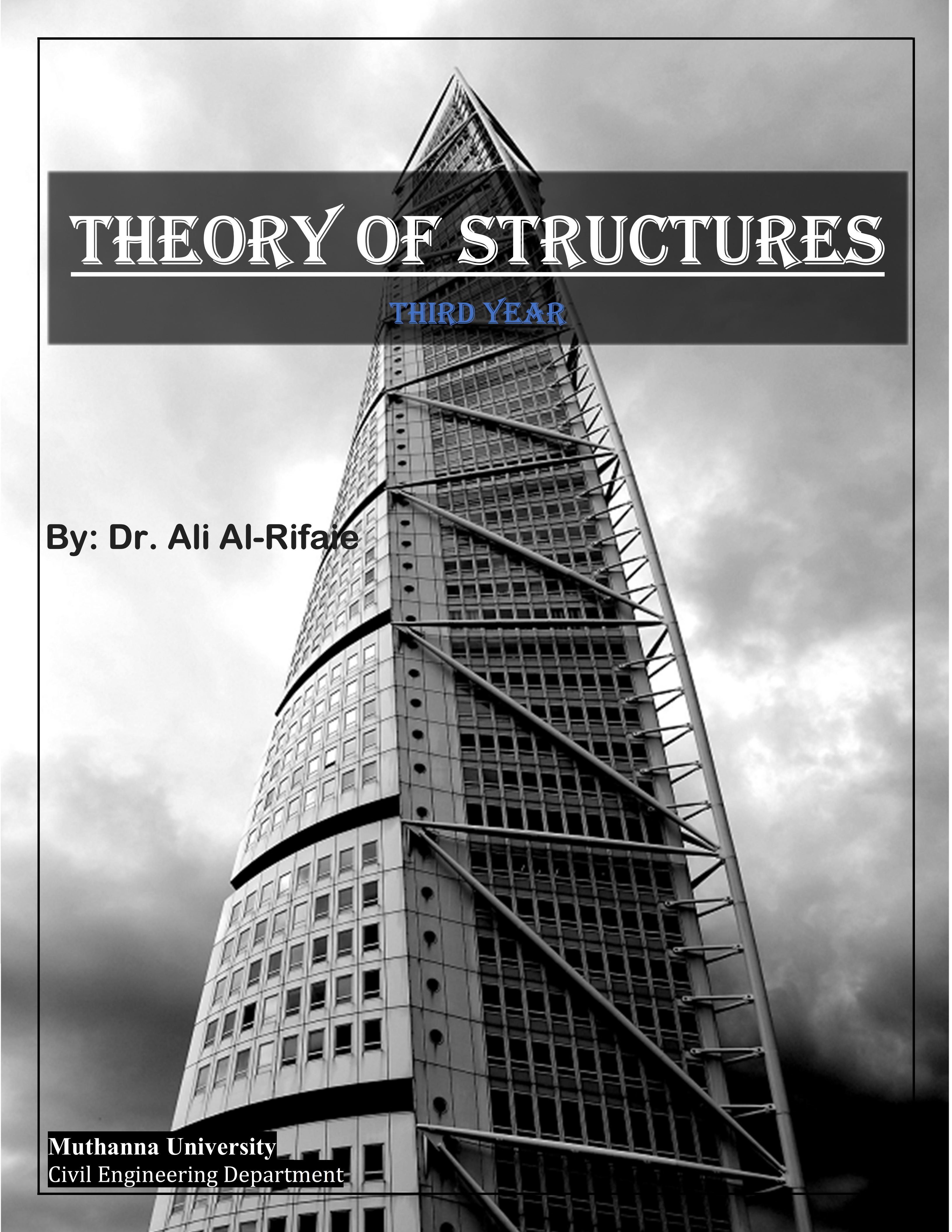

THEORY OF STRUCTURES

THIRD YEAR

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Theory of structure

1- Introduction

2- Stability and determinacy of :

- Beam
- Frame
- Truss

3- Analysis of statically determinate trusses

4- Axial, shear and bending moment diagram for frames and arches

5- Influence lines of statically determinate structure

References

1- Structural analysis by R.C Hibbeler (Text book)

2- Elementary theory of structures by Yuan Yu Hsieh

Introduction

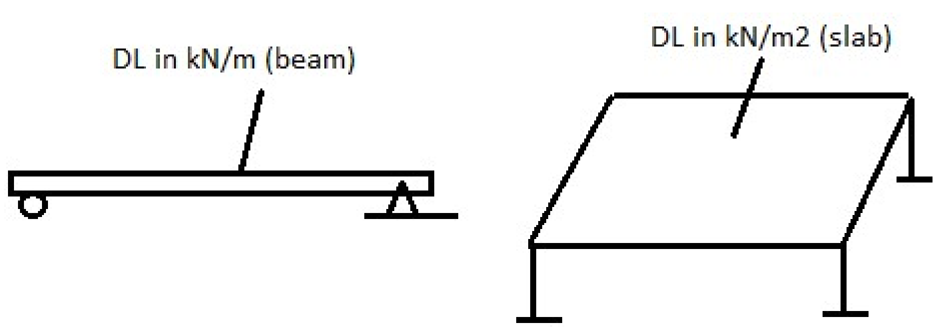
A structure refers to a system of connected parts used to support a load.

Examples in civil engineering

- ✓ **Buildings**
- ✓ **Bridges**
- ✓ **Towers**

Loads on structure

- **Dead loads : Dead loads consist of the weights of the various structural members and the weights of any objects that are permanently attached to the structure. Hence, for a building, the dead loads include the weights of the columns, beams, and girders, the floor slab, roofing, walls, windows, plumbing, electrical fixtures, and other miscellaneous attachments**



See also Table 1-3 Minimum design dead load

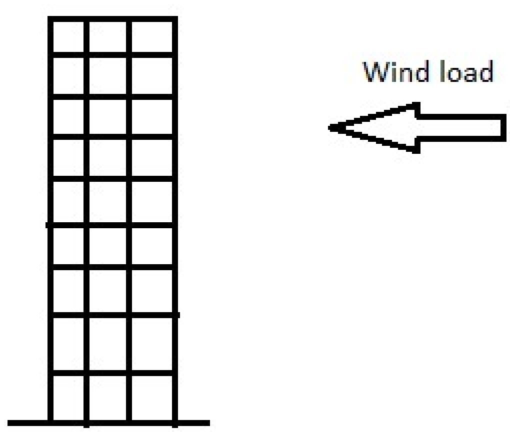
TABLE 1–3 Minimum Design Dead Loads*

Walls	psf	kN/m^2
4-in. (102 mm) clay brick	39	1.87
8-in. (203 mm) clay brick	79	3.78
12-in. (305 mm) clay brick	115	5.51
Frame Partitions and Walls		
Exterior stud walls with brick veneer	48	2.30
Windows, glass, frame and sash	8	0.38
Wood studs 2 × 4 in., (51 × 102 mm) unplastered	4	0.19
Wood studs 2 × 4 in., (51 × 102 mm) plastered one side	12	0.57
Wood studs 2 × 4 in., (51 × 102 mm) plastered two sides	20	0.96
Floor Fill		
Cinder concrete, per inch (mm)	9	0.017
Lightweight concrete, plain, per inch (mm)	8	0.015
Stone concrete, per inch (mm)	12	0.023
Ceilings		
Acoustical fiberboard	1	0.05
Plaster on tile or concrete	5	0.24
Suspended metal lath and gypsum plaster	10	0.48
Asphalt shingles	2	0.10
Fiberboard, $\frac{1}{2}$-in. (13 mm)	0.75	0.04

*Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-10.

- **Live Loads**. Live Loads can vary both in their magnitude and location
  - ✓ **Building Loads**. The floors of buildings are assumed to be subjected to uniform live loads, which depend on the purpose for which the building is designed.
  - ✓ **Highway Bridge Loads**. The primary live loads on bridge spans are those due to traffic.

- **Impact Loads**
  - ✓ Vehicle impact
  - ✓ Debris impact
- **Wind Loads**. When structures block the flow of wind, the wind's kinetic energy is converted into potential energy of pressure, which causes a wind loading

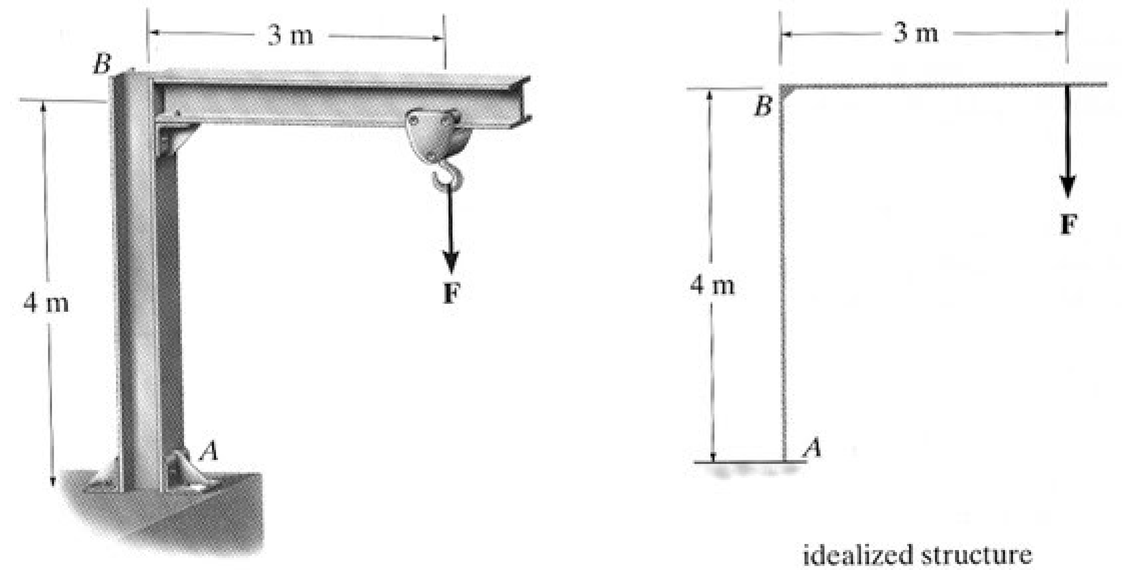


- **Snow Loads**. In some countries, roof loading due to snow can be quite severe, and therefore protection against possible failure is of primary concern.

Excessive snow and ice loadings act on this roof.

- **Earthquake Loads**. Earthquakes produce loadings on a structure through its interaction with the ground and its response characteristics. These loadings result from the structure's distortion caused by the ground's motion and the lateral resistance of the structure.

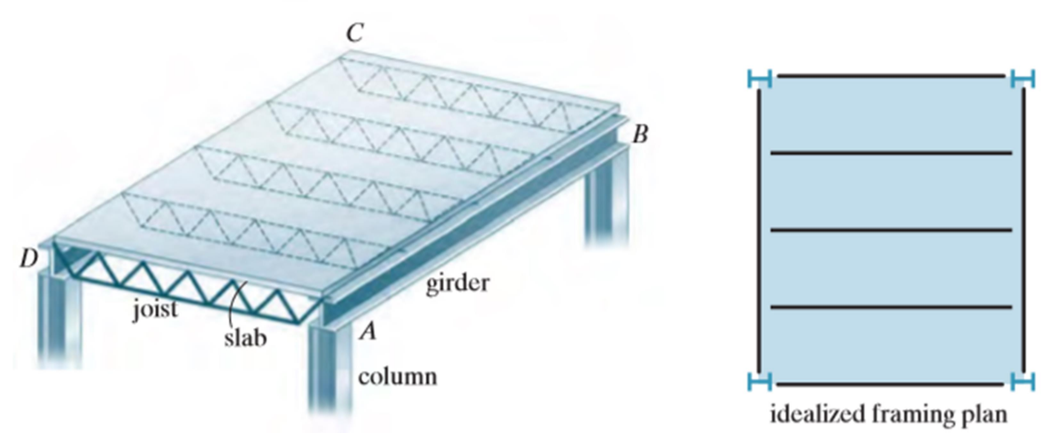
Idealized structure



actual structure

idealized structure

(b)



(a)

idealized framing plan

(b)

real Idealized

Equations of equilibrium

$$\Sigma F_x = 0$$
$$\Sigma F_y = 0$$
$$\Sigma M_O = 0$$

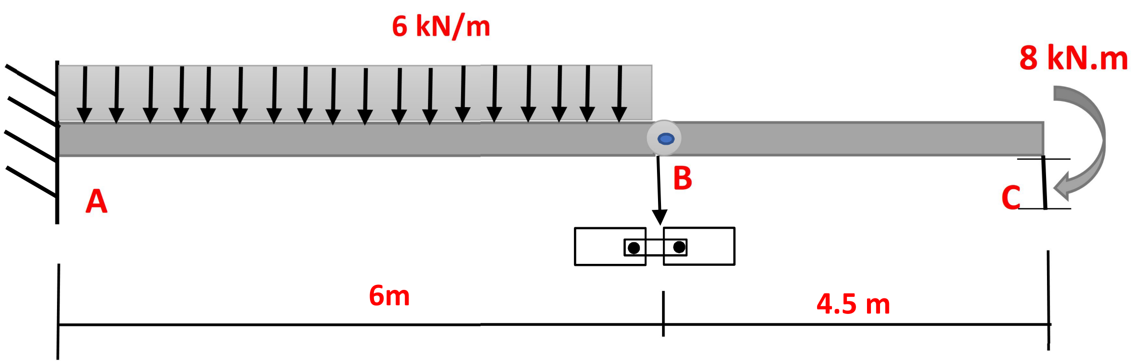
2D

$$\Sigma F_x = 0 \quad \Sigma F_y = 0 \quad \Sigma F_z = 0$$
$$\Sigma M_x = 0 \quad \Sigma M_y = 0 \quad \Sigma M_z = 0$$

3D

EX1

The compound beam shown in figure below is fixed at A. Determine the reaction at A,B and C. Assume that the connection at B is a pin and C is a roller.



Solution

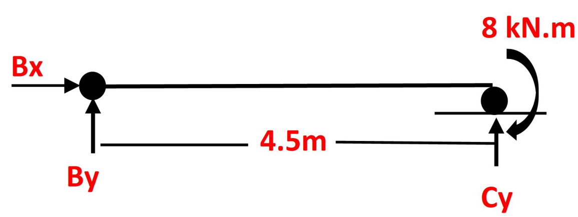
Segment BC:

$\sum Mc = 0$

$-8 + By(4.5) = 0 \rightarrow By = 1.78\ kN$

$\sum Fy = 0 \rightarrow -1.78 + Cy = 0 \rightarrow Cy = 1.78\ kN$

$\sum Fx = 0 \rightarrow Bx = 0$

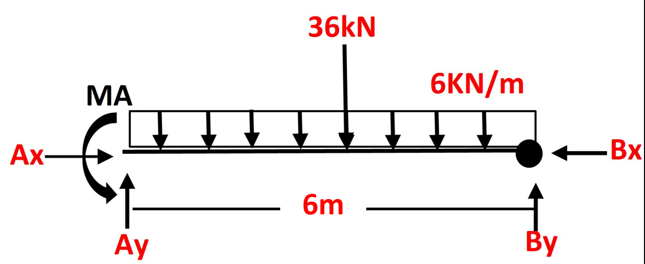


- **Segment AB**:

$\sum M_B = 0$

$M_A - 36(3) + 1.78(6) = 0$

$M_A = 973KN.m$



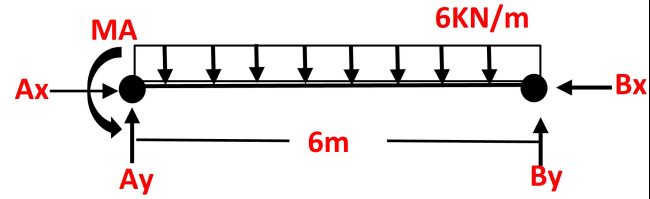
$\sum Fy = 0$

$Ay - 36 + 1.78 = 0 \rightarrow Ay = 34.2\ kN$

$\sum Fx = 0 \rightarrow Ax - 0 = 0 \rightarrow Ax = 0$

- **Another solution:**

All body :



$\circlearrowleft + \sum Mc = 0$

$-36(7.5) + 8 - M_A + Ay(10.5) = 0$

$10.5\ Ay - M_A = 262 \ldots \ldots .1$

- **Segment AB**

$\circlearrowleft + \sum MB = 0:$

$-MA + 6Ay - 36(3) = 0$

$6Ay - MA = 108 \ldots \ldots \ldots .(2)$

$MA = 6Ay - 108\ \ sub\ in \ldots \ldots \ldots ..(1)$

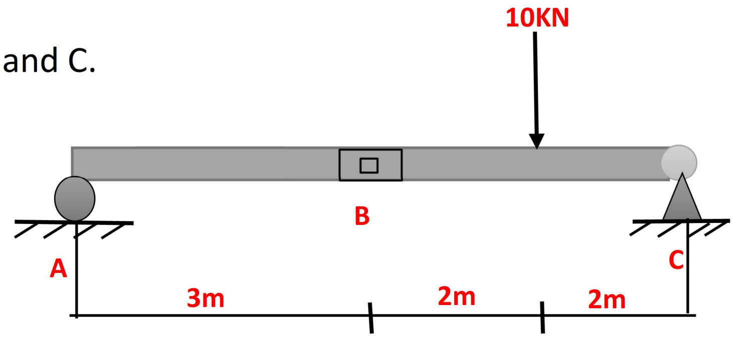
$10.5\ Ay - 6Ay + 108 = 262$

$4.5\ Ay = 154\ \rightarrow Ay = 34.2\ kN$

$MA = 6(34.2) - 108 \rightarrow MA = 97.3$

EX2

Determine the reactions at points A and C.

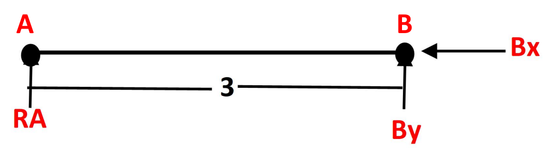


Solution

- **Segment AB:**

$\circlearrowleft + \sum MB = 0$

$RA = 0$



- **All body**

$+\uparrow \sum Fy = 0$

$RA + Rc = 10$

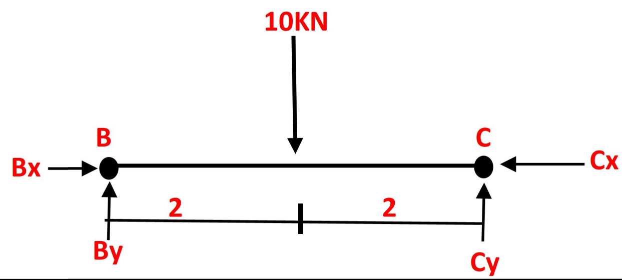
$0 + Rc = 10 \rightarrow Rc = 10\ KN$

- **Another method:**

Segment BC:

$\circlearrowleft + \sum MB = 0$

$10(2) = Cy(4) \rightarrow Cy = 5KN$



Compare with the first solution!!