Selvam College of Technology (Autonomous),
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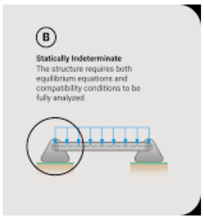
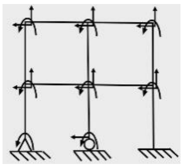
CASE STUDY BOOK

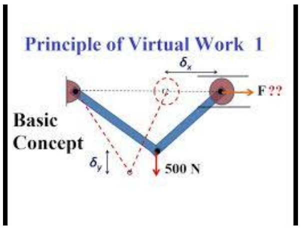
CE3502- STRUCTURAL ANALYSIS-1

UNIT-1-ANALYSIS OF TRUSSES

PART-A

2 MARKS QUESTIONS

S.No	Questions	Marks	CO'S
1.	**Question:** An engineering student is tasked with analyzing a continuous concrete beam that spans across multiple columns in a new multi-story building. Unlike a simple beam supported only at its ends, this beam has intermediate supports, creating a more complex structural system. The student attempts to determine all the support reactions and internal forces using only the basic equations of static equilibrium (ΣFx=0, ΣFy=0, ΣM=0)"static indeterminacy" of structures, and explain why the student would encounter difficulties in analyzing the continuous beam using only the equilibrium equations.  **Answer:** 1.The structure which cannot be analysed using static equilibrium equations alone is called as statically indeterminate. i.e., number of unknowns are greater than number of available equilibrium equations. 2.The deformation of the structure must also be considered. 3.The number of unknowns are more than independent equations.	2	CO1
2.	**Question:** A structural engineer is using specialized software to analyze a multi-story, multi-bay rigid frame building. This software relies on displacement-based methods (like the Slope-Deflection Method or Stiffness Method) to determine the forces and deformations within the structure. Before running the analysis, the engineer needs to input the "degrees of freedom" for each joint and member. Define "kinematic indeterminacy" of structures, and explain its relevance when using displacement-based analysis methods for this building frame. 	2	CO1

	Answer: 1.The structure in which the displacement components of joints cannot be determined by compatibility equation alone, is called kinematic indeterminacy. 2.The equations of static equilibrium must be considered. 3.The number of unknown displacement components is more than compatibility equations. 4.The additional components taken for solution of a problem is called as degree of freedom.		
3.	**Question:** junior structural engineer has designed a steel cantilever beam to support a small balcony. To ensure the balcony's serviceability, the engineer needs to accurately calculate the deflection at the free end of the beam under the maximum design load. Traditional force-based methods can be complex for this calculation, so the supervisor suggests using an energy method, specifically the Principle of Virtual Work. **Question:** Explain the Principle of Virtual Work in the context of structural analysis, and how it can be applied to find the deflection of the cantilever beam  **Answer:** The principle of virtual work is based on the conservation of energy for a structure which implies that work done on a structure by external loads is equal to workdone on a structure by internal loads	2	CO1
4.	**Question:** civil engineering student is analyzing a complex bridge truss that is statically indeterminate, meaning the forces in its members cannot be determined solely by equilibrium equations. The student's professor suggests using Castigliano's First Theorem, an energy method, to solve for the unknown forces. State Castigliano's First Theorem and briefly explain its application in determining forces within a structure like this truss. **Answer:** The partial derivative of the total stain energy with respect to an applied force or moment gives the displacement or rotation at the point of application of the force and in the direction of application to the forces.	2	CO1
5.	**Question:** A civil engineering student is assigned to perform the preliminary structural analysis for a small footbridge that will span a creek. The professor advises the student to first consider "statically determinate" beam types, as they are simpler to analyze by hand before moving to more complex designs or software. What defines a statically determinate	2	CO1

<table>
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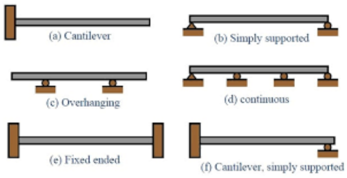
<td>beam, and what are two common types of such beams that the student might consider for this footbridge?


Answer:
• Simply Supported Beam
• Cantilever Beam
• Overhanging Beam
• Propped Cantilever Beam (with roller)
• Beam with Internal Hinges</td>
<td></td>
<td></td>
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<tr>
<td>6.</td>
<td>Question: A structural engineer is reviewing the design of a large bridge truss. This truss is not only supported by multiple piers and abutments but also features a complex arrangement of members with additional diagonal bracing to enhance its stiffness and load-carrying capacity. The engineer notes that due to these complexities, the truss cannot be analyzed solely by the basic equations of static equilibrium, and needs to understand both its external and internal redundancies. Define "externally indeterminate structures" and "internally indeterminate structures" in the context of structural analysis, referring to how they contribute to the overall complexity of the bridge truss
Answer: Internally indeterminate structures:
In a pin jointed frames redundancy caused by too many members is called internally indeterminate structures or internal redundancy.
externally indeterminate structures :
In a pin jointed frames redundancy caused by too many supports is called externally indeterminate structures or external redundancy.</td>
<td>2</td>
<td>CO1</td>
</tr>
<tr>
<td>7.</td>
<td>Question: A structural engineer has designed a new cantilever beam that supports a significant load. To ensure the beam's serviceability and prevent excessive sagging, the engineer needs to accurately predict the vertical deflection at the free end under the applied loading. The engineer decides to use the "Unit Load Method" for this calculation due to its versatility.
State the basic unit load formula used to determine the deflection of a beam like this, and briefly explain its components.
Answer: 1.Find the forces P1,P2,…. In all the member due to external loads.
2)remove the external loads and apply the unit vertical point load at the joint if the vertical deflection is required and find the stress.</td>
<td>2</td>
<td>CO1</td>
</tr>
</table>

<table>
<tr><td></td><td>3)apply the equation for vertical and horizontal deflection.</td><td></td><td></td></tr>
<tr><td>8.</td><td>Question: geotechnical engineer is reviewing SPT (Standard Penetration Test) N-values obtained from a site where a new building will be constructed. The site predominantly consists of saturated fine to silty sands, and some of the N-values recorded are relatively high (e.g., N > 15). The engineer knows that in such conditions, the raw N-values might be misleadingly high due to a phenomenon called dilatancy during rapid penetration. To get a more accurate representation of the soil's true strength, a correction needs to be applied.
Explain what "Mohr's correction" (also known as the dilatancy correction) is in the context of SPT, and why it is applied in the given scenario.
Answer: The williot diagram does not give the true deflection of the joints but the same can be modified and correlated to the true deflection by applying certain correction is known as Mohr's correction.</td><td>2</td><td>CO1</td></tr>
<tr><td>9.</td><td>Question: A structural engineering student is tasked with analyzing two different truss designs for a factory roof. One design appears to have the minimum number of members required for stability, while the other seems to have either too few members or too many. The student needs to understand how to classify these trusses to determine if they are stable and statically determinate.
Differentiate between a "perfect frame" and an "imperfect frame" (deficient vs. redundant) in the context of truss analysis, and explain how this classification helps in evaluating a truss design

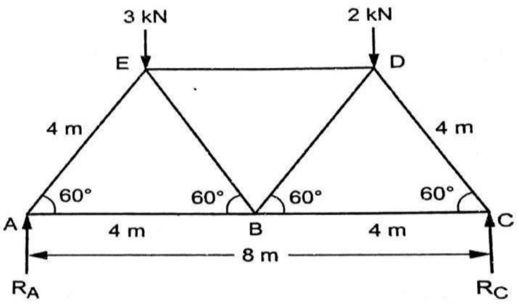
Answer: A structure frame that is stable under loads imposed upon it from any direction is known as perfect frame.A structure frame that is unstable if one of its members were removed or one of its fixed ends became hinged is known as imperfect frame.</td><td>2</td><td>CO1</td></tr>
<tr><td>10.</td><td>Question: A structural engineer is preparing a computer model of a building frame for a detailed analysis. The software requires the engineer to define the "degrees of freedom" at each joint and for the entire structure. Correctly identifying these is crucial for setting up the stiffness matrix and ensuring an accurate solution for displacements and internal forces. Define "degree of freedom" in the context of structural analysis, and explain its significance when modelling a structure for computer-aided analysis.
Answer: In a structure the number of independent joint displacement that the structures can undergo are known as degree of freedom. It is also known as kinematic indeterminacy.</td><td>2</td><td>CO1</td></tr>
</table>

PART-B

11.

Question: A civil engineering student is learning about truss analysis and is given the task of determining the internal forces in a small portion of a roof truss structure, as shown in the diagram. The supervisor specifically requests the use of the "Method of Joints" to find the forces in members AB, AG, and BG, emphasizing the importance of clearly identifying tension or compression.

Question: A truss of 8m span consisting of seven members each of 4m length supported at its ends and loaded as shown in Fig. Determine the forces in the members by method of joints.



Solution:

Determine the reactions at A and C

Taking moment about A

$R_C \times 8 = R_D \times 6 \times R_E \times 2$

$R_C \times 8 = 2 \times 6 \times 3 \times 2$

RC = 2.25 kN

We know that ,

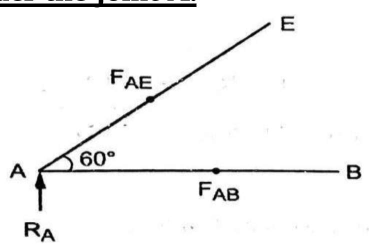
Upward vertical reaction = Download vertical reaction

$RA + RC = 3 + 2$

$R_A + 2.25 = 5$

$\mathbf{R_A = 2.75\ kN}$

Consider the joint A.



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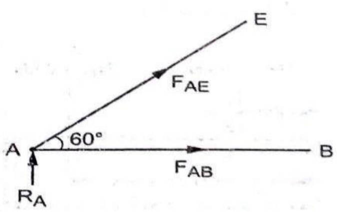
CO1

Assume the forces (F_{AE} and F_{AB}) acting on joint A are tensile forces (acting away from joint A). If we get negative value the force in that member is compressive



At joint A:

Resolving the force (F_{AE}) vertically, we know that the sum of vertical forces =0.

$$R_A + F_{AE} \sin 60^\circ = 0$$

$$2.75 = -F_{AE} \sin 60^\circ$$

$$\mathbf{FAE = -3.17KN} \text{ (Compression)}$$

Resolving the force (F_{AE}) horizontally,

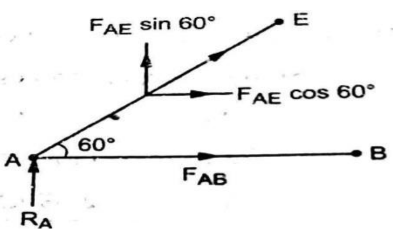
Sum of horizontal forces =0

$$F_{AB} + F_{AE} \cos 60^\circ = 0$$

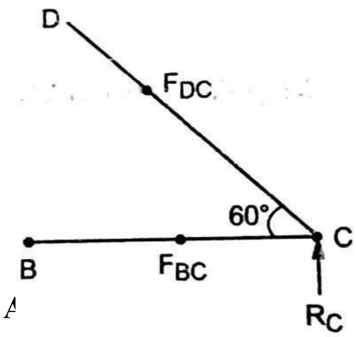
$$F_{AB} = -F_{AE} \cos 60^\circ$$

$$\mathbf{FAB = -1.58kN} \text{ (Tension)}$$

Consider the joint C.



Assume the forces (F_{DC} and F_{BC}) acting on joint A are tensile forces (acting away from joint A). If we get negative value the force in that member is compressive.

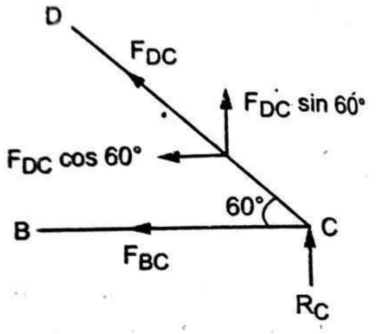


Resolving the force (F_{DC}) vertically,

Sum of horizontal forces = 0

$R_C + F_{DC} \sin 60^o = 0$

FDC = -2.59kN (Compression)



Resolving the force horizontally,

Sum of horizontal forces = 0

$- F_{BC} - F_{DC} \cos 60^o = 0$

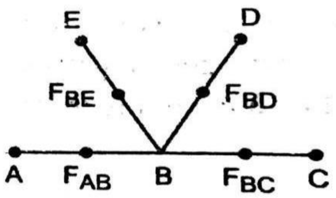
(Force acting towards left side is –ve)

Or $F_{BC} = - F_{DC} \cos 60^o$

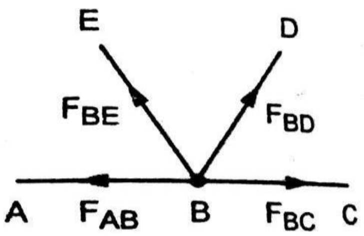
Or $F_{BC} = - 2.59 \times \cos 60^o$ Or

FBC = 1.295kN (Tension)

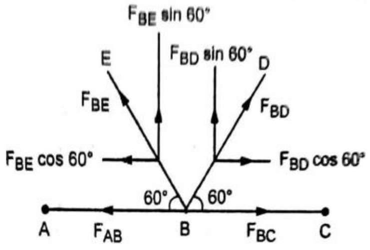
Consider the joint B.



Assume the forces (F_{AB}, F_{BC}, F_{BD} and F_{BC}) acting on joint B are tensile forces (acting away from joint B). If we get negative value the force in that member is compressive.



At joint B:



Resolving the force (F_{BE} & F_{BD}) vertically,

Sum of horizontal forces = 0

$F_{BE} \sin 60^{\circ} + F_{BD} \sin 60^{\circ} = 0$

$F_{BE} \sin 60^{\circ} = -F_{BD} \sin 60^{\circ}$

FBE = - FBD

Resolving the force (F_{BE} & F_{BD}) horizontally,

Sum of horizontal forces = 0

$\Sigma H = 0$

- FAB –FBE cos 60o + FBC +FBD cos 60o = 0

(Force acting towards right side is –ve, force towards left side is -ve)

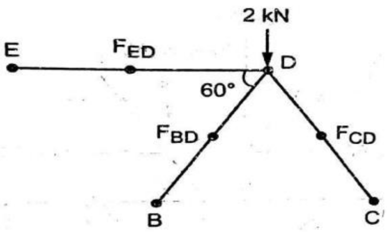
- 1.58 –FBE cos 60o + 1.29 +FBD cos 60o = 0

(Since, FBE = - FBD)

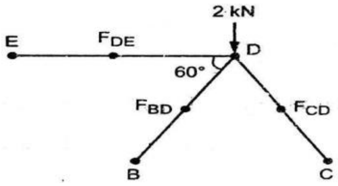
FBD = 0.29 kN (Tension)

FBE = -0.29 kN (Compression)

Consider the joint D.

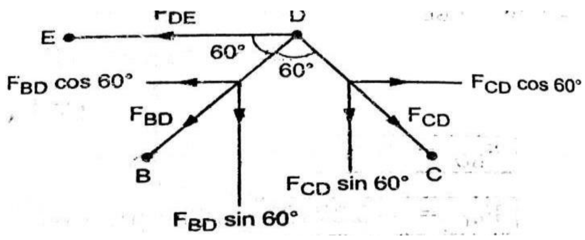


Assume the forces (F_{ED}, F_{BD}, and F_{CD}) acting on joint D are tensile forces (acting away from joint D). If we get negative value, the force on that member is compressive.



At joint D:

Resolving the force (F_{BD} & F_{CD}) horizontally, sum of horizontal forces = 0



$- F_{DE} - F_{BD} \cos 60^\circ + F_{CD} + F_{BD} \cos 60^\circ = 0$

(Force towards right side +ve, force towards left side –ve)

$- F_{DE} - 0.29 \times \cos 60^\circ - 2.59 \times \cos 60^\circ = 0$

FDE = -1.44 kN (Compression)

Result:

Sl.No.	Member	Force (kN)	Nature of force.
1	AE	-3.17	compression
2	AB	1.58	Tension
3	CD	-2.59	compression
4	BC	1.29	Tension
5	BD	0.29	Tension
6	BE	-0.29	compression
7	DE	-1.44	compression

12. **Question :** A civil engineering firm has been contracted to design a lightweight and cost-effective roof support system for an industrial warehouse. As part of the preliminary design phase, an engineer is tasked with analyzing a planar truss to ensure it can safely carry the anticipated loads.

The truss structure in question is represented in **Figure**. It is statically determinate and composed of pin joints and straight members. The truss is subjected to the following external loads:

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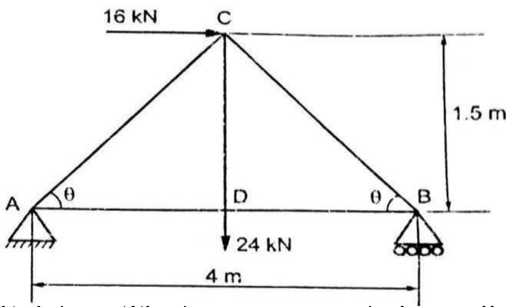
- A **horizontal force** of **16 kN** applied at a specific joint.
- A **vertical force** of **24 kN** applied at another joint.



Solution: The truss is supported on rollers at B and hence the reaction at B should be vertical 9(R_B).

The truss in hinged at A and hence end A consists of a horizontal reaction (H_A) and vertical reaction (R_A).

Determine the reaction at A and B

(R_A and R_B).

Taking moment about A.

$$R_B \times 4 = 24 \times 2 + 16 \times 1.5$$

$$\mathbf{RB = 18\ kN}$$

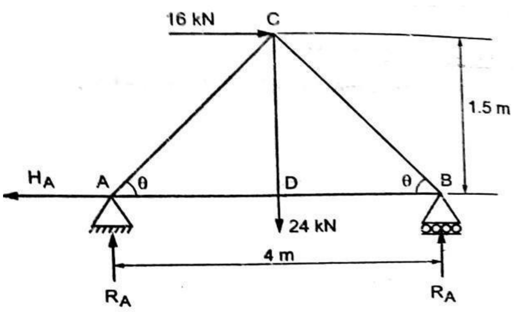
We know that,

Upward vertical load = Download vertical load

$R_A + R_B = 24$

$$R_A + 18 = 24$$

$$\mathbf{RA = 6\ kN}$$



Right side horizontal load = Left side horizontal load

$$16 = H_A$$

$$\mathbf{HA = 16kN}$$

In the triangle BCD

$BC^2 = CD^2 + BD^2$

$BC^2 = (1.5)^2 + 2^2$

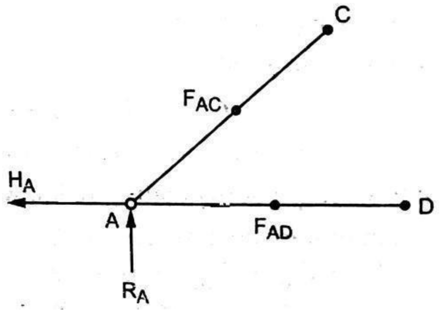
BC = 2.5 m

Sin θ = $\frac{DC}{BC} = \frac{1.5}{2.5}$

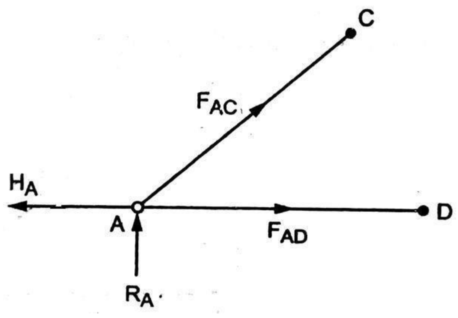
Sin θ = 0.6

θ = 36.8^{0}

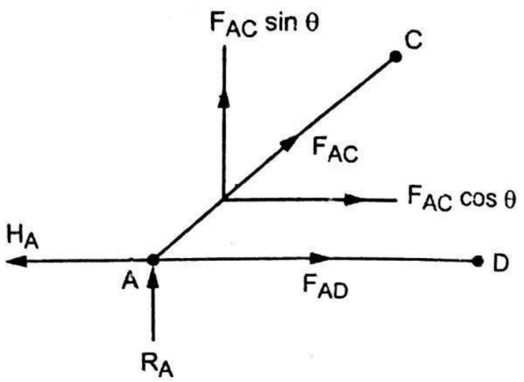
Consider the joint A.



Assume the forces F_{AC} and F_{AD} acting on joint A are tensile forces (acting away from joint A). If we get negative value force on that member is compressive.



At joint A:



Resolving the force (F_{AC}) vertically,
we know that Sum of vertical forces

= 0

$R_A + F_{AC}$ Sin

$\theta = 0$

$6 + F_{AC}$ Sin

$36.8^0 = 0$

$6 = - F_{AC} \text{ Sin } 36.8^0$

$F_{AC} = - 10KN$ (Compressive)

Resolving the force (F_{AC}) horizontally,

we know that,

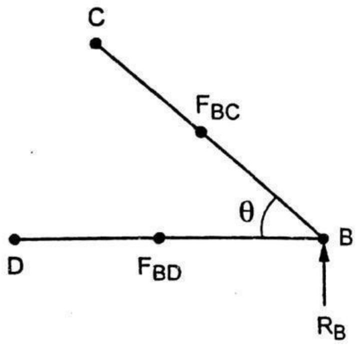
Sum of horizontal forces = 0

$-H_A + F_{AD} + F_{AC} \text{ Cos } \theta = 0$

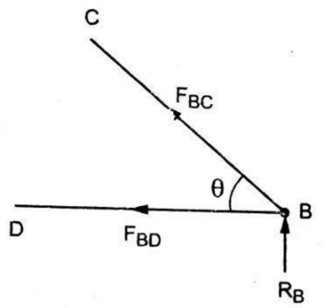
$-16 + F_{AD} + -10 \times \text{Cos } 36.8^0 = 0$

FAD = 24kN (Tension)

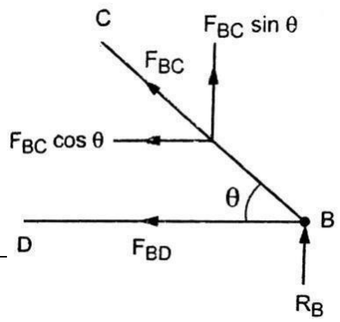
Consider the joint B.



Assume the forces F_{BC} and F_{BD} acting on joint B are tensile forces (acting away from B). If we get negative value, force in that member is compressive.



At joint B:



Resolving the force (F_{BC}) vertically,
we know that,
Sum of vertical forces = 0
$R_B + F_{BC}$ Sin
$\theta = 0$
$18 + F_{BC}$ Sin
$\theta = 0$

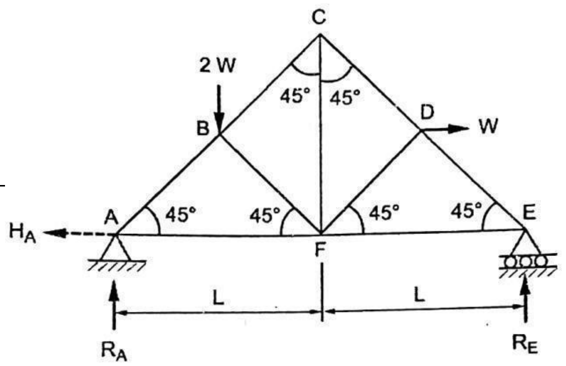
$$F_{BC} = -\frac{18}{\sin 36.8}$$

FBC = - 30kN
(Compressive)
Resolving the force (F_{BC})
horizontally,
we know that,
Sum of horizontal forces = 0
$- F_{BC} \cos\theta - F_{BD} = 0$
$- F_{BC} \cos\theta = F_{BD}$
$30 \cos\theta = FBD$
$30 \cos 36.80 = FBD$
FBD = 24kN (Tension)

Result:

Sl.No.	Member	Force (kN)	Nature of force
1	AC	-10	Compression
2	AD	24	Tension
3	BC	-30	Compression
4	BD	24	Tension

13. Question: A structural engineering team is evaluating the integrity of a roof truss system in an industrial warehouse. The truss, part of a roof framework, is subjected to a combination of vertical and horizontal loads due to wind pressure and dead loads from roofing materials. | 16 | CO1



Solution: To solve the above problem, consider W = 1kN

To find the reactions at the support:

$$R_A + R_E = 2W = 2$$

$$H_A = W = 1$$

Taking moment about point A,

$$i.e., \quad \Sigma MA = 0$$

$$-(RE \times 2L) \times \left(2 \times \frac{L}{2}\right) + \left(1 \times \frac{L}{2}\right) = 0$$

$$\left(L \times \frac{L}{2}\right) = R_E \times 2L$$

$$\frac{3}{2} L = R_E \times 2L$$

$$\mathbf{R_E = 0.75}$$

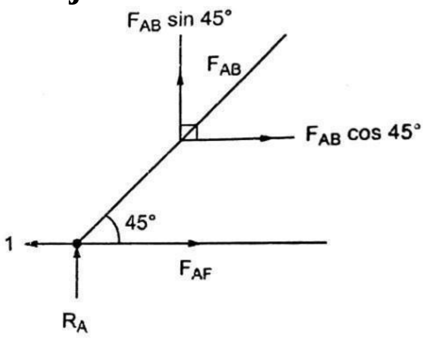
$$R_A + R_E = 2$$

$$R_A = 2 - R_E = 2 - 0.75$$

$$R_A = 1.25$$

Solving the above problem using method of joints:

At joint A:



Sum of horizontal forces $=\sum H = 0$

Sum of vertical forces $=\sum V = 0$

$\sum V = 0$

$R_A + F_{AB}. \sin 45^0 = 0$

$R_A = 1.25$

FAB = -1.77 (Compression)

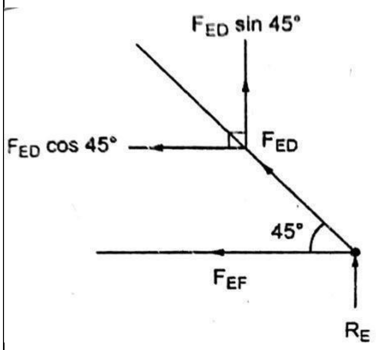
$\sum H = 0,$

$-1 + F_{AB} \cos 45^0 + F_{AF} = 0$

$-1 + (-1.77 \times \cos 45^0) + F_{AF} = 0$

FAF = 2.25 (Tension)

At joint E:



$\Sigma V = 0$

$F_{ED}. \sin 45 + R_E = 0$

$\mathbf{F_{ED} = -1.06}$ (Compressive)

$\sum H = 0$

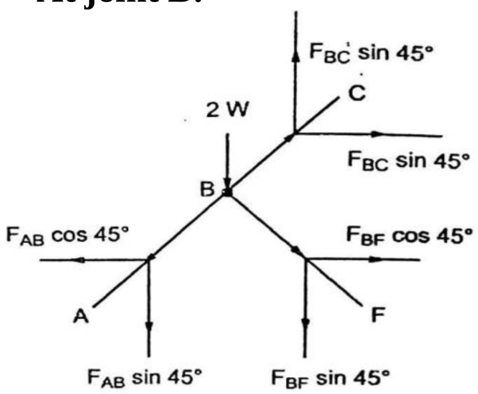
$-F_{EF} - F_{ED} \cos 45^0 = 0$

$-F_{EF} - (-1.06 \times \cos 45^0) = 0$

$-F_{EF} + 0.75 = 0$

$\mathbf{F_{EF} = 0.75}$ (Tensile)

At joint B:



$\Sigma H = 0$

$-F_{AB} \cos 45^0 + F_{BC} \cos 45^0 + F_{BF} \cos 45^0 = 0$

$-\cos 45^0 [- F_{AB} + F_{BC} + F_{BF}]$

$= 0$

$F_{BC} + F_{BF} = + F_{AB} = -1.77$

$F_{BC} + F_{BF} = -1.77$--------1

$\sum V = 0$

$F_{BC} \sin 45^0 - F_{AB} \sin 45^0 - F_{BF} \sin 45^0$

$- 2 = 0$

$F_{BC} \sin 45^0 - F_{BF} \sin 45^0 = 2 + F_{BA}$.

$\sin 45^0$ $F_{BC} \sin 45^0 - F_{BF} \sin 45^0 = 2 +$

$(-1.77 \sin 45^0)$

$(F_{BC} - F_{BF}) \sin 45^0 = 0.75$

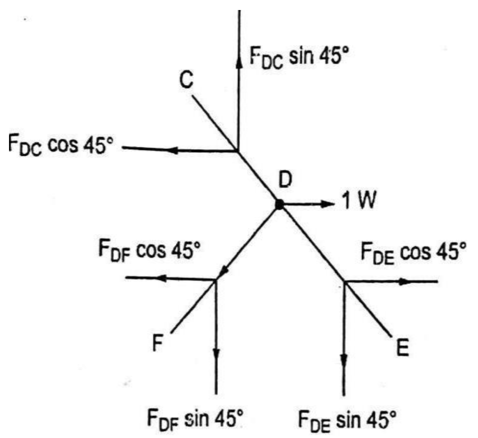
$F_{BC} - F_{BF} = 1.06$------------2

Solving equations (1) and (2), we get

FBC = - 0.36 (Compression)

FBF = - 1.42 (Compression)

At joint D:



$- F_{DC} \cos 45^0 - F_{DF} \cos 45^0 + F_{DE} \cos 45^0 + 1 = 0$

$- F_{DC} \cos 45^0 - F_{DF} \cos 45^0 - (1.06 \times \cos 45^0) + 1 = 0$

$- F_{DC} \cos 45^0 - F_{DF} \cos 45^0 = -0.25$

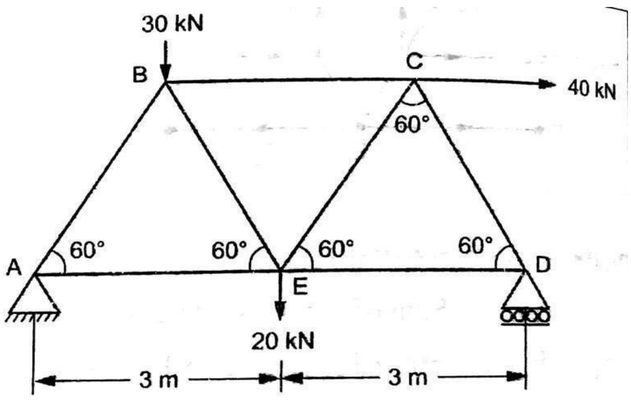
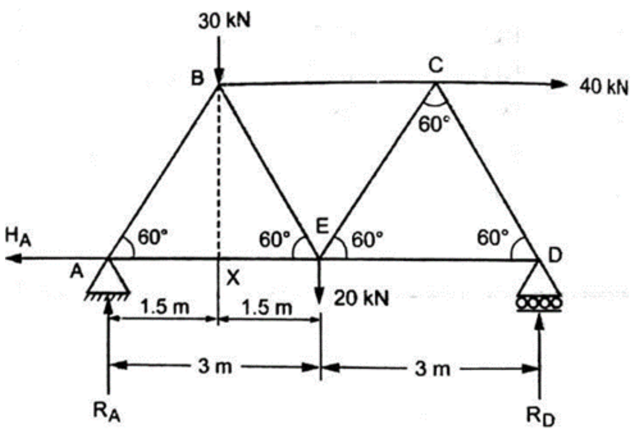
$-(F_{DC} + F_{DF}) \cos 45^0 = -0.25$

$F_{DC} + F_{DF} = 0.35$ -----------3

$\Sigma V = 0$

+ FDC sin 450 – FDF sin 450 _ FDE sin 450 = 0
FDC – FDF _ FDE = O
FDC – FDF = + FDE
FDC – FDF = - 1.06----------4
Solving (3) and (4), we get
FDC = - 0.35 (Compression)
FDF = 0.71 (Tension)

Member	Force (kN)	Nature of force
AB	-1.77W	Compression
BC	-0.36W	Compression
CD	-0.35W	Compression
DE	-1.06W	Compression
EF	0.75W	Tension
FA	2.25W	Tension
FD	0.71W	Tension
CF	0.5W	Tension
BF	-1.42W	Compression

14.	**Question:** In the field of structural engineering, trusses are essential components used to support loads in buildings, bridges, towers, and industrial facilities. Accurate analysis of truss structures is crucial to ensure safety, reliability, and efficiency in design. The **method of joints** is a classical technique used to determine the internal forces in truss members by isolating individual joints and applying the equations of static equilibrium.  **Solution:** The truss is supported on rollers at D and hence the reaction at D should be vertical (R_D). The truss is hinged at A and hence end A consists of horizontal reaction (H_A) and vertical reaction (R_A) 	16	CO1

From Δ^{le} BEX,

tan 60° = $\frac{BX}{XE} = \frac{BX}{1.5}$

BX = tan 60° × 1.5

BX = 2.6 m

Determine the reactions. Taking moment about A

RD × 6 = 40 × BX + 20 × 3 + 30 × 1.5

= 40 × 2.6 + 20 × 3 + 30 × 1.5

RD = 34.8 kN

We know that,

ard vertical forces = Downward vertical forces $R_A + R_D = 30 + 20$

$R_A = 50 - R_D$

RA = 50 – 34.8

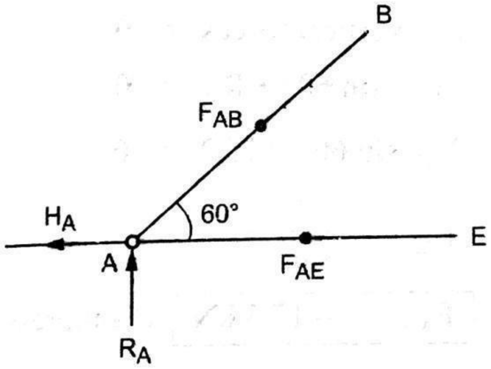
$\mathbf{R_A = 15.2\ kN}$

We know that,

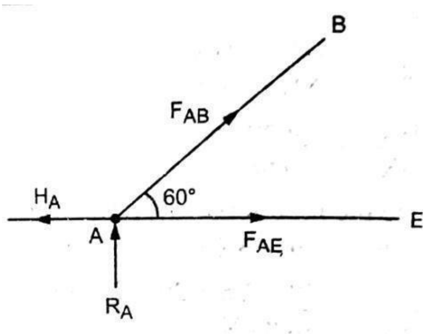
Horizontal forces towards right side = Horizontal forces towards left side

40kN = HA, ∴ HA = 40kN

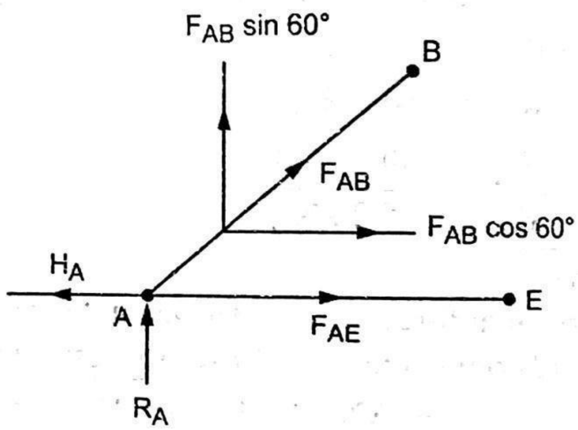
Consider the joint A.



Assume the forces FAB and FAE acting on joint A are tensile forces (acting away from A). If we get negative value, the force in that member is compressive.



At joint A:



Resolving the force vertically,

Sum of vertical forces = 0

F_{AB} Sin 60° + R_A = 0

F_{AB} Sin 60° + 15.2 = 0

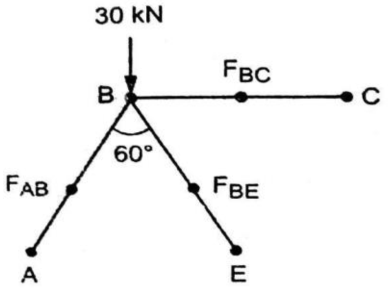
FAB = - 17.5kN (Compressive)

Resolving the force horizontally,

Sum of horizontal forces = 0

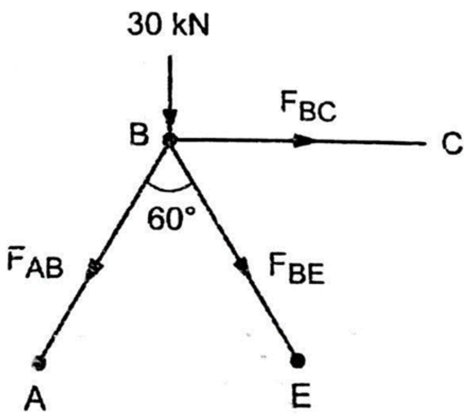
$F_{AB} \cos 60^0 - H_A + F_{AE} = 0$
$-17.5 \cos 60^0 - 40 + F_{AE} = 0$
$-17.5(0.5) - 40 + F_{AE} = 0$

F_{AE} = 48.75kN (Tension)



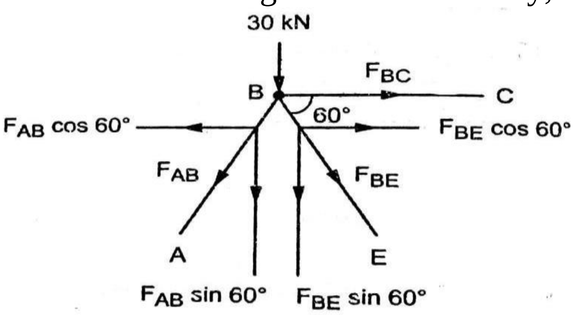
Consider the joint B.

Assume the forces acting on joint B are tensile forces . If we get negative value, force in that member is compressive.



At joint B

Resolving the force vertically, Sum of vertical forces = 0



$30kN – F_{AB} \sin 60^0 – F_{BE} \sin 60^0 = 0$

$-30 + 17.5 \times \sin 60^0 = F_{BE} \sin 60^0$

FBE = - 17.1kN (Compression)

Resolving the force horizontally,

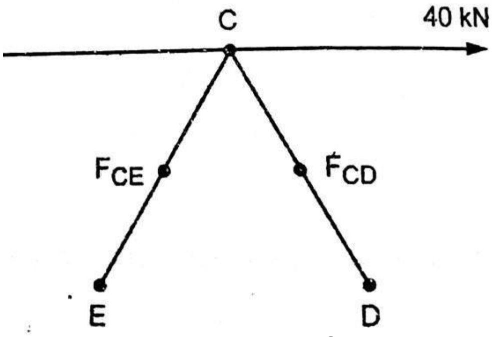
Sum of horizontal forces = 0

FBC + FBE cos 600 - FAB cos 600 = 0

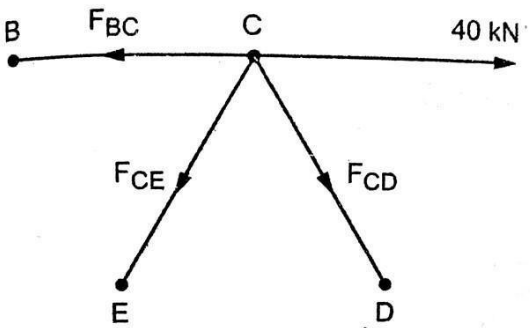
FBC - 17.1(0.5) + 17.1(0.5) = 0

FBC = -0.2kN (Compression)

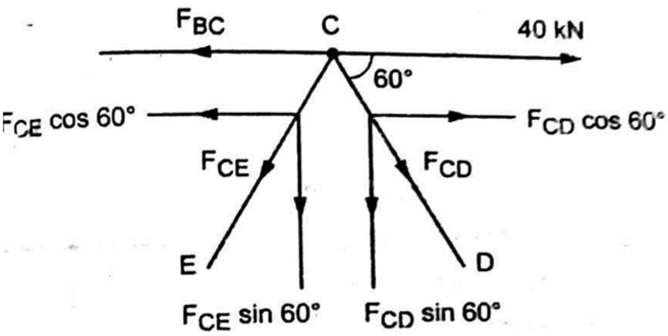
Consider the joint C:



Assume the forces acting on C are tensile forces. If we get negative value, the force on that member is compressive.



At joint B:



Resolving the force vertically,

Sum of vertical forces = 0

$-F_{CE} \sin 60^\circ - F_{CD} \sin 60^\circ = 0$

$F_{CE} = - F_{CD}$

Resolving the force horizontally,

Sum of horizontal forces = 0

$$- F_{BC} + 40 - F_{CE} \cos 60^\circ + F_{CD} \cos 60^\circ = 0$$

$$0.2 + 40 + 2 F_{CD} \cos 60^\circ = 0$$

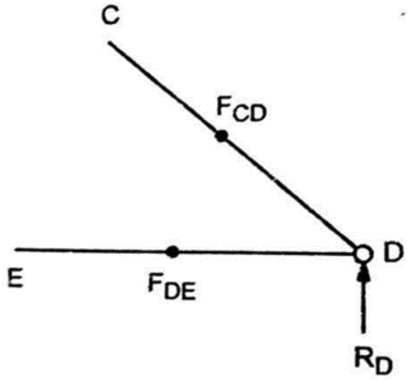
(Since, $F_{CE} = - F_{CD}$)

$F_{CD} = -40.2$ kN (Compression)

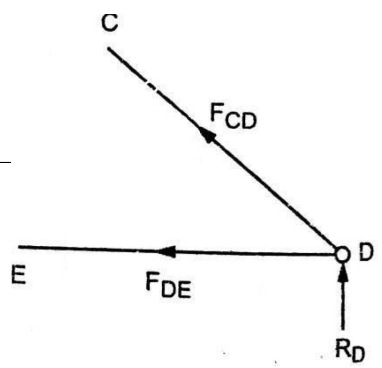
Apply in (A),

F_{CE} = 40.2 kN (Tension)

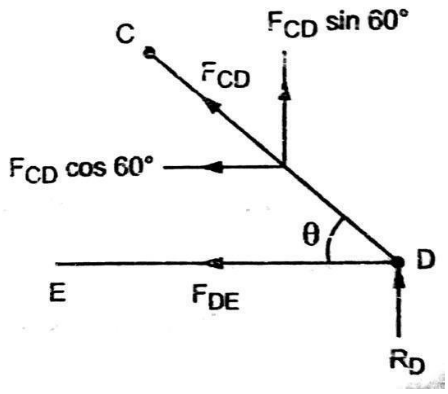
<u>Consider the joint D:</u>



Assume the forces acting on joint D are tensile forces if we get negative value, the force in that member is compressive.



Resolving the force horizontally,



Sum of horizontal forces = 0
- FDE - FCD cos 600 = 0
- FDE + 40.2 cos 600 = 0

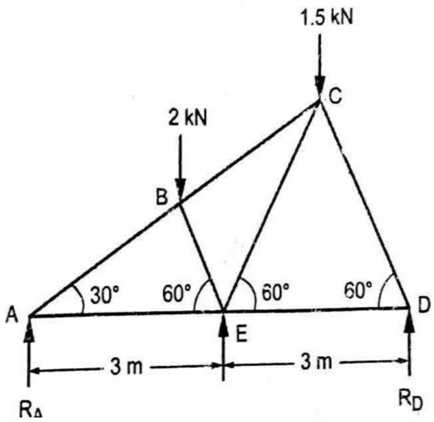
FDE = 20.1kN (Tension)

Sl.No	Member	Force (kN)	Nature of force
1	AB	-17.5	Compression
2	AE	48.75	Tension
3	BE	-17.1	Compression
4	BC	-0.2	Compression
5	CD	-40.2	Compression
6	CE	40.2	Tension
7	DE	20.1	Tension

15.	**Question :** You are part of a structural engineering team assessing the safety of a roof truss installed in a small industrial shed. The truss spans 6 meters and is subjected to vertical loads at specified joints. The structure and loading details are illustrated .(assumed to be provided).	16	CO1

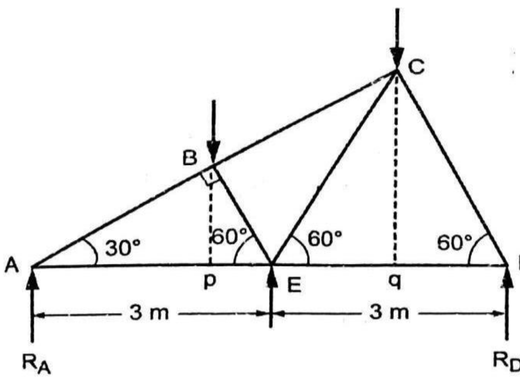
Your manager has asked you to evaluate the internal forces in selected members of the truss to ensure they meet strength requirements. Due to time constraints, you are advised to use the method of sections instead of analyzing every joint individually.

A truss of span 6 m is loaded . Find the reactions and forces in the members of the truss by method of section.



Solution:

Reaction at RC = 1.5 kN
Reaction at RB = 2 kN
Determine the reactions at A and D (RA and RD)



From ΔCED,

Eq = qD = 1.5 m

From ΔABE,

$\sin 60° = \frac{AB}{AE}$

$AB = AE \times \sin 60° = 3 \times 0.866$

$AB = 2.59$ m

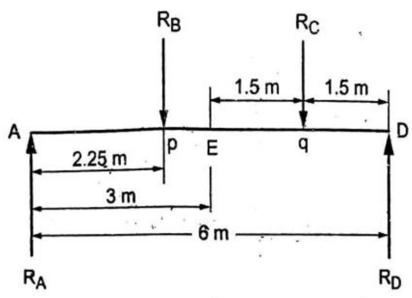
From ΔABp,

$\cos 30° = \frac{Ap}{AB}$

$Ap = AB \times \cos 30° = 2.59 \times 0.866$

$Ap = 2.25$ m

Taking moment about A:



We know that,

Clockwise moment = Anticlockwise moment

$R_B \times A_p + R_C \times Aq = R_D \times AD$

$R_B \times 2.25 + R_C \times 4.5 = R_D \times 6$

$2 \times 2.25 + 1.5 \times 4.5 = R_D \times 6$

$R_D = 1.875$ KN

We know that,

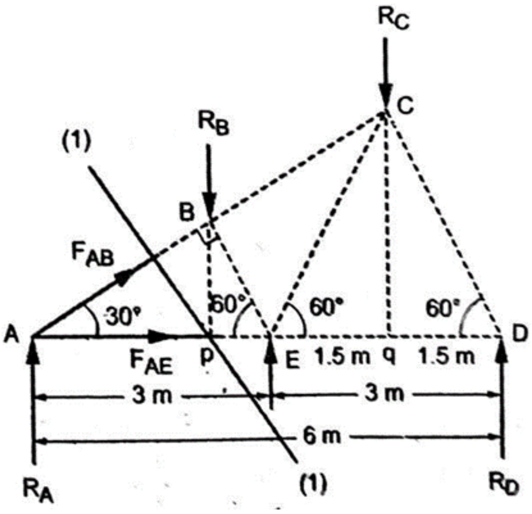
Upward reaction = Downward reaction

RA + RD = RB + RC

RA + 1.875 = 2 + 1.5

RA = 1.625 KN

Draw the section line (1, 1) cutting the members AB and AE



Now consider the equilibrium of the left part of the truss (since, it is similar than right part).

Taking moments of all forces acting from the left of the section (R_A, F_{AE} and F_{AB}) about point E.

Since force F_{AE} passing through the point E, moment about point E is zero. So, we have to consider R_A and F_{AB} forces only.

We know that,

Sum of Clockwise moment = Sum of Anticlockwise moment

Force (R_A) × perpendicular distance between the force (R_A) and a point E + Force (R_{AB})

× perpendicular distance between the force (R_{AB}) and a point E = 0

(since, there is no anticlockwise moment)

$R_A \times 3 + F_{AB} \times BE = 0$

$1.625 \times 3 + F_{AB} \times BE = 0$------------1

From Δ AEB,

$\sin 30° = \frac{BE}{AE}$

$BE = AE \times \sin 30°$

$= 3 \times 0.5$

BE =

1.5 m $1.625 \times 3 + F_{AB} \times$

$1.5 = 0$

$F_{AB} = -3.25$kN (Compression)

(since, we are assuming all the forces are tensile forces. If we get negative value, the force in that member is compressive.)

Now taking moment of all forces acting to the left of section(R_A,F_{AB} and F_{AE}) about point C.

Since force F_{AB} passing through the point C, the moment about point C is zero.

So, we have to consider R_A and F_{AE} force only.

We know that, sum of Clockwise moment = sum of Anticlockwise moment

Or Force (R_A X perpendicular distance between the force R_A and a point C + Force (F_{AE}) X perpendicular distance between the force F_{AE} and a point C =0.

$R_A \times A_q = F_{AE} \times C_q$

$1.625 \times 4.5 = F_{AE} \times Cq$ ------------------------2

From Δ CqD

$$\text{Cos } 60^o = \frac{qD}{CD} = \frac{1.5}{CD}$$

CD = 3m

$$\sin 60^o = \ = \frac{Cq}{CD}$$

$Cq = CD \times \sin 60$

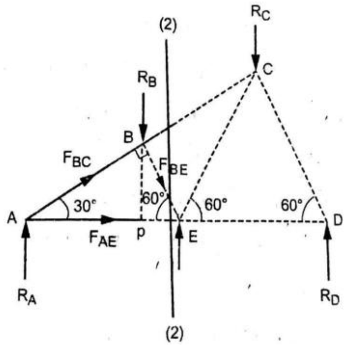
$Cq = 3 \times 0.866 = 2.59$m

From equation (2)

$1.625 \times 4.5 = F_{AE} \times 2.59$

$F_{AE} = 2.8$ kN (Tension)

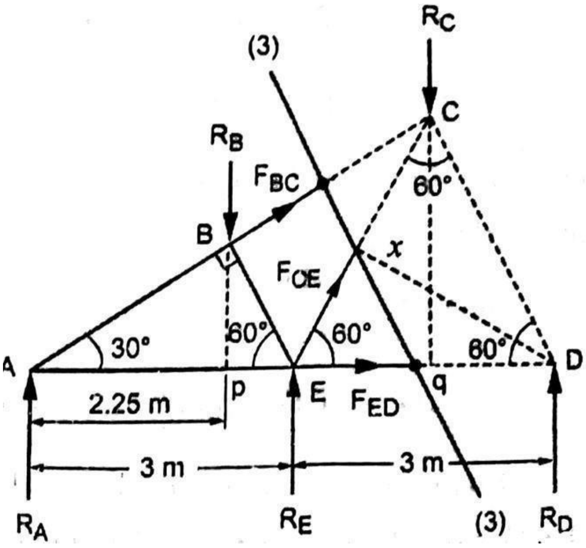
Draw a section line (2,2) cutting the members BC, BE and AE.



(only two unknown forces are permitted while considering a section.

	Here, BC,BE – unknown forces AE – known Force) Now taking moment of all forces acting to the left of section (R_A, F_{AE}, F_{BC}, R_B and F_{BE}) about point A. Consider R_B and F_{BE} forces only. (Since R_A, F_{AE} and F_{BC} passing through a point A) We know that, Sum of Clockwise moment = Sum of Anticlockwise moment Or Force (F_{BE}) X perpendicular distance between the force (F_{BE}) and a point A + Force R_B X perpendicular distance between the force R_B and a point A = 0 F_{BE} X AB + R_B X A_p = 0 F_{BE} X 2.59 +2 X 2.25 = 0 F_{BE}= -1.73kN Compression (Since F_{BE} and F_{AE} passing through a point E.) We know that, Sum of Clockwise moment = Sum of Anticlockwise moment Force R_A X Perpendicular distance between the force R_A and a point E + Force F_{BC} X Perpendicular distance between the force F_{BC} and a point E = Force(R_B) X Perpendicular distance between R_B and a point E R_A X AE + F_{BC} X BE = R_B X pE 1.625 X 3 + F_{BC} X 1.5 = R_B XpE 1.625 X 3 + F_{BC} X 1.5 =2 X 0.75 (AP = 2.25, AE = 3m and pE = 3-2.25 = 0.75m) F_{BC} = -2.25 kN Compression Draw a section line (3,3) cutting the members BC, CE and ED. (Only two unknown forces are permitted while considering a section. Here, BC is known force, CE and ED are unknown		

forces).



Taking moment of all forces acting from the left of section (R_A,R_B,F_{BC}, F_{CE} and F_{ED}) about point D.

Consider R_A, R_B , F_{BC}, F_{CE} forces only.

(Since F_{ED} passing through a point D)

We know that, Sum of Clockwise moment = Sum of Anticlockwise moment

Force R_A X perpendicular distance between the force R_A and a point D + Force F_{BC} X perpendicular distance between the force F_{BC} and a point D + Force F_{CE} X perpendicular distance between F_{CE} and a point D = Force R_B X Perpendicular distance between R_B and a point D

R_A X AD + F_{BC} X CD + F_{CE} X xD = R_B XpD

1.625 X 6 + -2.25 X 3 + F_{CE} X xD = 2 X 3.75

(ED = CE = CD = 3m)

ED =3m, Ap = 2.25m, pD = 3+0.75 = 3.75m

From Δ CxD

$$\text{Sin } 60^o = \frac{xD}{CE}$$

xD = CD X Sin 60° = 3 X Sin 60°

$1.625 \times 6 - 2.25 \times 3 + F_{CE} \times xD = 2 \times 3.75$

$1.625 \times 6 - 2.25 \times 3 + F_{CE} \times 3 \times \sin 60^o = 2 \times 3.75$

$F_{CE} = 0.96$ kN (Tension)

Now taking moment of all the forces acting from the left of the section (R_A, R_B, F_{BC}, F_{CE} and F_{ED}) about point C.

Consider R_A, R_B, F_{ED} forces only.

(since F_{BC}, F_{CE} passing through a point C)

Force R_A X Perpendicular distance between R_A and a point C = Force R_B X Perpendicular distance between R_B and a point C + Force F_{ED} X perpendicular distance between F_{ED} and a point C

$R_A \times A_q = R_B \times Pq + F_{ED} \times Cq$

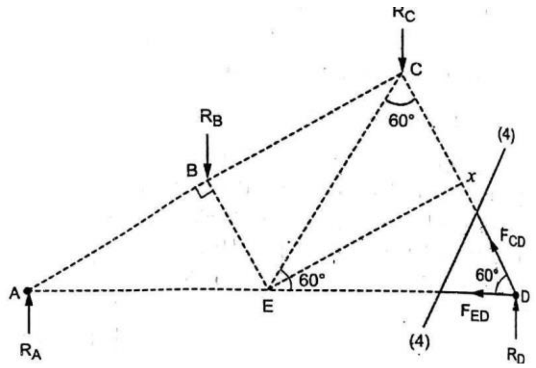
$1.625 \times 4.5 = 2 \times 2.25 + F_{ED} \times 3 \times \sin 60^o$

$\therefore F_{ED} = 1.08$ kN (Tension)

We know that From

Aq = 4.5m
Ap = 2.25
(PE = 3-2.25 = 0.75m
Pq = PE + Eq = 0.75+1.5 = 2.25m
Cq = xD = 3 X sin60^o)

Consider a section line (4,4) cutting the members CD and ED.



Consider the equilibrium of the right part of truss (since It is smaller than left part). Now taking moment of all forces acting from the right of the section (R_D, F_{CD} and F_{CE}) about point E.

We know that,

Sum of Clockwise moment = Sum of Anticlockwise moment

Force R_D X perpendicular distance between the force R_D and a point E + Force F_{CD} X

perpendicular distance between the force F_{CD} and a point E. = 0

R_D X DE + F_{CD} X xE = 0

1.875 X 3 + F_{CD} X 3 X sin 60° = 0

$\text{Sin } 60^\circ = \frac{xE}{CE}$

From Δ CEx

xE = CE X Sin 60° = 3 X Sin 60°

∴ F_{CD} = -2.16 kN Compression

Result:

Sl.No.	Member	Force (kN)	Nature of force
1	AB	-3.25	Compression
2	AE	2.8	Tension
3	BE	-1.73	Compression
4	BC	-2.25	Compression
5	CE	0.96	Tension
6	ED	1.08	Tension
7	CD	-2.16	Compression
