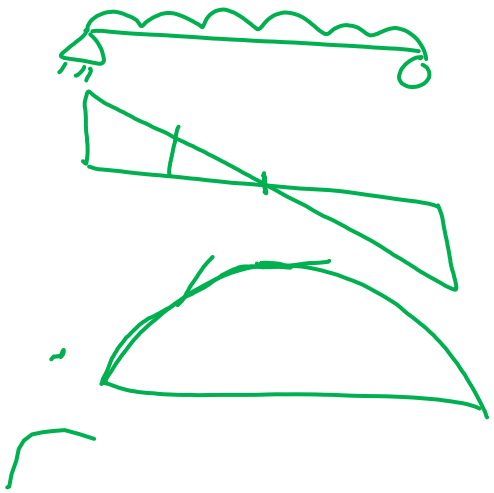
Relationship of forces



Rate of change of bending moment wrt x gives the shear force.

$$V = \frac{\partial}{\partial x} M$$

Slope of BM diagram gives the shear at that point

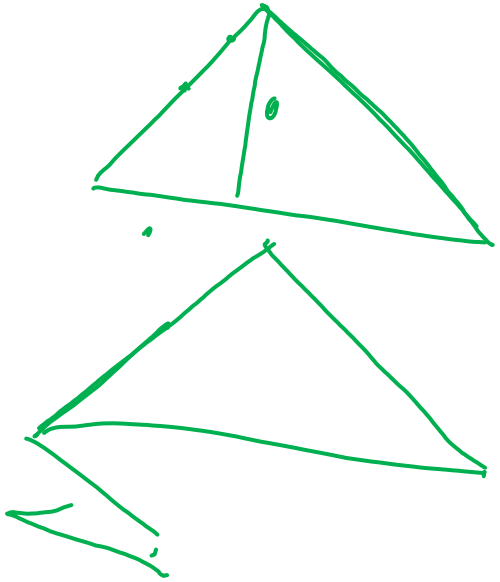


$$\int V dx = \int \partial M$$

$$\int V dx = M_2 - M_1$$

$$M_2 = M_1 + \int V dx$$

$M_2 = 0 + \text{Ar}$



Relationship of forces

Rate of change of shear wrt x gives the load.

$$L = \frac{\partial}{\partial x} V$$

Slope of shear force diagram gives the load at that point

Diagram interpretation

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Area of SFD to left or right of section = moment at that section

Slope of SFD at a point gives load at that point

Slope of SFD zero/ SFD is horizontal means no load applied at that point

Diagram interpretation

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Maximum moment occurs at point of zero shear. (SF changes sign)

Point of contraflexure / inflection = BM = 0 (BM changes sign)

While moving left to right:

When shear diagram is increasing , moment diagram is concave upward.

When shear diagram is decreasing, moment diagram is concave downward.

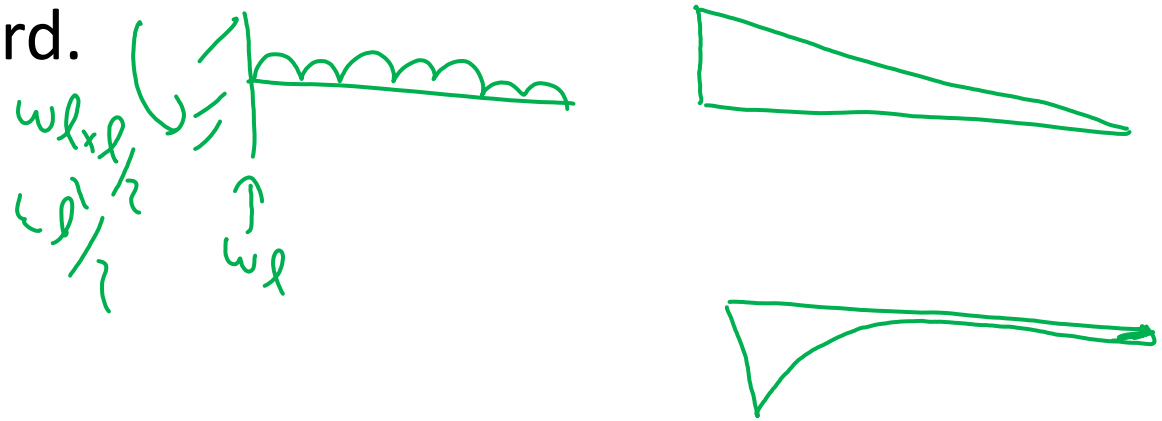

Diagram interpretation

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Slope of BMD at a point gives shear at that point

Slope of BMD zero/ BMD is horizontal means no shear force at that point.

Diagram interpretation

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BM at internal hinge =0

Roller and hinge support has BM zero if present at end.

Have BM value in continuous beams

Fixed support has nonzero BM

BM, SF at end of beam =0

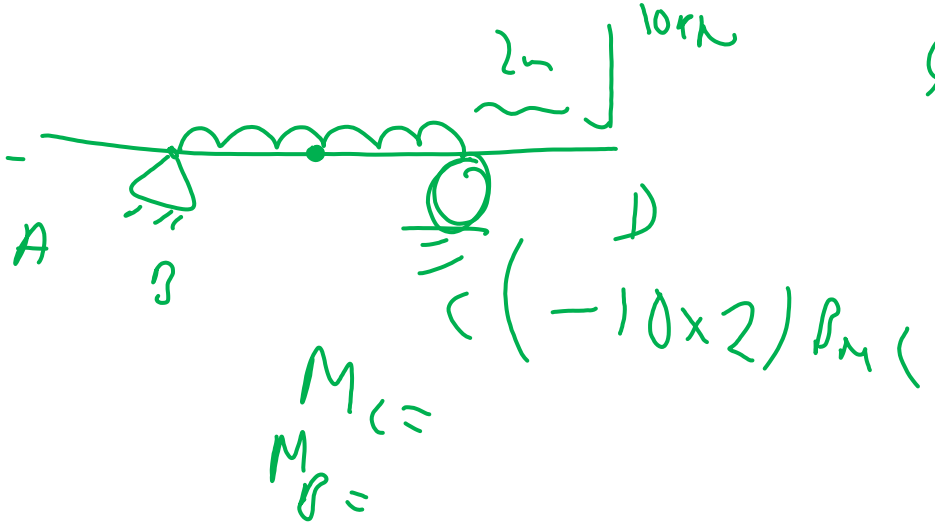

Diagram interpretation

LOAD	SFD	BMD
Zero	constant	Linear (increasing or decreasing)
UDL	linear	parabolic
UVL	parabolic	cubic

Point load (vertical in SF)

Moment

a) No load is acting bet A & B

b) BMD bet A & B is parabolic

Diagram interpretation

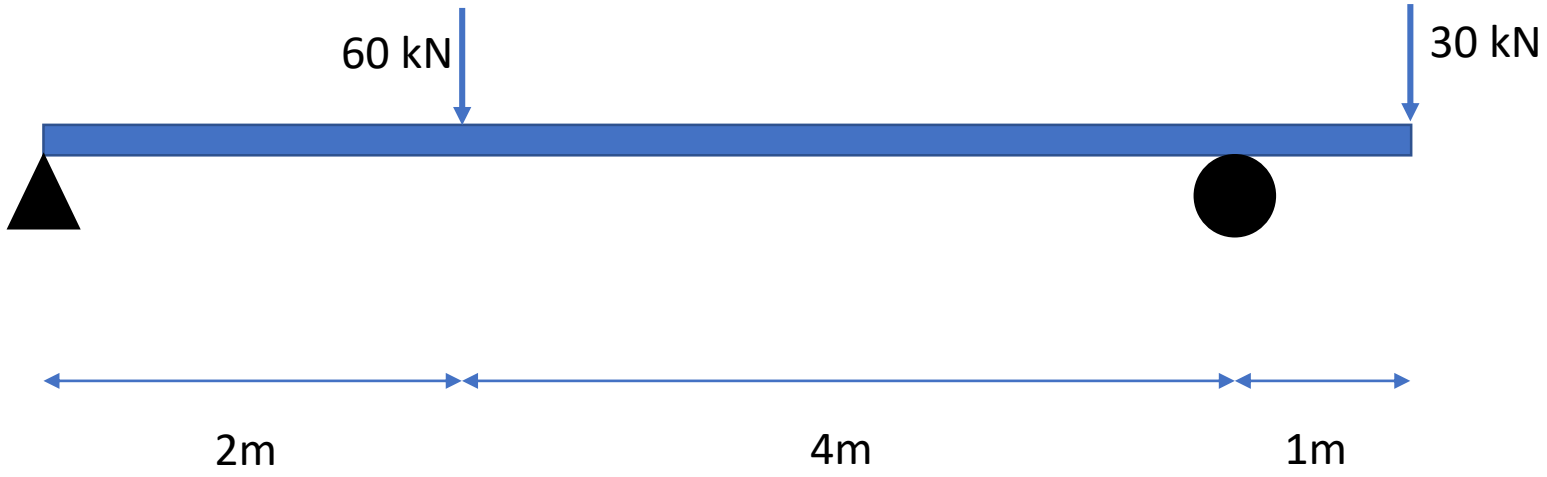

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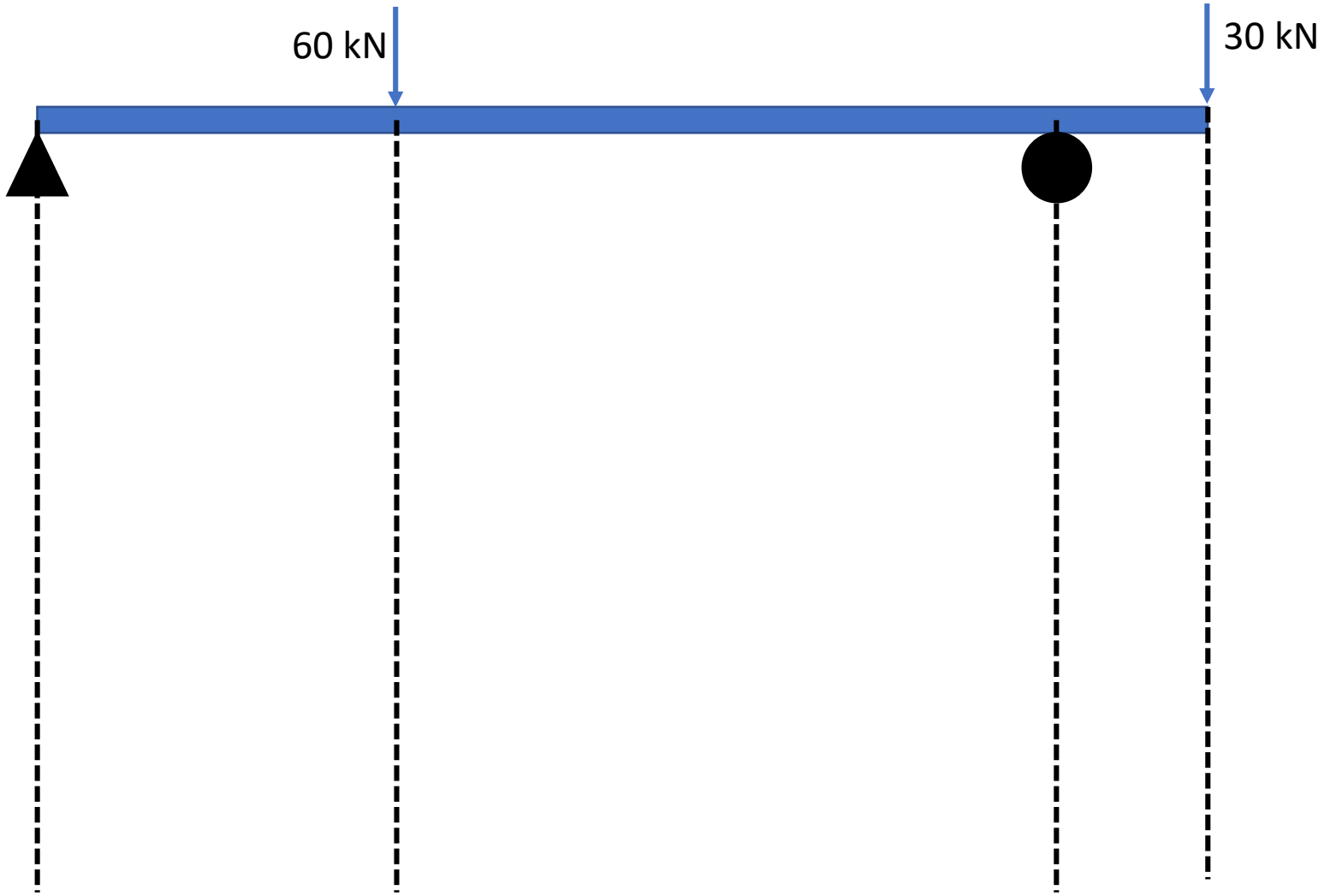
Diagram interpretation



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MCQs

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In a bending beam, the point of contraflexure is a point where:

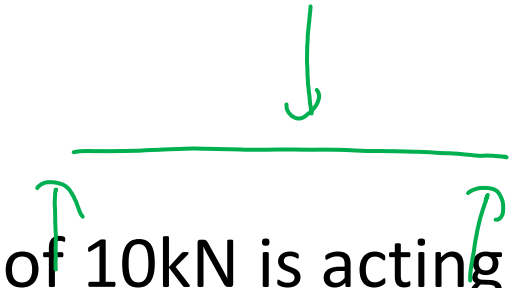
a) Shear Force changes its sign

b) Bending Moment changes its sign

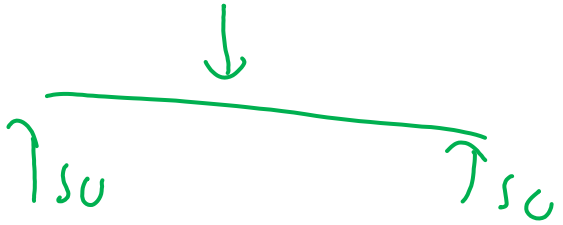
c) Shear Force remains constant

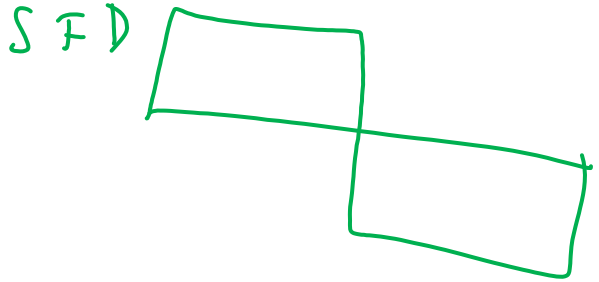
d) Bending Moment remains constant

MCQs



A point load of 10kN is acting at midspan of simply supported beam. Bending moment is maximum at





a) Midspan ✓

b) One-third length from support

c) At support

d) Cannot be determined

MCQs

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When a cantilever beam is loaded with UDL bending moment diagram will be

a) Horizontal line

b) Vertical straight line

c) Inclined line

d) Parabolic curve

MCQs

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When a cantilever beam is loaded with UVL bending moment diagram will be

a) Horizontal line

b) Cubic curve

c) Inclined line

d) Parabolic curve

MCQs

When shear force diagram is parabolic curve between two points, it indicates that there is

a) Point load at two points

b) No loading between points

c) UDL between points

d) UVL between two points

MCQs

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When bending moment diagram is vertical at a point, it indicates that there is _____ at that point

a) Point load

b) Moment

c) Torsion

d) Series of point load

MCQs

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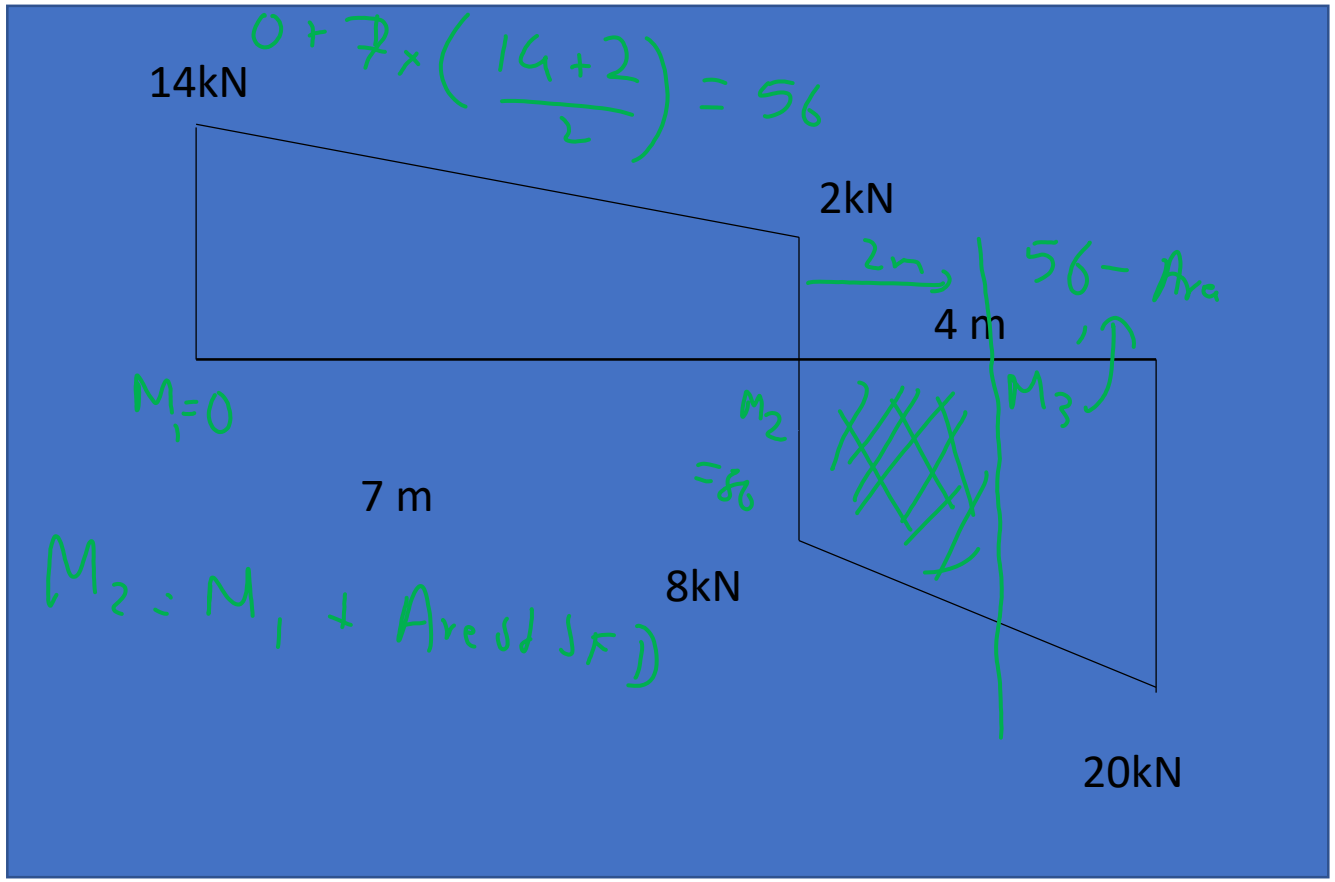
The maximum bending moment for beam with shear force diagram given below is:

a) 16 kNm

b) 56 kNm

c) 28 kNm

d) 8 kNm



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Thank YOU !!!