TRUSSES

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INTRODUCTION :

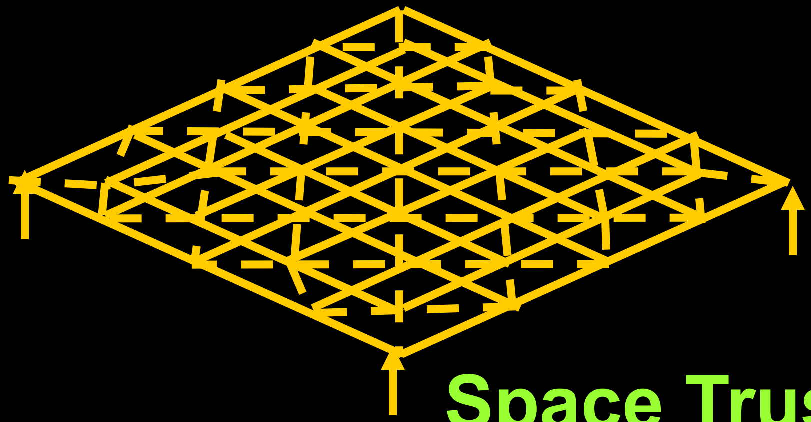
A truss is an articulated (skeletal) structure with hinged or ball and socket joints. It is an assemblage of slender bars fastened together at their ends by smooth pins or ball and socket joints acting as hinges.

Plane truss: A truss consisting of members which lie in a plane and are loaded in the same plane is called a plane truss. Ex: Roof truss, bridge truss, etc.

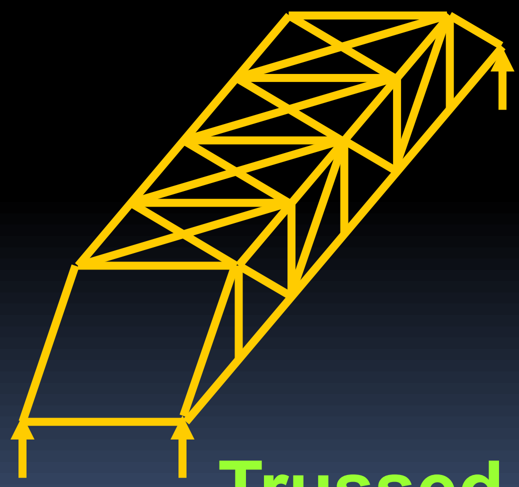
Space truss: A truss made up of members not lying in the same plane is referred to as space truss. Ex: Electric power transmission tower, microwave tower, etc.

APPLICATIONS

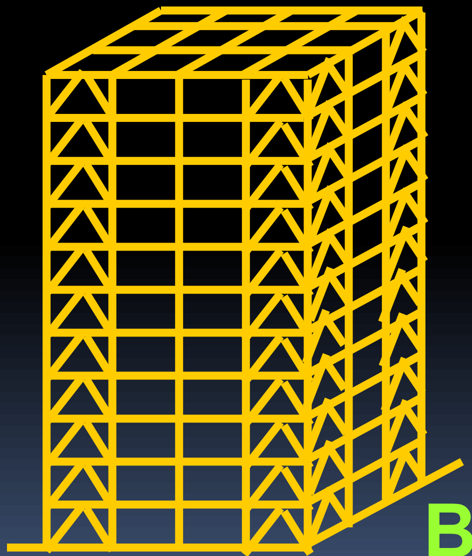
Plane Truss



Space Truss



Trussed Bridge

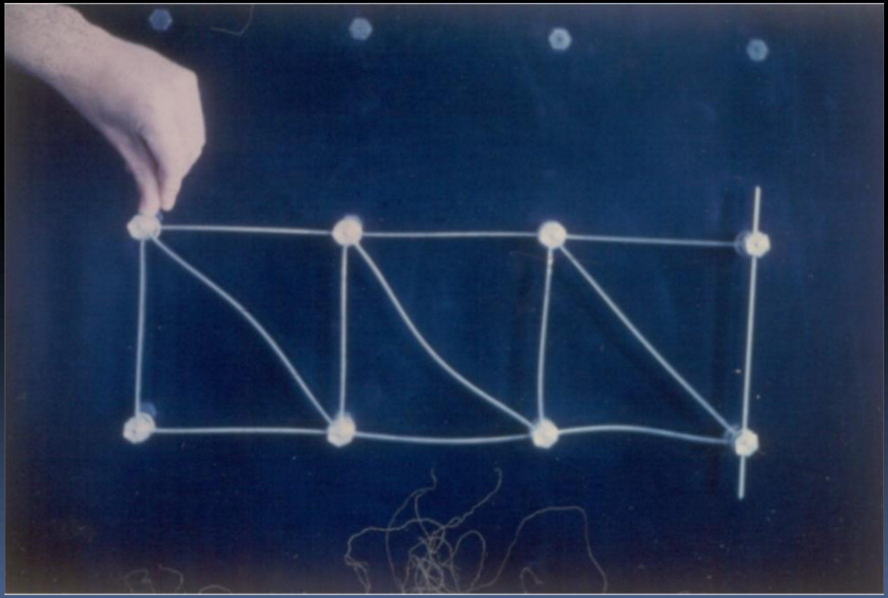


Braced Frame




PLANE TRUSS :

The basic element of a plane truss is three members (bars, angles,tubes,etc) arranged to form a triangle. To this base triangle, two more members are added to locate a new joint, and the process continued to form the complete truss.

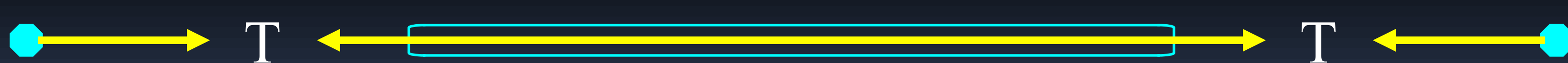


The truss built in such a manner is called as ‘Simple Truss’.

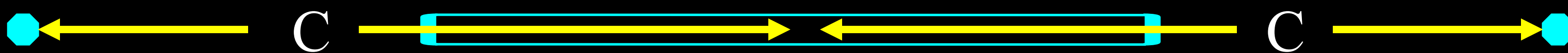
A truss is held in position by the supports and the loads are applied only at joints.

The free body diagram of a member shows that it is acted upon by two equal and opposite forces.

The hinged joint permits members to rotate with respect to each other and hence the members are subjected to purely axial forces.

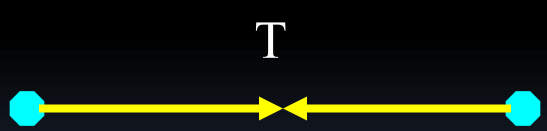


Tension Member

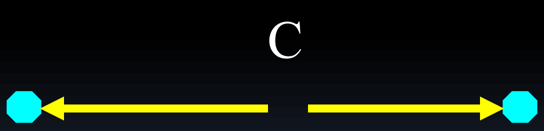


Compression Member

The convention for internal forces, i.e., the action of forces in the members on the joints is shown.



TENSION



COMPRESSION

STATICAL DETERMINACY AND STABILITY OF TRUSSES :

Let m = number of unknown member forces.

c = number of unknown constrained reaction components (usually three, if statically determinate externally)

j = number of joints

Each joint has two equations of equilibrium ($\Sigma H=0$ and $\Sigma V=0$).

Hence number of equilibrium equations available = 2j.

Total number of unknowns = m + c

STATICAL DETERMINACY AND STABILITY OF TRUSSES : (contd..)

If total number of unknowns is equal to total number of equations available, then the truss is statically determinate.

i.e., $m+c = 2j$

If number of unknowns is more than the number of available equations, then the truss is statically indeterminate.

i.e., $m+c > 2j$

If the number of unknowns is less than the number of available equations, then the truss is unstable.

i.e., $m+c < 2j$

STATICAL DETERMINACY AND STABILITY OF TRUSSES : (contd..)

Degree of indeterminacy, $i = (m+c) - 2j$

Degree of external indeterminacy, $i_e = c - 3$

Degree of internal indeterminacy. $i_i = i - i_e = m+3 - 2j$

STATICAL DETERMINACY AND STABILITY OF TRUSSES : (contd..)

When we consider the internal indeterminacy, we have the following cases of truss:

(i) When $i_i = 0$, $m = 2j - 3$ and the structure is statically determinate internally and is stable. Such a truss is called a perfect truss.

(ii) When $i_i < 0$, the number of members provided is less than that required for stability. Such a truss is called unstable or deficient truss.

(iii) When $i_i > 0$, number of members is more than the number required. Such a truss is called statically indeterminate or redundant truss.

STATICAL DETERMINACY AND STABILITY OF TRUSSES : (contd..)

When we consider the external indeterminacy, we have the following cases of truss:

(i) When $c = 3$ ($\Rightarrow i_e = 0$), the truss is said to be statically determinate externally.

(ii) When $c < 3$ ($\Rightarrow i_e < 0$), the truss is said to be unstable externally.

(iii) When $c > 3$ ($\Rightarrow i_e > 0$), the truss is said to be statically indeterminate externally.

ANALYSIS OF STATICALLY DETERMINATE PLANE TRUSS :

The assumptions made in the analysis are as follows:

- The members of the truss are connected at the ends by frictionless hinges.
- The axes of all members lie in a single plane called 'middle plane of the truss'.
- All the external forces acting on the truss are applied at the joints only.
- All the loads are applied in the plane of the truss.

The following methods of analysis will be adopted :

A.) Method of joints.   B.) Method of sections.

<u>SIGN CONVENTIONS USED</u> :

Positive sign is used for tension.

Negative sign is used for compression.

Clockwise moment (↻)is taken positive and anti-clockwise moment (↺) is taken as negative.

<u>METHOD OF JOINTS</u> :

A member in a pin - jointed truss has only one internal force resultant i.e., the axial force. Hence the F.B.D of any joint is a concurrent system in equilibrium.

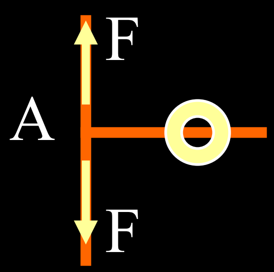
METHOD OF JOINTS : (contd..)

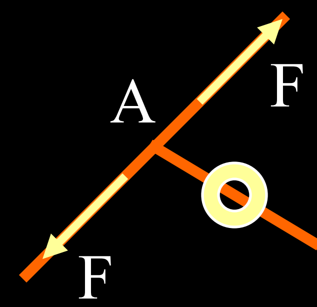
The procedure for method of joints is as follows :

- The support reactions of the truss are first obtained considering the three conditions of equilibrium, applied to the truss as a whole ($\Sigma H=0$, $\Sigma V=0$ and $\Sigma M=0$).
- Taking the F.B.D of a joint which has not more than two unknowns (preferably), and applying the equations of equilibrium for a coplanar concurrent force system ($\Sigma H=0$ and $\Sigma V=0$), the unknowns are evaluated.
- The analysis is continued with the next joint with two unknowns (preferably), until the forces in all the members are obtained.

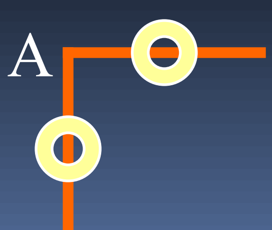
IDENTIFICATION OF ZERO FORCE MEMBERS :

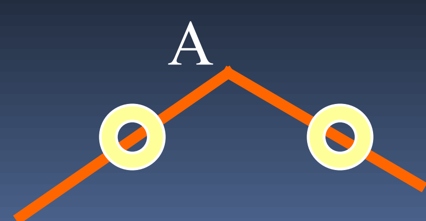
1. When two of the three members meeting at a joint are collinear, and no load is acting at the joint, then the force in the third member is zero.

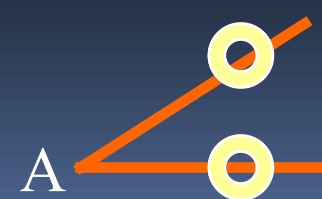




2. When two members meet at a joint where no load is acting, then the forces in those members are zero.

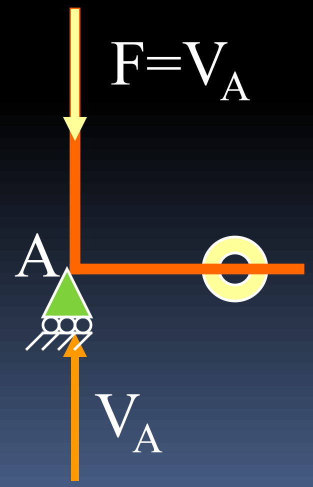






IDENTIFICATION OF ZERO FORCE MEMBERS : (contd..)

3. When two members meet at a joint where there is a support such that the support reaction is collinear with any one member, then the force in the other member is zero.



METHOD OF SECTIONS :

In this method we can directly determine the force in any member without proceeding to that member by a joint by joint analysis. The method is as follows :

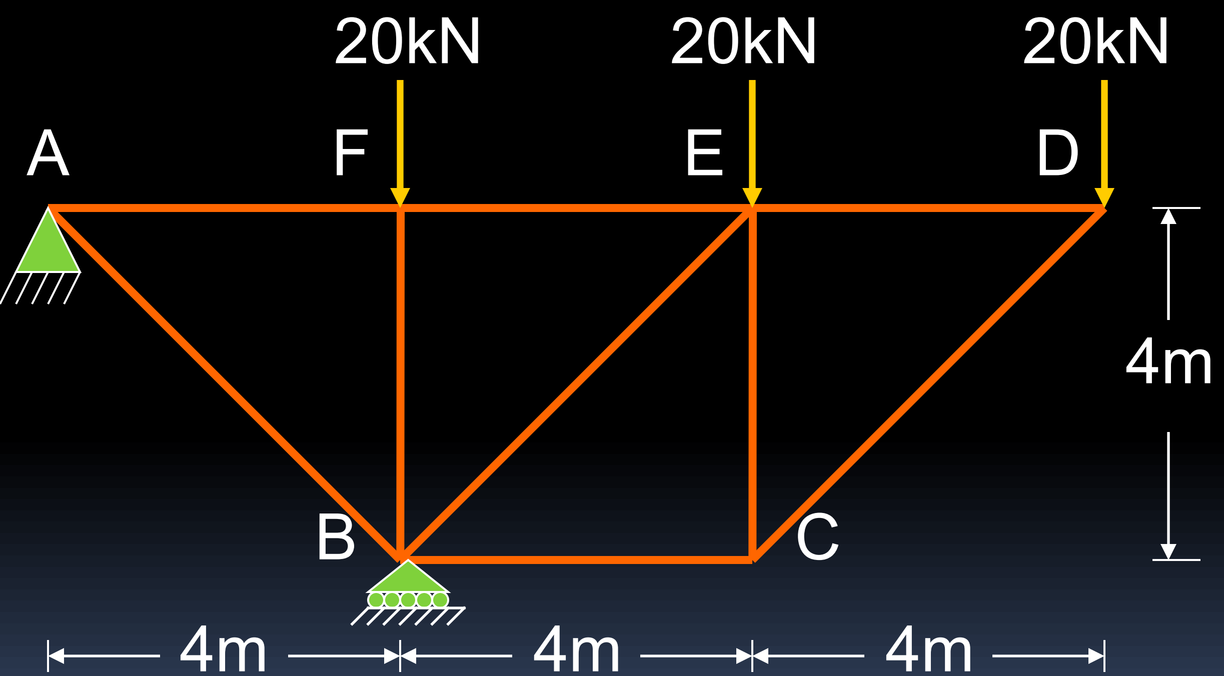
- Determine the reactions at the supports of the truss given.
- Take an imaginary cutting plane through the truss, dividing it into two parts, such that it passes through members in which forces are required.

METHOD OF SECTIONS : (contd..)

- The cutting plane should be taken in such a way that it cuts a maximum of three members in which forces are unknown, preferably.

- Now consider any one part to the left or right of the section, and evaluate the unknowns by applying the conditions of equilibrium for the coplanar non-concurrent force system ($\Sigma H=0$, $\Sigma V=0$ and $\Sigma M=0$).

EXERCISE 1: Find the forces in members of the truss shown below.



Solution :

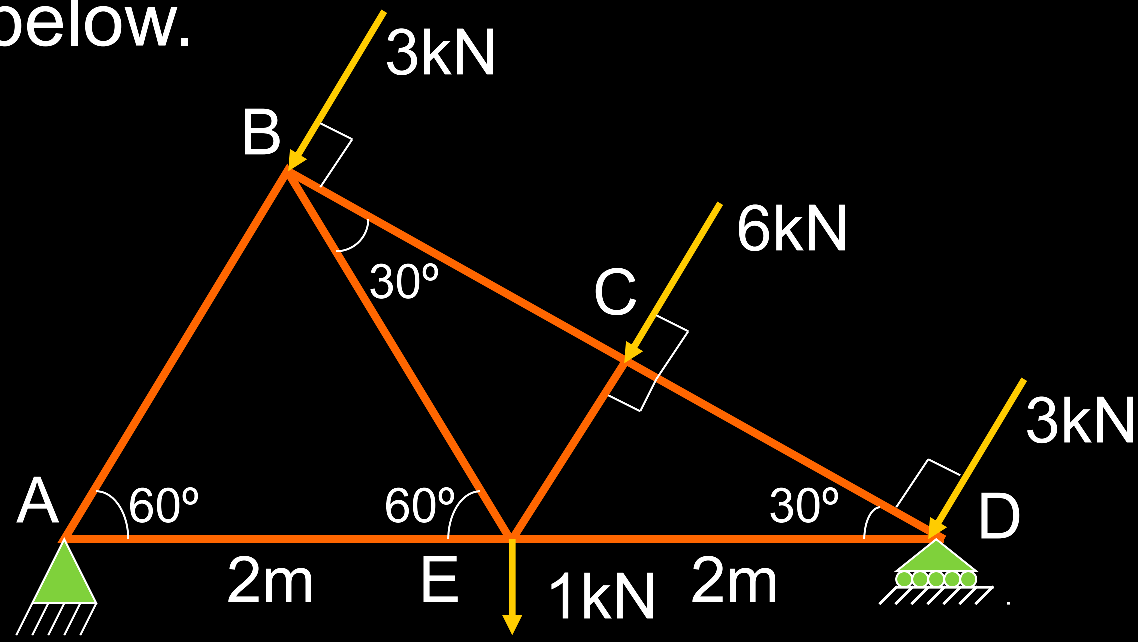
F_{AB} = 84.9kN(C)

F_{EF} = 60kN(T)

F_{BC} = 20kN(C)

F_{BE} = 56.67kN(C)

EXERCISE 2: Find the forces in members of the truss shown below.



Solution :

F_{AB} = 6.57kN(C)

F_{BC} = 6.19kN(C)

F_{AE} = 2.71kN(C)

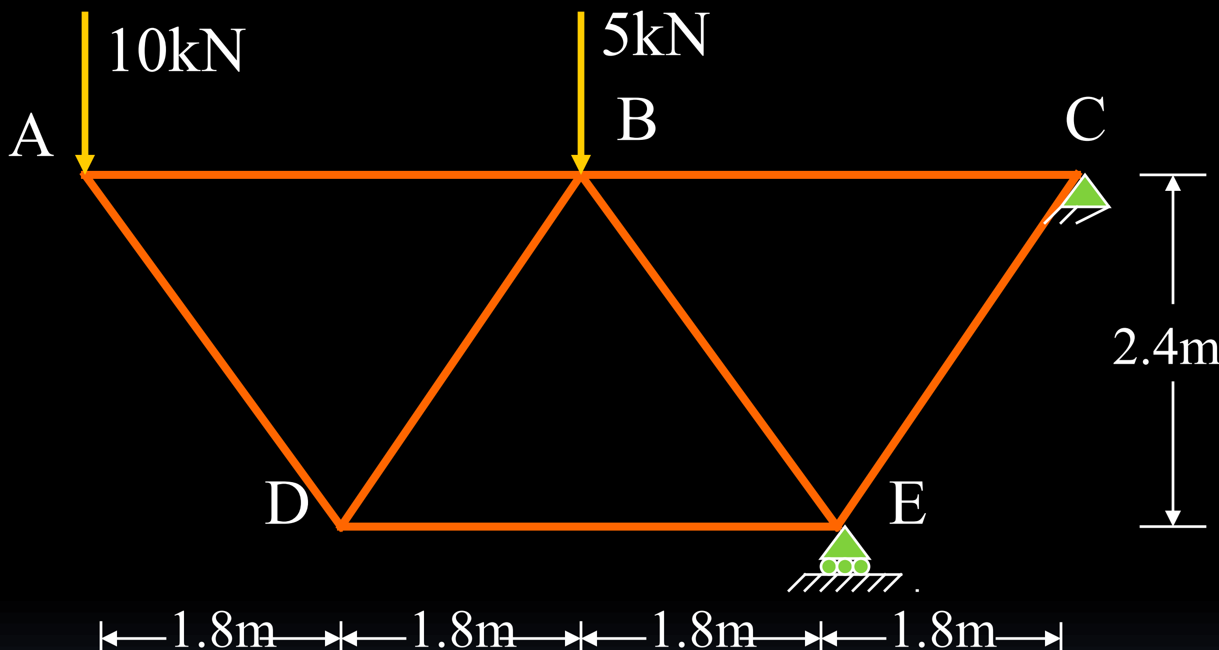
F_{BE} = 7.15kN(T)

F_{CE} = 6kN(C)

F_{DE} = 3.87kN(T)

F_{CD} = 6.19kN(C)

EXERCISE 3: Find the forces in members of the truss shown below.



Solution :

$F_{AB} = 7.5kN(T)$

$F_{BC} = 26.25kN(T)$

$F_{AD} = 12.5kN(C)$

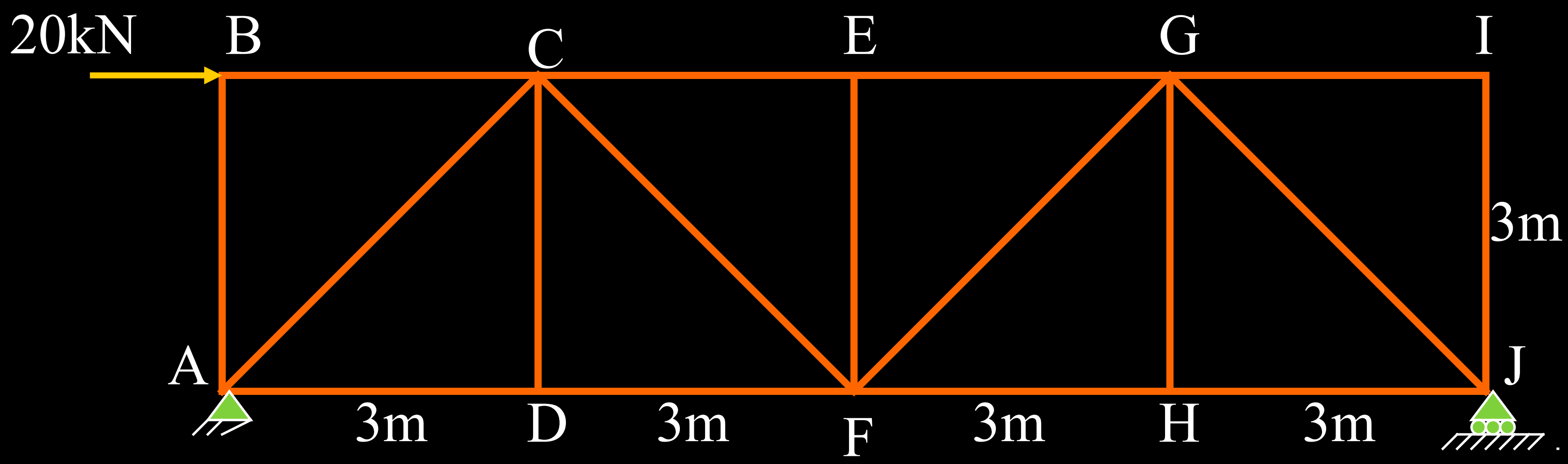
$F_{BD} = 12.5kN(T)$

$F_{BE} = 18.75kN(C)$

$F_{CE} = 43.75kN(C)$

$F_{DE} = 15kN(T)$

EXERCISE 4: Find the forces in members CE, CF and FH of the truss shown below.

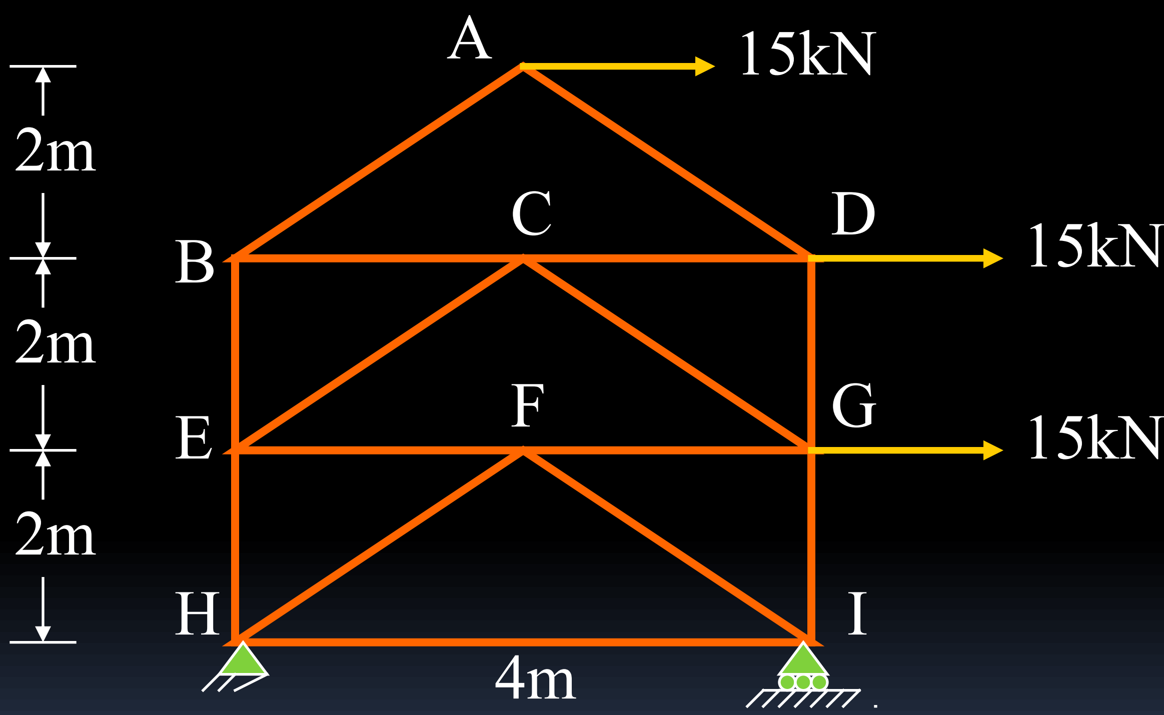


Solution : $F_{CE} = 10kN(T)$

$F_{CF} = 7.07kN(C)$

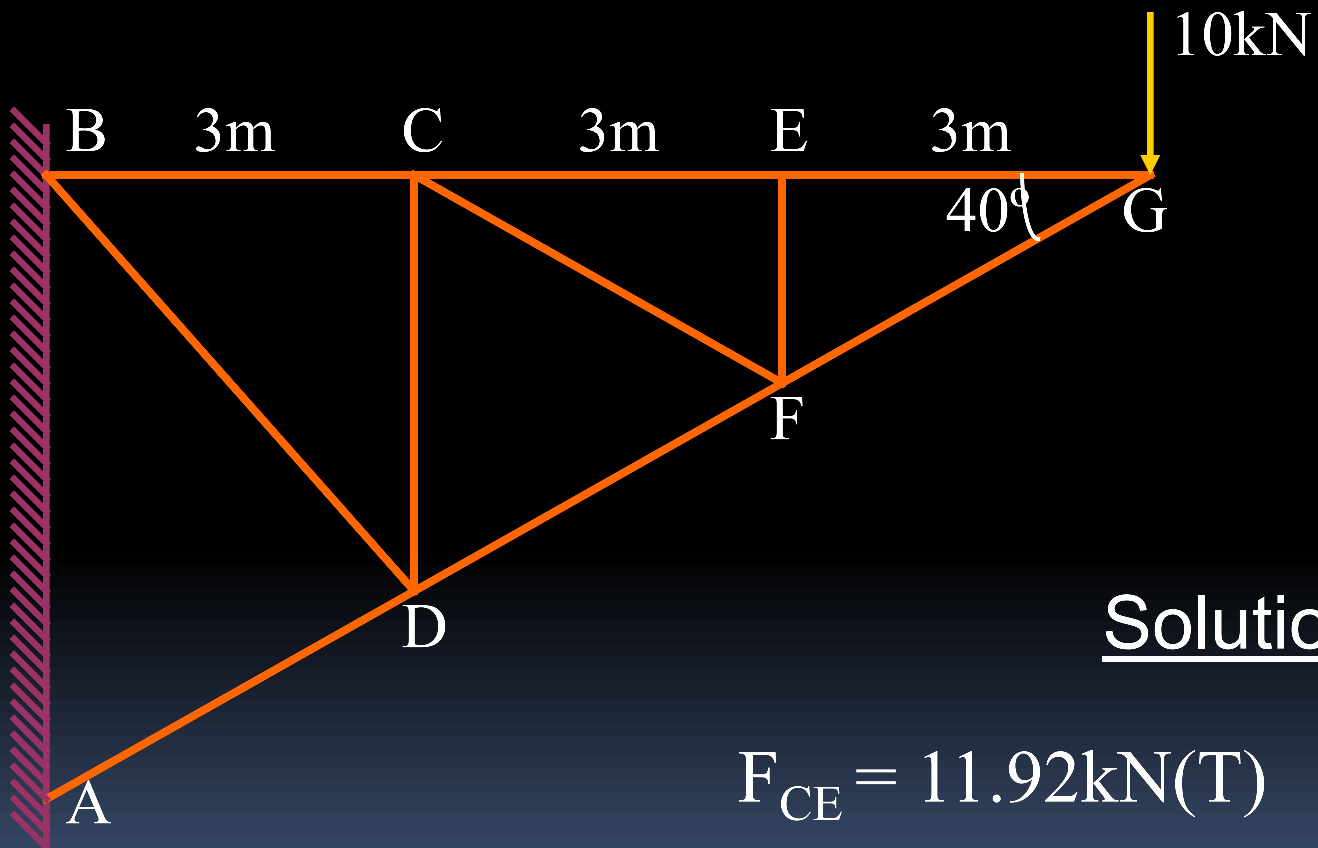
$F_{FH} = 5kN(T)$

EXERCISE 5: Find the force in member GI of the truss shown below.



Solution : $F_{GI} = 22.5kN(C)$

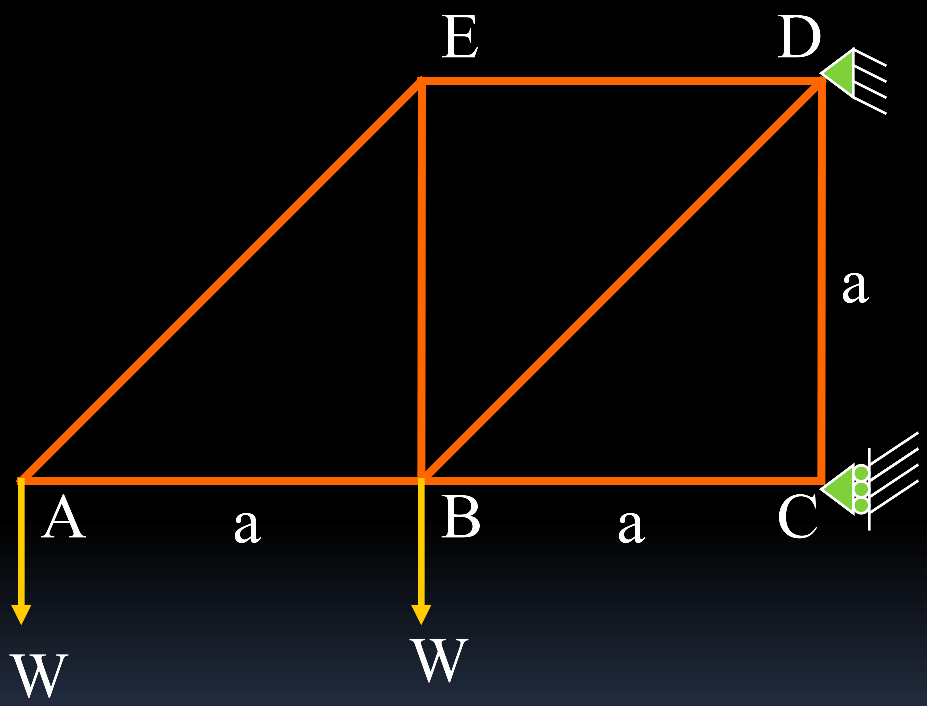
EXERCISE 6: Find the forces in members CE and CD of the truss shown below.



Solution :

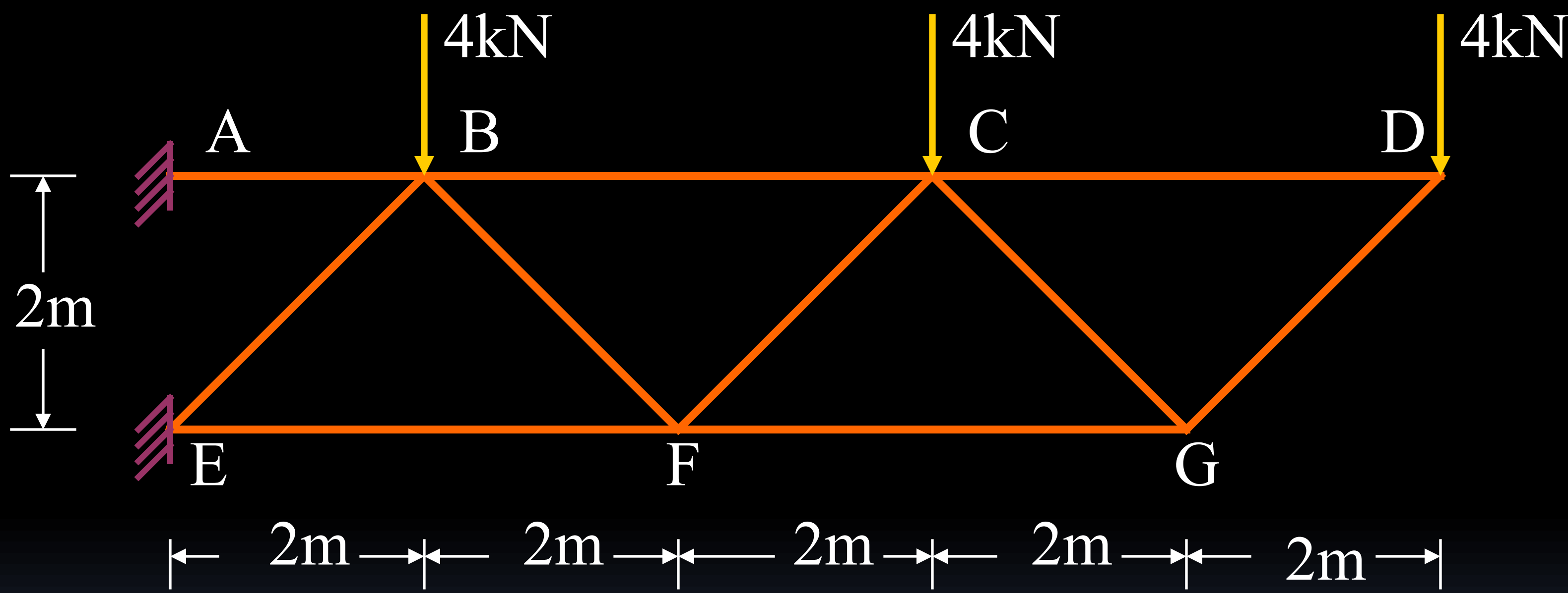
$F_{CE} = 11.92kN(T)$ $F_{CD} = 0$

EXERCISE 7: If force in member BC is 30kN(C), find magnitude of load W.



Solution : $W = 10kN$

EXERCISE 8: Find the forces in members AB, BC and CF of the truss shown below.



Solution : $F_{AB} = 3.6kN(T)$