Course Code: ESC106A
Course Title: Construction Materials and Engineering Mechanics

Lecture No. 31:
Problems on Trusses

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Lecture Intended Learning Outcomes

At the end of this lecture, students will be able to:

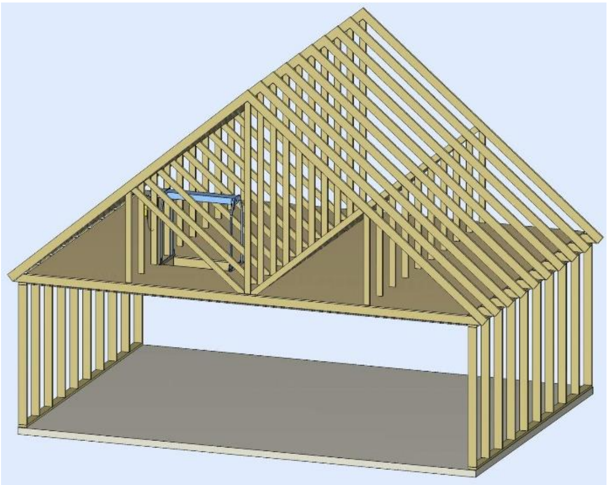
- Define and recognise determinate trusses
- Calculate the forces in the members of trusses by choosing and applying methods of sections or method of joints

Contents

Trusses, Types of Trusses, Assumptions during analysis, Nature of force in trusses, Different method of analysis – Joint and sections method, Problems for Joint method

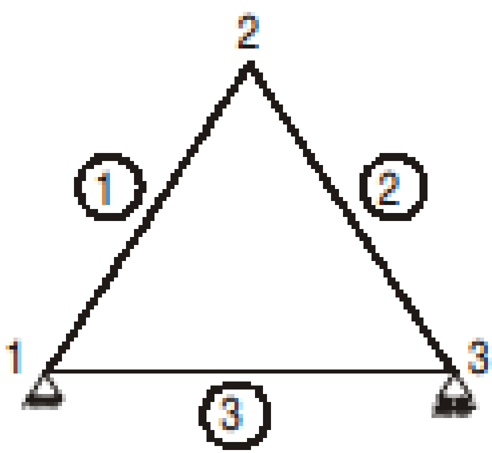
Trusses

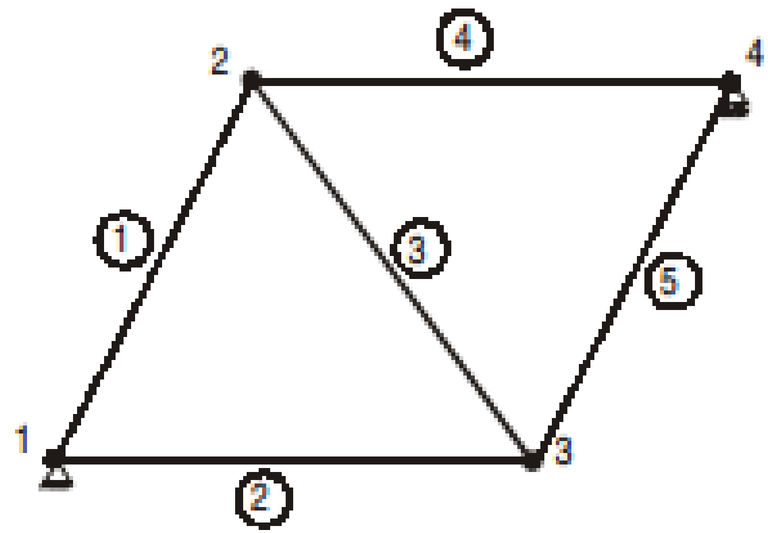
- A truss is a structure made up of slender members pin-connected at ends and is capable of taking loads at joints
- They are used as roof trusses to support sloping roofs and as bridge trusses to support deck.
- In many machines steel trusses are used. Transmission towers are also the examples of trusses.
- Trusses are also known as ‘Pinjointed frames’.



Perfect, Deficient and Redundant Trusses

- A Pinjointed truss which has got just sufficient number of members to resist the loads without undergoing appreciable deformation in shape is called a perfect truss
- Triangular truss is the simplest perfect truss and it has three joints and three members
- Perfect trusses with three and four joints are shown in Figs





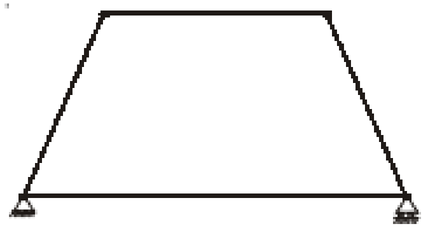
Perfect, Deficient and Redundant Trusses

- It may be observed that to increase one joint in a perfect truss, two more members are required.
- Hence the following expression may be written down as the relationship between number of joints j and the number of members m, in a perfect truss.

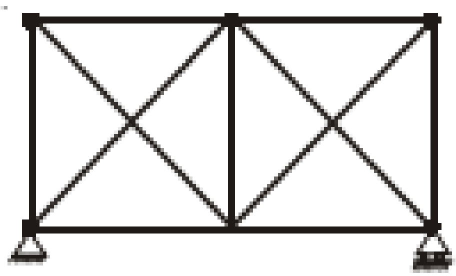
  i.e. $m = 2j - 3$

Perfect, Deficient and Redundant Trusses

- A truss is said to be deficient if the number of members in it are less than that required for a perfect truss.
- Such trusses cannot retain their shape when loaded



- A truss is said to be redundant if the number of members in it are more than that required in a perfect truss.
- Such trusses cannot be analysed by making use of the equations of equilibrium alone



Assumptions

- The ends of the members are pin-connected (hinged)
- The loads act only at the joints
- Self-weights of the members are negligible
- Cross-section of the members is uniform

Reactions of supports of a frame

Generally the frames are supported on

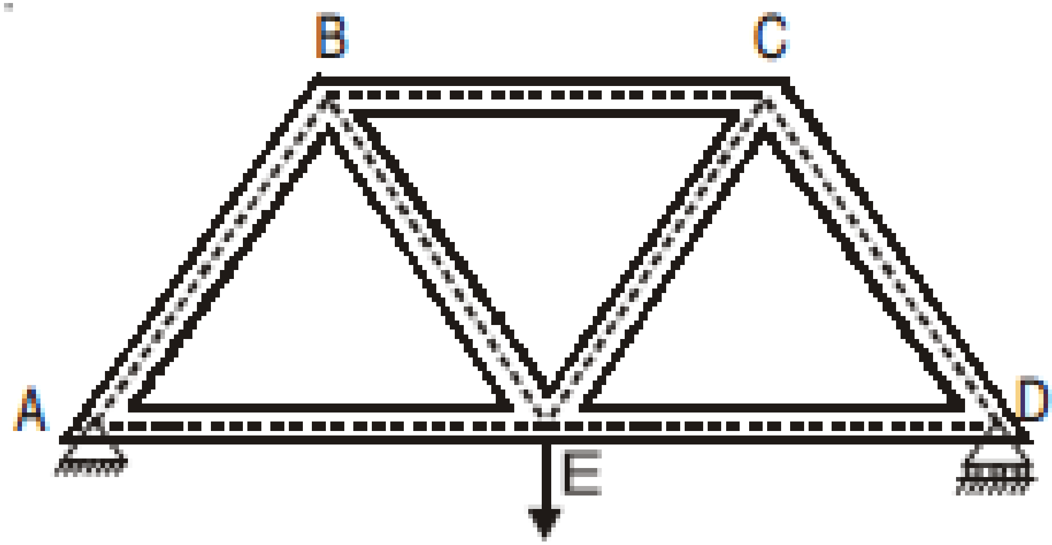
- Roller Support
- Hinged Support

Reactions of supports of a frame are determined by conditions of equilibrium.

The external load on the frame and the reactions at the supports must form a system of equilibrium

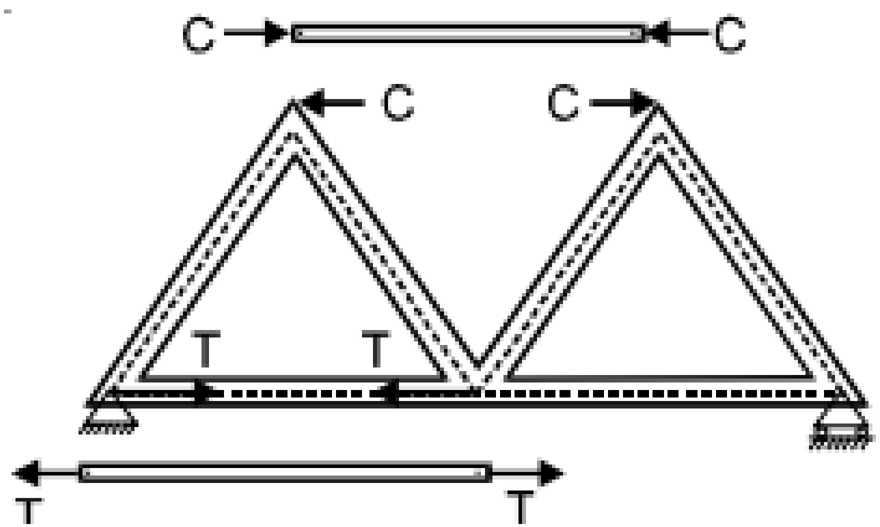
Nature of Forces in Members

- The members of a truss are subjected to either tensile or compressive forces.
- A typical truss ABCDE loaded at joint E is shown in Fig



Nature of Forces in Members

- The member BC is subjected to compressive force C as shown in Fig
- Effect of this force on the joint B (or C) is equal and opposite to the force C as shown in the fig
- The member AE is subjected to tensile force T



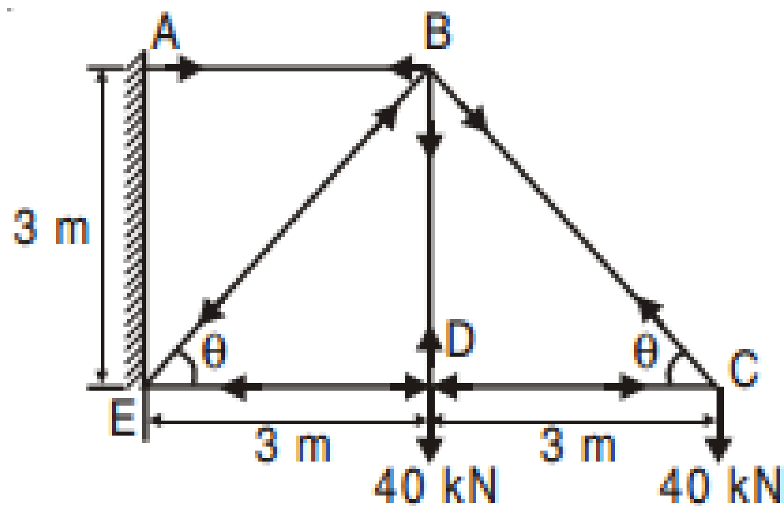
Methods of Analysis

Following three methods are available for the analysis of pin-connected frames:

- Method of joints
- Method of section
- Graphical method

Method of Joints
Example Problem:

Find the forces in all the members of the truss shown in Fig Tabulate the results



Method of Joints

Example Problem:

Step 1:

- Determine the inclinations of all inclined members.
- In this case, $\tan\theta = 3/3$

$$= 1$$

$$\therefore \theta = 45°$$

Step 2:

- Look for a joint at which there are only two unknowns.
- If such a joint is not available, determine the reactions at the supports, and then at the supports these unknowns may reduce to only two.
- Now at joints C, there are only two unknowns, i.e., forces in members CB and CD, say F_{CB} and F_{CD}

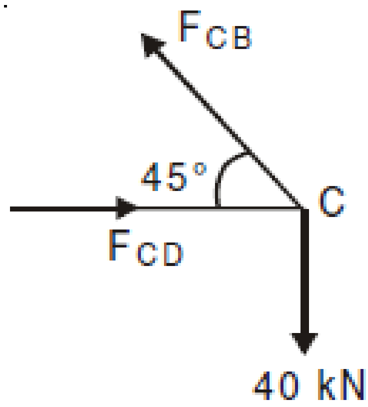
Method of Joints

Step 3:

- Now there are two equations of equilibrium for the forces meeting at the joint and two unknown forces
- Hence, the unknown forces can be determined
- At joint *C* ,ΣV = 0 condition shows that the force *FCB* should act away from the joint *C* so that its vertical component balances the vertical downward load at *C*

$$F_{CB} \sin 45° = 40$$

$$\therefore \boldsymbol{F_{CB} = 40\sqrt{2}\ \textbf{kN}}$$



- Now $\Sigma\ H$ = 0 indicates that *FCD* should act towards *C*.

$$F_{CD} - F_{CB} \cos 45° = 0$$

- $\boldsymbol{F_{CD}} = F_{CB} \cos 45° = 40\sqrt{2}\ \text{x}\ \frac{1}{\sqrt{2}} = \textbf{40 kN}$

Method of Joints

Step 4:

- On the diagram of the truss, mark arrows on the members near the joint analysed to indicate the forces on the joint.
- At the other end, mark the arrows in the reverse direction.
- In the present case, near the joint *C*, the arrows are marked on the members *CB* and *CD* to indicate forces F_{CB} and F_{CD} directions as found in the analysis of joint *C*.
- Then reversed directions are marked in the members *CB* and *CD* near joints *B* and *D,* respectively.

Method of Joints

Step 5:

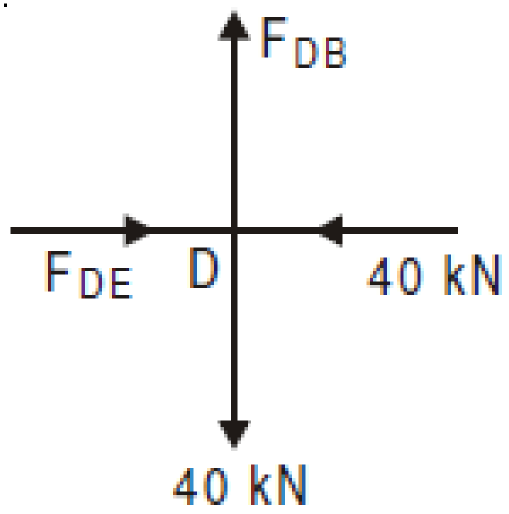
- Look for the next joint where there are only two unknown forces and analyse that joint.
- In this case, there are only two unknown forces at the joint *D*

$\Sigma V = 0$

$FDB = 40$ kN

$\Sigma H = 0$

$\boldsymbol{FDE = 40}$ **kN**



Method of Joints

Step 6:

- Repeat steps 4 and 5 till forces in all the members are found.
- In the present case, after marking the forces in the members DB and DE, we find that analysis of joint B can be taken up.

$\Sigma V = 0,$

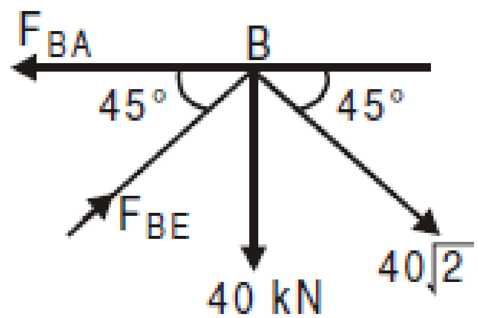
$F_{BE} \sin 45° - 40 - 40\sqrt{2} \times \sin 45° = 0$

$\boldsymbol{F_{BE} = 80\sqrt{2}\,\mathrm{kN}}$

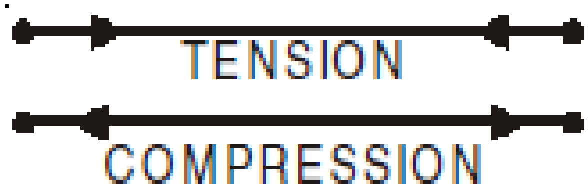
$\Sigma H = 0$

$F_{BA} - F_{BE} \cos 45° - 40\sqrt{2} \times \cos 45° = 0$

$\boldsymbol{F_{BA} = 120\ \mathrm{kN}}$



Method of Joints



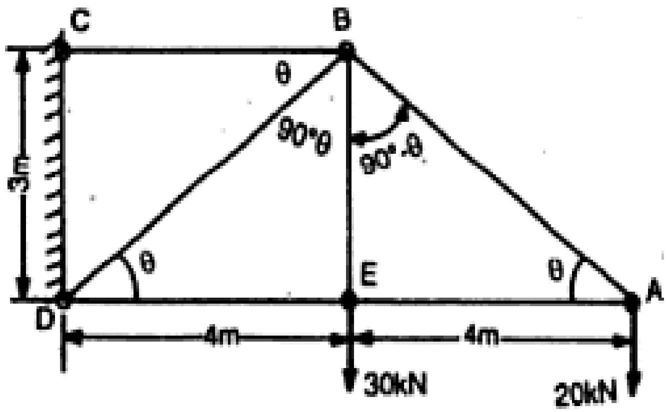
Step 7:

- Determine the nature of forces in each member and tabulate the results
- If the arrow marks on a member are towards each other, then the member is in tension
- If the arrow marks are away from each other, the member is in compression

Member	*Magnitude of Force in kN*	*Nature*
AB	120	Tension
BC	$40\sqrt{2}$	Tension
CD	40	Compression
DE	40	Compression
BE	$80\sqrt{2}$	Compression
BD	40	Tension

Problems on Trusses

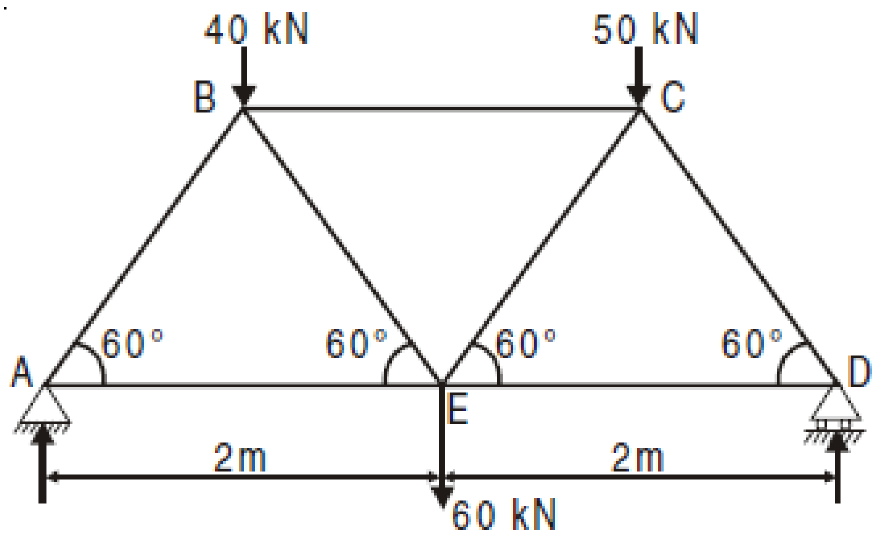
1.Compute the forces in all the members of the cantilever truss shown in the fig and indicate the forces on a sketch of the truss along with their nature



F_{AB}=33.33kN
F_{AE}=26.67kN
F_{BE}=30kN
F_{ED}=26.67kN
F_{BD}=83.33kN
F_{BC}=-93.33kN

Problems on Trusses

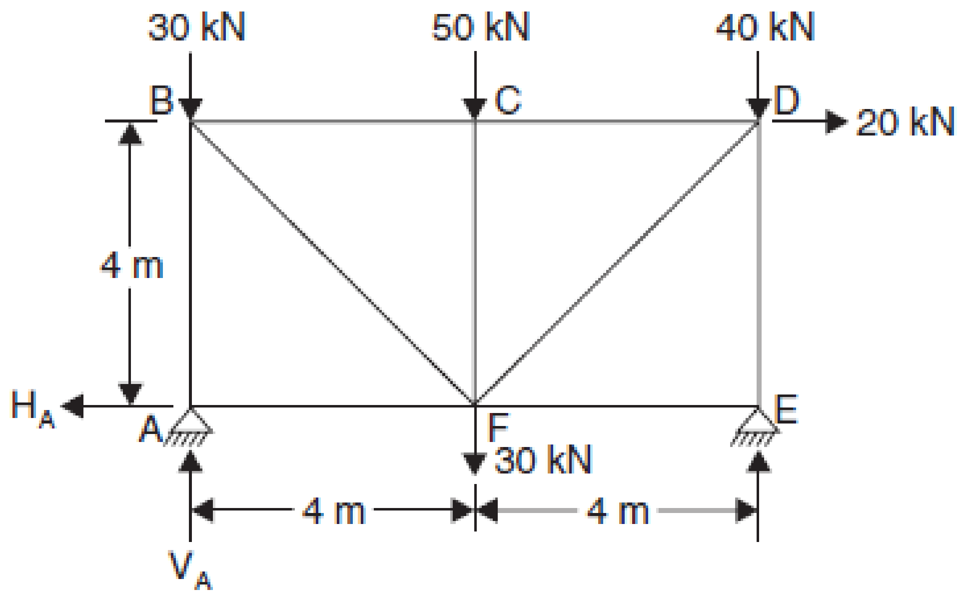
2.Determine the forces in all the members of the truss shown in Fig and indicate the magnitude and nature of forces on the diagram of the truss. All inclined members are at 60° to horizontal and length of each member is 2 m.



F_{AB}=83.71 kN (C)
F_{AE}=41.85 kN (T)
F_{DC}=89.48kN (C)
F_{DE}=44.74kN (T)
F_{BE}=37.52kN (T)
F_{BC}=60.62kN (C)

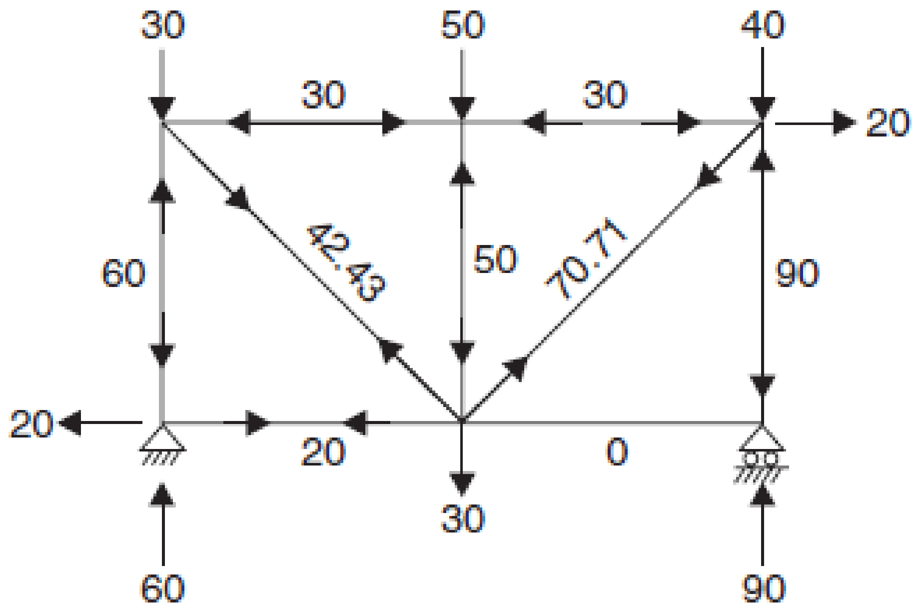
Problems on Trusses

3.Determine the forces in the members of truss shown in Figure



Problems on Trusses

3.Solution



Summary

- A truss is a structure made up of slender members pin-connected at ends and is capable of taking loads at joints

- Trusses are also known as 'Pinjointed frames'.

- Following three methods are available for the analysis of pin-connected frames:
  - Method of joints
  - Method of section
  - Graphical method