DEPTT: "CIVIL ENGINEERING"

EXAM :

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STRUCTURAL ANALYSIS

SUBMITTED TO :

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Q1: Write a detailed note in your own words
(CLO1) on different types of loads that different types of structures are designed to support throughout its life. Elaborate with examples.

Ans: LOADS: Probably the most important thing for a structure is to determine its dimensional design. The 2nd most important thing is to determine the loads for that particular structure that it must support. For example, very tall structures and buildings are designed in a way that endure large lateral loadings caused by wind. Therefore, shear walls and tubular frame systems are selected according to the loads. Similarly in areas where earthquakes happen, buildings are designed having ductile frames and connections.

Codes are used to specify design loading for a structure. Generally, there are two types of such codes: (i) general building codes
(ii) design codes

TYPES OF LOADS:

(i) **Dead Loads:** Objects that are permanentey attached to a structure constitute dead loads. It includes:

(a) weights of the various structural members

(b) weights of any objects that are permanently attached to the structure.

Example: For a building, the dead loads include the weights of the columns, beams, and girders, the floor slab, roofing, walls windows, plumbing, electrical fixtures etc.

(ii) **Live Loads:** In contrast to dead loads live loads are caused by the weights of the objects which are temporarily attached to the structure.

Example: The weight of the people, movable partitions, weight of furniture and equipment etc.

(iii) **Wind Loads:** A very high speed wind can cause damage to a structure. This is because the pressure created by wind is proportional to the square of the wind speed. In large hurricanes, for example in coastal regions of the US, this speed can reach to over a 100m/h. Similarly, an F5 tornado (Fujita scale) has wind speeds even over 300 m/h.

The very high speed wind cause lateral loadings that can cause racking, or leaning of a building frame. However, this effect can be resisted with some techniques. For example, cross bracing, knee or diagonal bracing, or shear walls.

(iv) Impact Loads: Impact load is caused by the impact of the objects that constitute live load. For example, moving vehicles may bounce or sideway as they move over a bridge, and therefore they impart an impact to the deck. The percentage increase of the live loads due to impacts is called the 'impact factor' I. This factor is generally obtained from formulae developed from experimental evidence. For example, for highway bridges the AASHTO specifications require that

$$I = \frac{50}{L+125} \quad \text{but not larger than } 0.3$$

(v) **Highway Bridge Loads**: The primary live loads on bridge spans are those due to traffic, and the heaviest vehicle loading encountered is that caused by a series of trucks. Specifications for truck loadings on highway bridges are reported in the LRFD Bridge Design Specifications" of the American Association of State and Highway Transportation Officials (AASHTO).

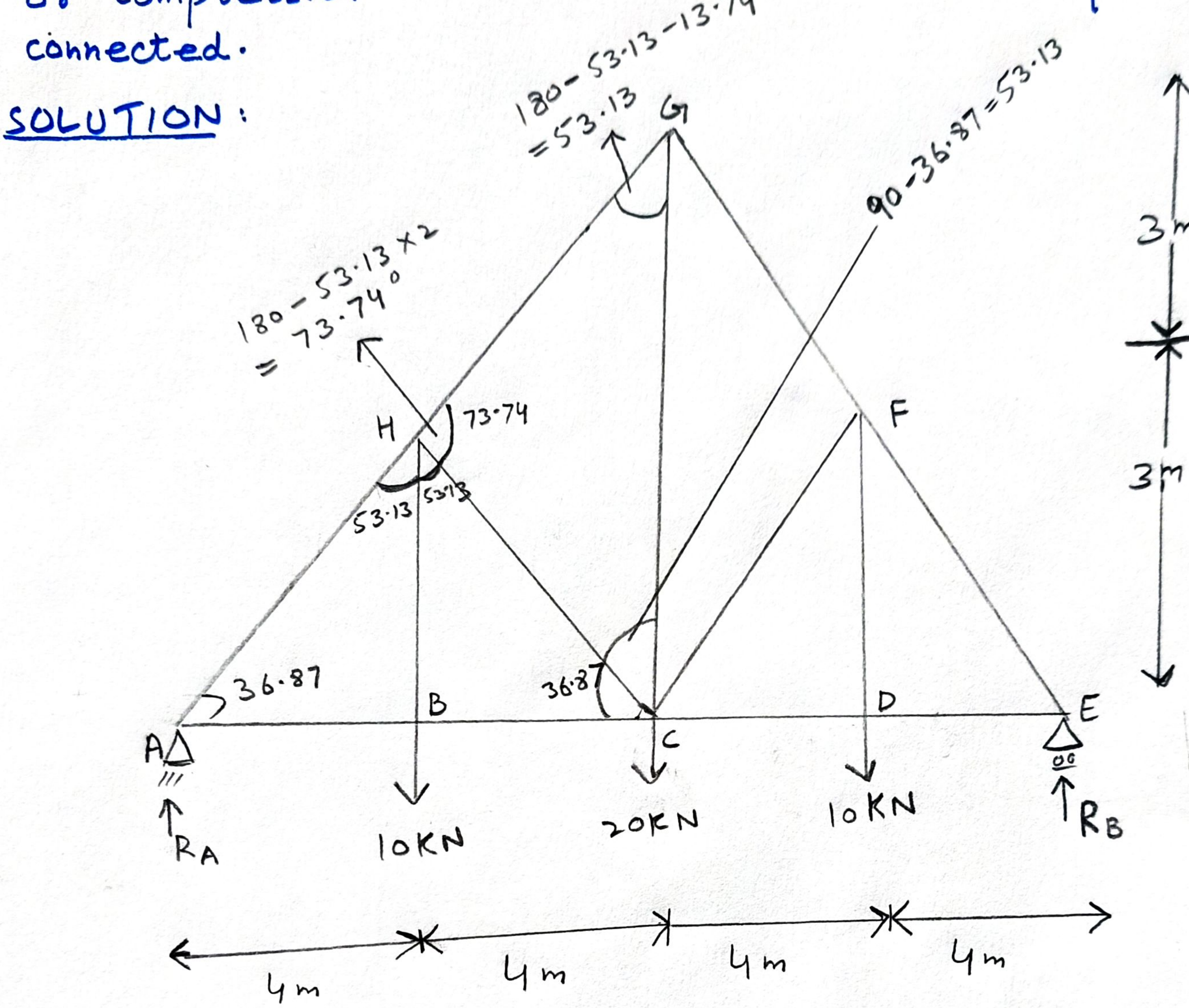
Example: Highway bridge load is capable of supporting vehicle load, pedestrian load and other loads. This is because bridges located on major highways, which carry a great deal of traffic, are often designed for two-axle trucks plus a one-axle semitrailer

(vi) **Railroad Bridge Loads**: The loadings on railroad bridges are specified in the "Specifications for Steel Railway Bridges" published by the American Railroad Engineers Association (AREA). Since train loads involve a complicated series of concentrated forces, to simply hand calculations, tables and graphs are sometimes used in conjunction with inflence lines to obtain the critical load. Also, computer programs are used for this purpose.

(vii) **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. These loadings are generally tabulated in local, state, or national codes. The values are determined from a history of loading various buildings. They include some protection against the possibility of overload due to emergency situations, construction loads, and serviceability requirements due to vibration.

Q2: (CLO2) Determine the force in each member of the truss. State if the members are in tention or compression. Assume all members are pin connected.

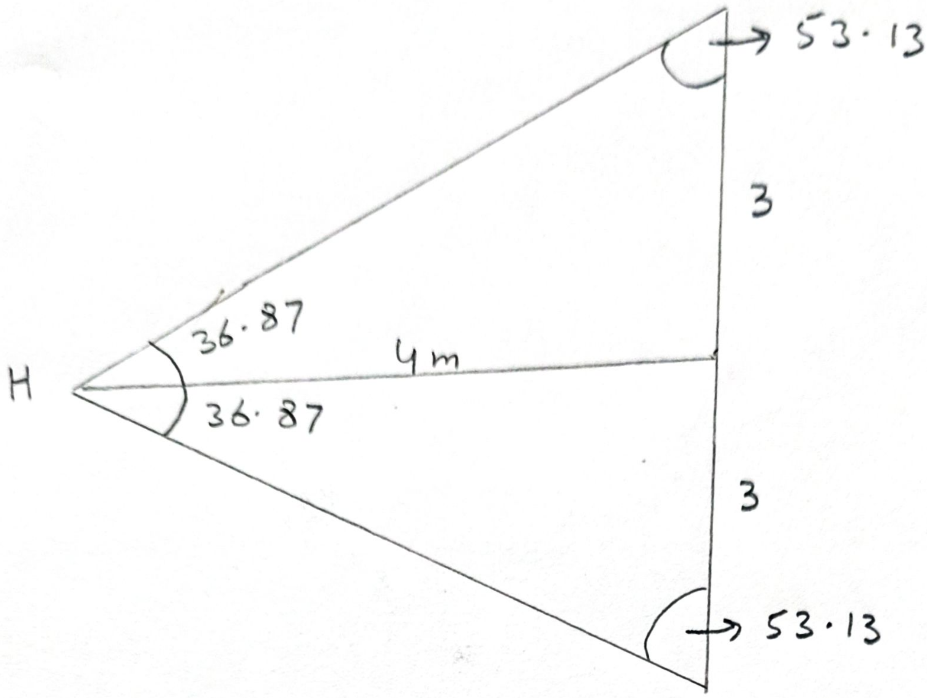
SOLUTION:



$$\tan \theta_A = \frac{3}{4} \Rightarrow \boxed{\theta_A = 36.87^\circ}$$

$$\theta_H = 90 - 36.87 = 53.13$$

$$\boxed{\theta_H = 53.13^\circ}$$



For Reaction Forces

$+\uparrow\downarrow- \quad \Sigma F_y = 0$

$R_A + R_B - 10 - 20 - 10 = 0$

$R_A + R_B = 40$

As the truss is symmetrical so

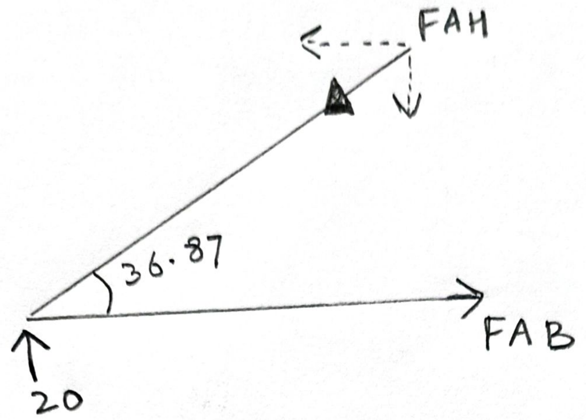
$R_A = R_B$

$\boxed{R_A = 20 \text{ KN}}$ $\boxed{R_B = 20 \text{ KN}}$

Joint Analysis

Joint A :-

FBD



$+\uparrow\downarrow- \quad \sum F_y = 0$

$20 - F_{AH} \sin 36.87 = 0$

$F_{AH} = 33.33 \text{ KN } (C)$

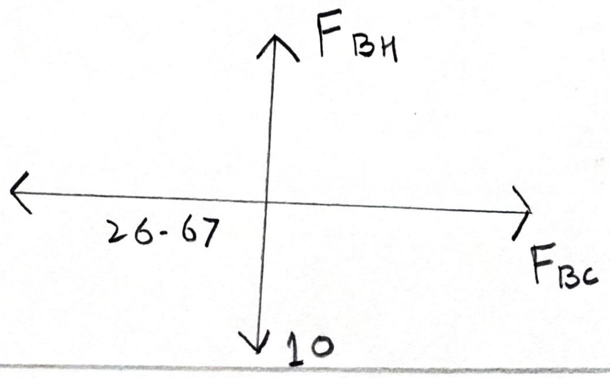
$\xrightarrow{+} \quad \sum F_x = 0$

$F_{AB} - F_{AH} \cos 36.87 = 0$

$\Rightarrow F_{AB} - 33.33 \times \cos 36.87 = 0$

$F_{AB} = 26.67 \text{ KN } (T)$

Joint B :



FBD

$+\uparrow\downarrow- \quad \sum F_y = 0$

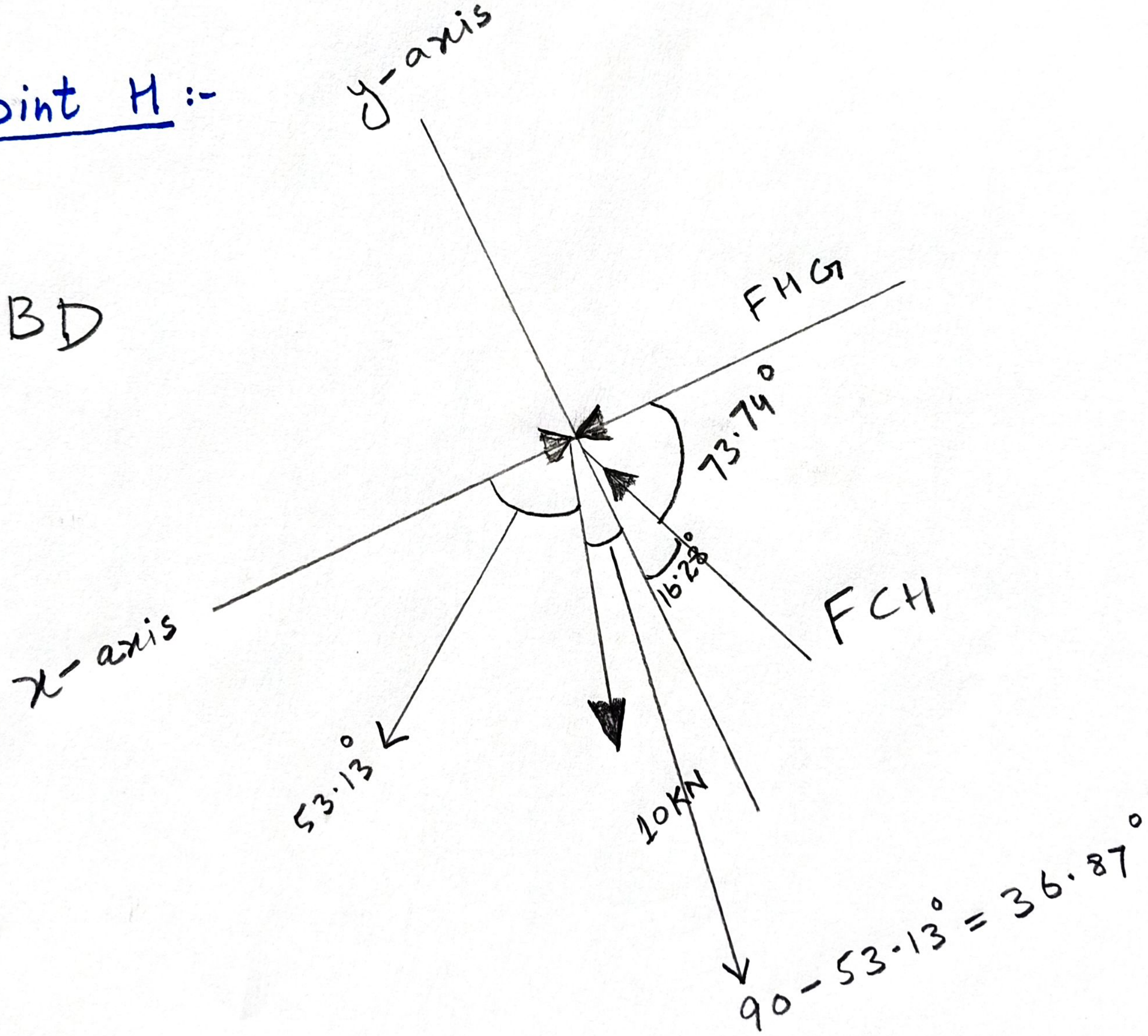
$$\boxed{F_{BH} = 10\ KN(T)}$$

$\overset{+}{\rightleftarrows}_{-} \quad \sum F_{BC} = 0$

$$F_{BC} = 26.67\ KN(T)$$

Joint H :-

FBD



$\sum F_x = 0$

$$33.33 - F_{HG} - F_{CH} \sin 16.26^\circ = 0$$

$$F_{HG} + F_{CH} \sin 16.26 = 33.33 \quad \text{— (1)}$$

$+\uparrow\downarrow \quad \Sigma F_y = 0$

$$F_{CH} \cos 16.26 - 10 \cos 36.87 = 0$$

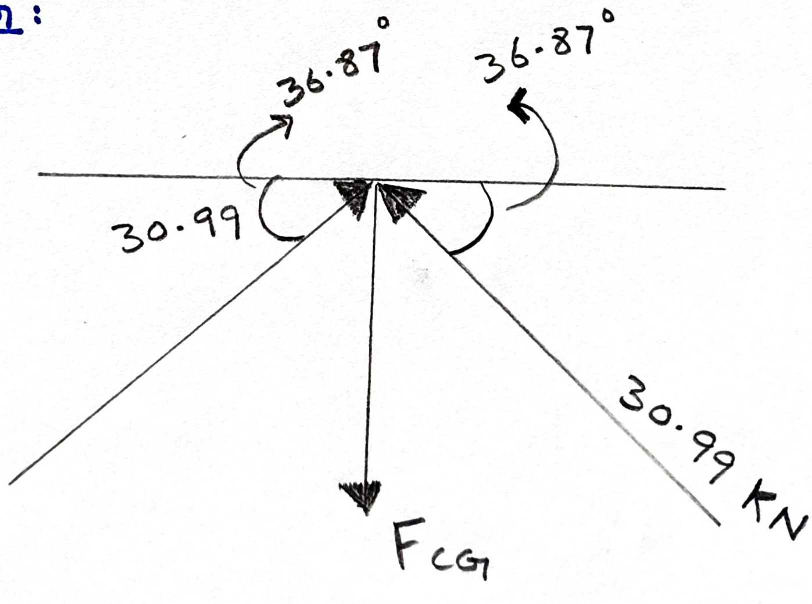
$$F_{CH} = 8.33 \text{ KN (C)}$$

eq. (1)

$$F_{HG} = 33.33 - (8.33) \times \sin 16.26$$

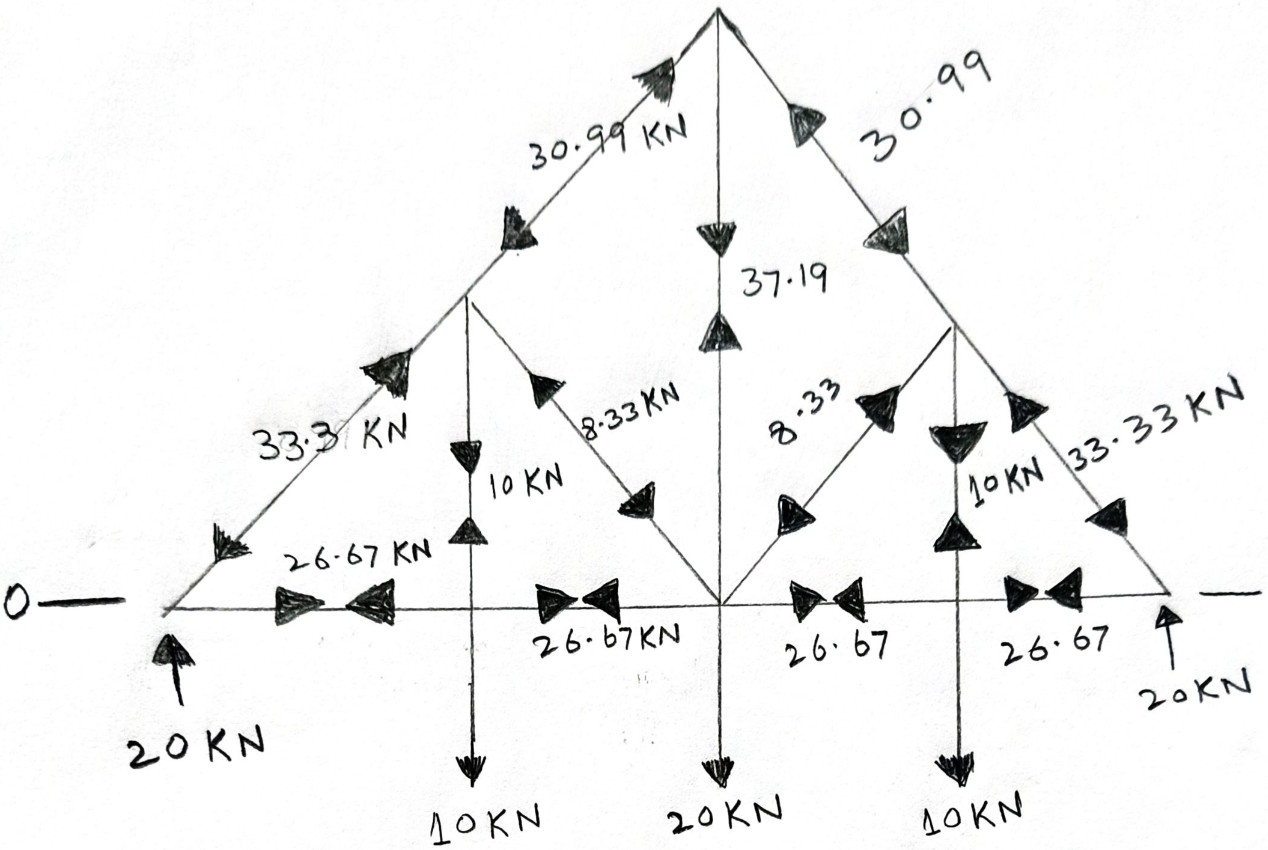
$$F_{HG} = 30.99 \text{ KN (C)}$$

Joint G:



$$F_{CG} - 30.99 \times \sin 36.87^\circ$$
$$- 30.99 \times \sin 36.87^\circ = 0$$

$$\boxed{F_{CG} = 37.19 \text{ KN (T)}}$$


30.99 KN
30.99
37.19
33.33 KN
8.33 KN
8.33
10 KN
10 KN
33.33 KN
26.67 KN
0
0
26.67 KN
26.67
26.67
20 KN
20 KN
10 KN
20 KN
10 KN

Q3 (CLO2) Determine the slope at A and displacement at C of the beam in the figure by

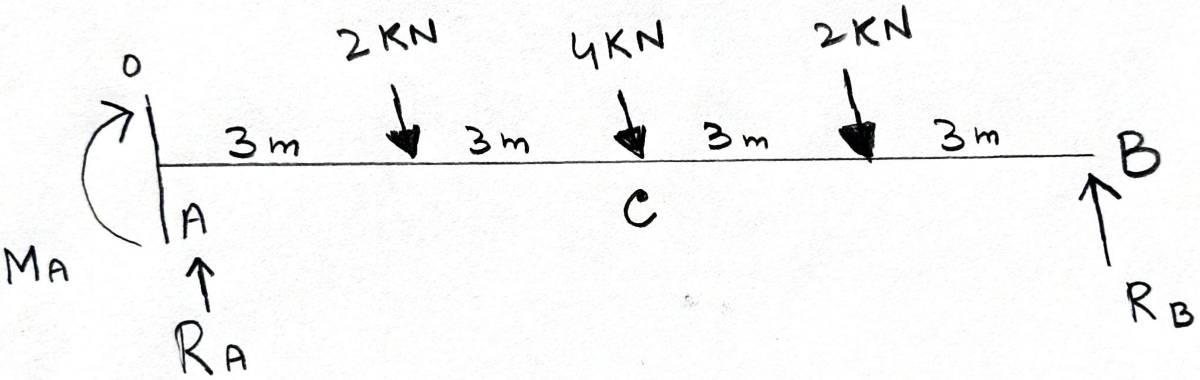
a) - Moment - Area Theorem and

Take $E = 200\ GPa$, $I = 6\ (10^6)\ mm^4$.

Solution: Required

$\Delta_c = ?$ $\theta_A = ?$

Calculation:



$+\uparrow\downarrow - \sum F_y = 0$

$R_A + R_B = 2 + 4 + 2$

$R_A + R_B = 8\ KN$

As the beam is symmetrical in terms of load

So $\boxed{R_A = R_B = 4\ KN}$

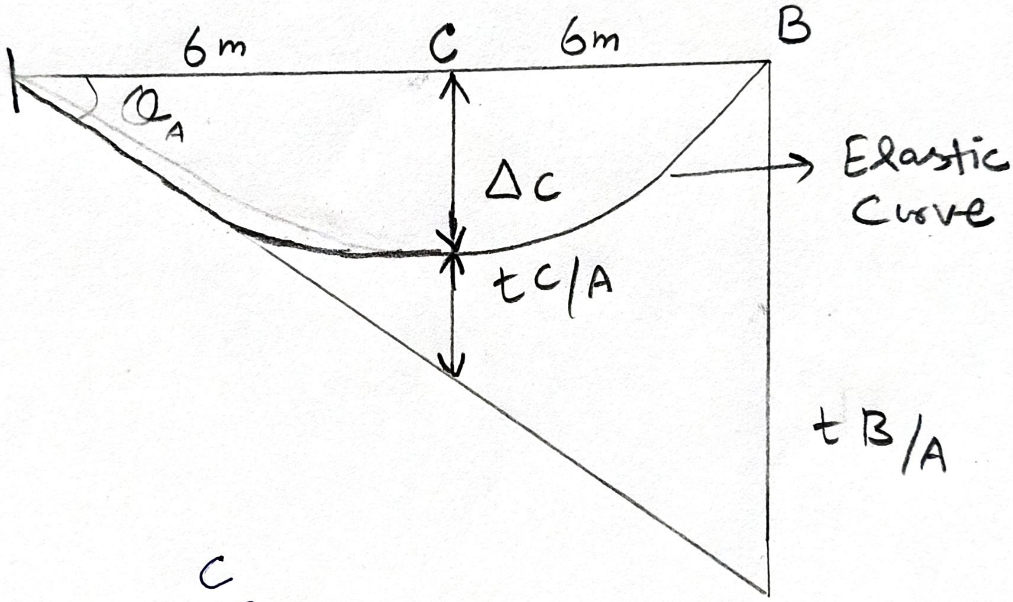
$\curvearrowleft +$ Now $\Sigma M_A = 0$

$$M_A + 2 \times 3 + 4 \times 6 + 2 \times 9 - 4 \times 12 = 0$$

$$M_A + 48 - 48 = 0$$

$$\boxed{M_A = 0}$$

Elastic Curve:



$$t_{C/A} = \int_A^C \frac{M}{EI} \times x \times dx$$

$$\tan \theta_A = \frac{\Delta c + t_{C/A}}{6}$$

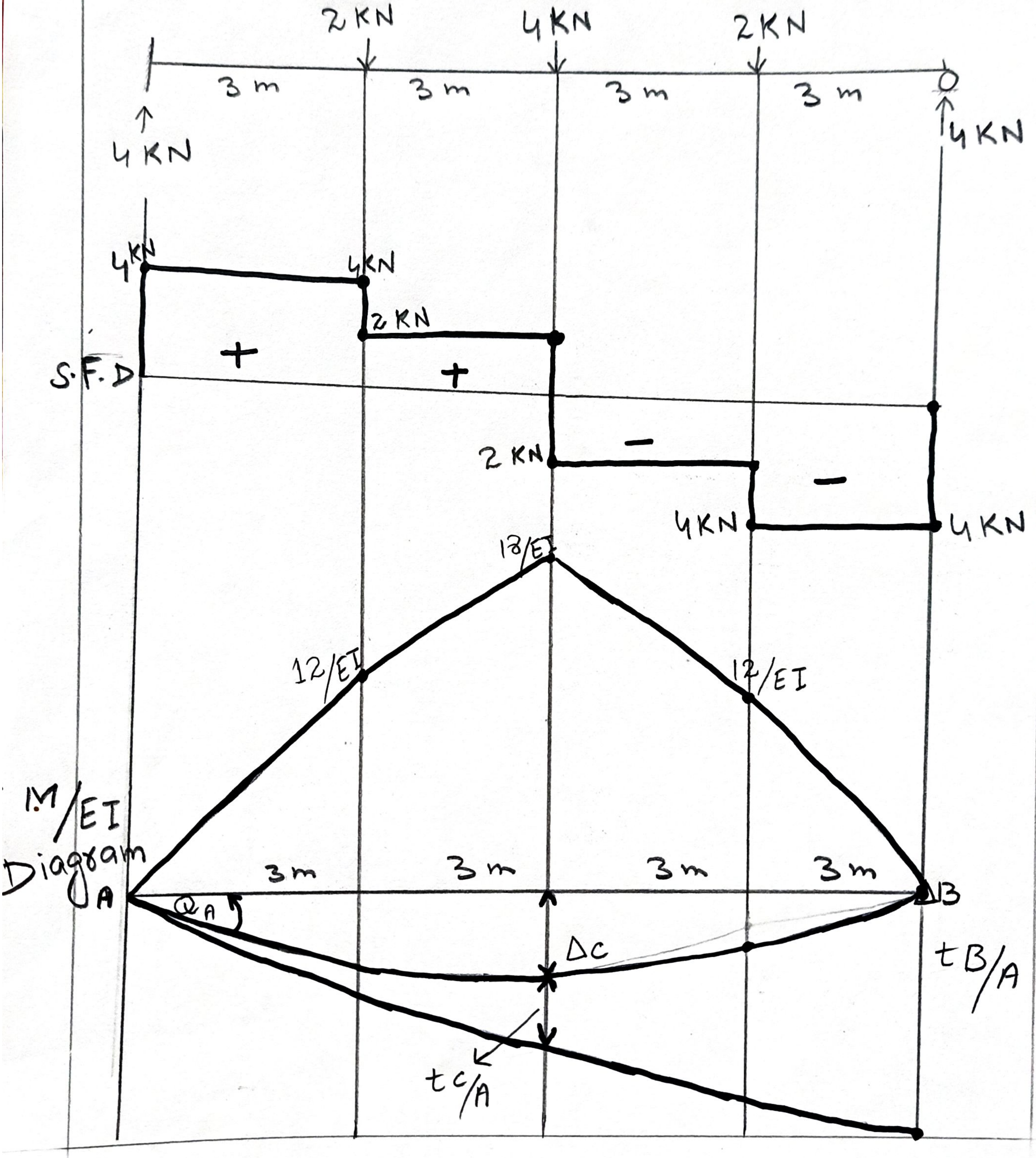
as $\theta_A <<<$

$$\tan \theta_A \approx \theta_A$$

$$\boxed{\theta_A = \frac{\Delta_C + t_{C/A}}{6}} = \frac{t_{B/A}}{2}$$

$$\Delta_C = t_{B/A} - t_{C/A}$$

S.F.D & B.M.D of beam



For $t_{B/A}$ & $t_{C/A}$:-

$$t_{B/A} = \int_A^B \frac{M}{EI}\, x \cdot dx$$

$$= \frac{1}{EI}\left[\left(\frac{12\times3}{2}\right)\times\frac{2}{3}\times3 + \left[\frac{6\times3}{2}\times\left(\frac{3+2}{3}\times3\right)\right.\right.$$
$$\left.+(12\times3)\times(3+1.5)\right]$$
$$+\left[\frac{6\times3}{2}\times\left(3+3+\frac{1}{3}\times3\right)\right.$$
$$\left.+\left(12\times3\times(3+3+1.5)\right)\right]$$
$$\left.+\left(\frac{12\times3}{2}\times\left(3+3+3+\frac{1}{3}\times3\right)\right)\right]$$

$$= \frac{1}{EI}\left[36+45+162+63+270+180\right]$$

$$\boxed{t_{B/A} = \frac{756}{EI}\ \text{KN-m}^3}$$

$$t_{C/A} = \int_A^C \frac{M}{EI}\, x\, dx$$

$$= \frac{M}{EI}\left[\left(\frac{12\times3}{2}\times\frac{2}{3}\times3\right)+\left(\frac{6\times3}{2}\right)\times\left(\frac{3+2}{3}\times3\right)\right.$$
$$\left.+(12\times3)\times(3+1.5)\right)$$

$$t_{C/A} = \frac{36+45+162}{EI} = 243\ \frac{KN\text{-}m^3}{EI}$$

Now :

For Slope at A :

θ_A = Area under curve A to C.

Method 1 :

$$\theta_A = \frac{I}{EP}\left[\frac{12\times3}{2}+\left[\frac{6\times3}{2}+12\times3\right]\right]$$

$$= \frac{63}{EI}$$

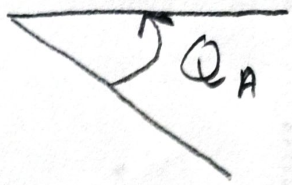
Method 2 :

$$\theta_A = t_{B/A}/12$$

$$= \frac{756}{12\times EI} = 63/EI$$

$$\theta_A = \frac{63 \text{ KN-m}^2}{200 \times 10^6 \frac{\text{KN}}{\text{m}^2} \times 6 \times 10^{-6} \text{ m}^4}$$

$$= 0.0525 \text{ radian}$$



Note: Value is positive, hence it is counter clockwise.

For displacement at C :-

As we know that

$$\theta_A = \frac{\Delta_C + t_{B/A}}{6}$$

$$\Delta_C = \theta_A \times 6 - t_{B/A}$$

$$= 0.0525 \times 6 - \frac{243}{EI}$$

$$= 0.315 - \frac{243}{200 \times 10^6 \times 6 \times 10^{-6}}$$

$$= 0.315 - 0.2025$$

$$\boxed{\Delta C = 0.1125 \text{ m}}$$

Note: ΔC is positive it means it lies above the tangent line.