Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

Winter 2017-18

MEE 1002 Engineering Mechanics

MODULE 2

Analysis of Structures

By

S.JEYANTHI

SMBS, VIT Chennai Campus

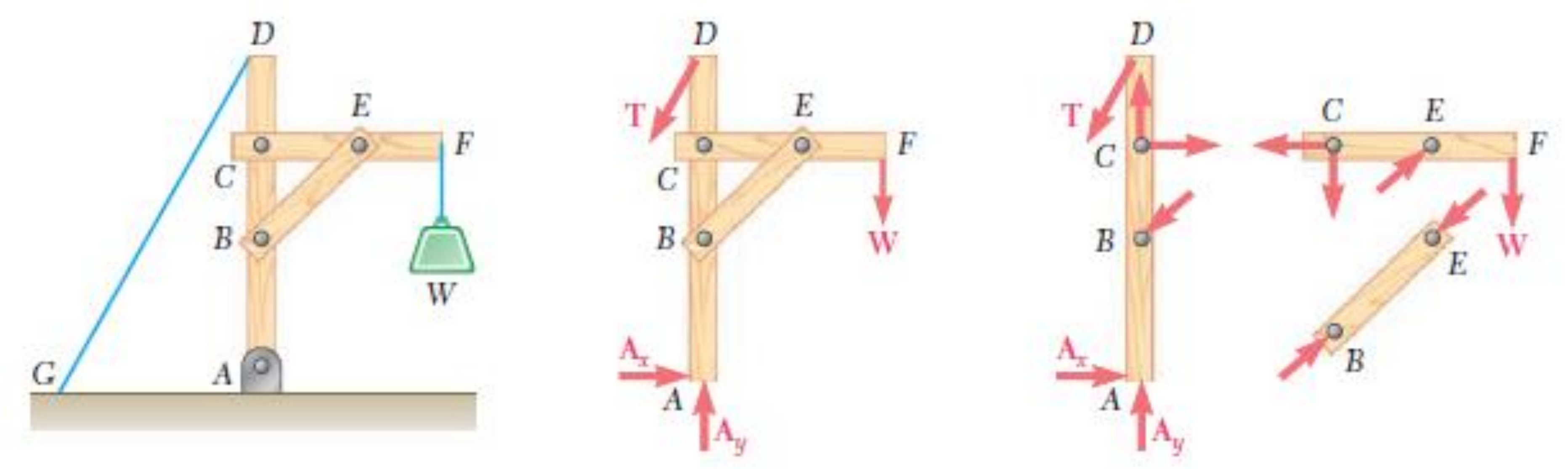
OUTLINE

- Introduction
- Analysis of trusses by
  - Method of joints
  - Method of sections
- Analysis of frame

Introduction

This module consider problems dealing with the equilibrium of structures made of several connected parts.

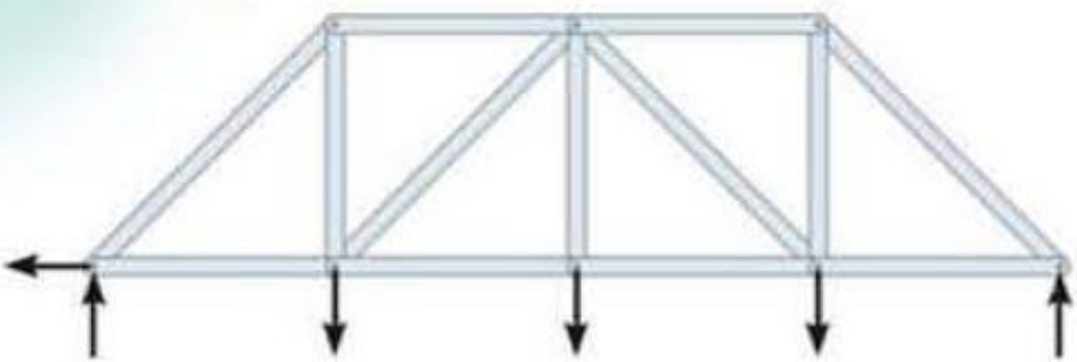
These problems call for the determination not only of the external forces acting on the structure but also of the forces which hold together the various parts of the structure.



Truss

- A truss is a structure composed of slender members joined together at their end points.

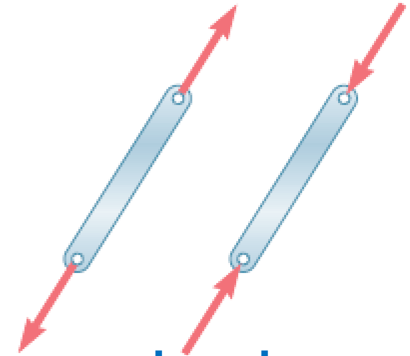
Roof truss

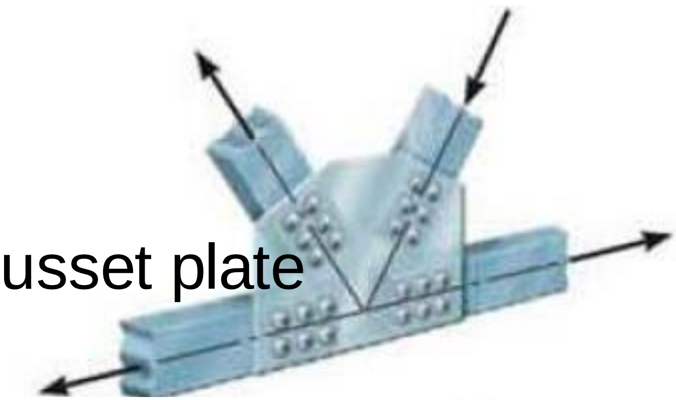


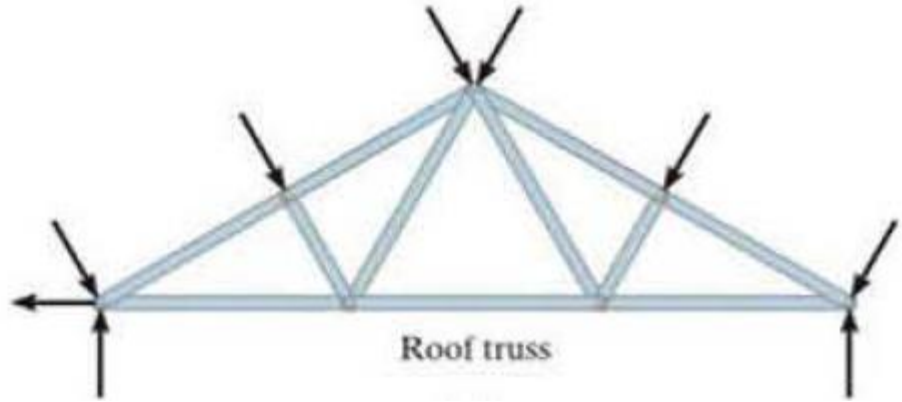
Bridge truss

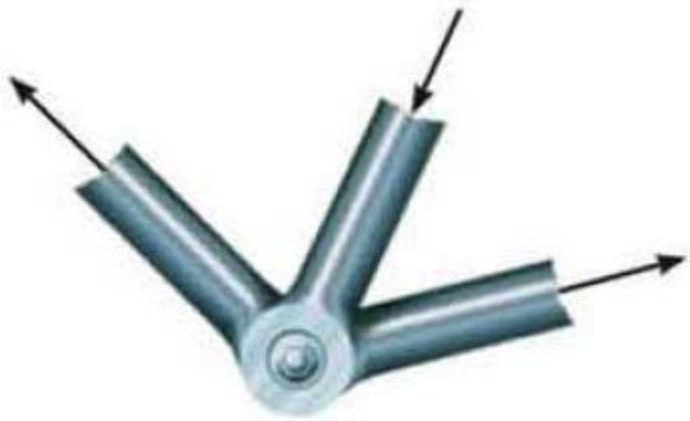
Assumptions for Design

- All loadings are applied at the joints
- The members are joined together by smooth pins



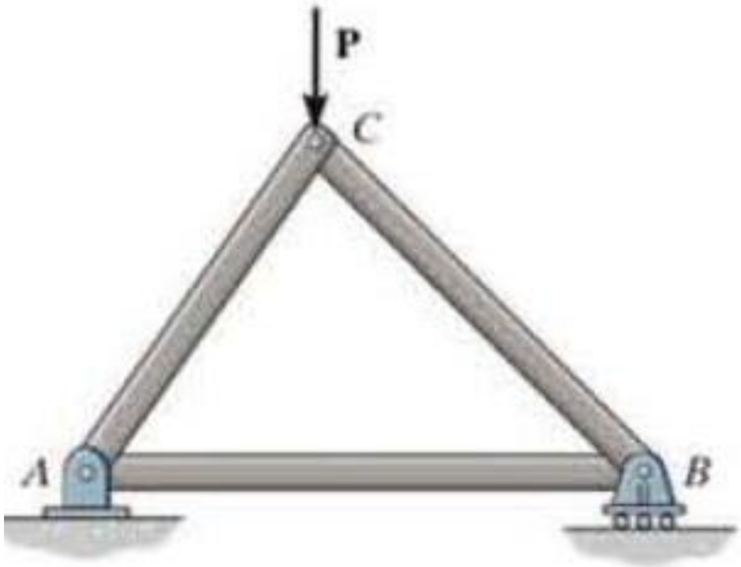


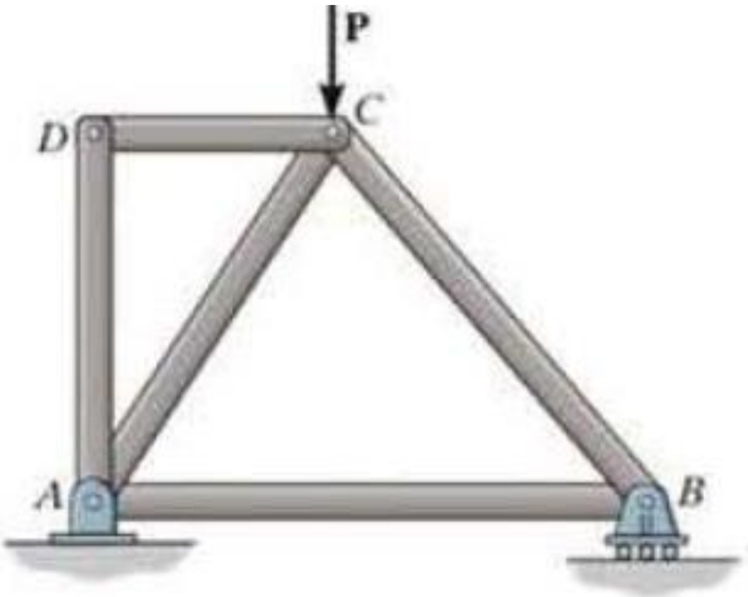




- Each truss member will act as a two force member
- Therefore the force acting at each end of the member will be directed along the axis of the member

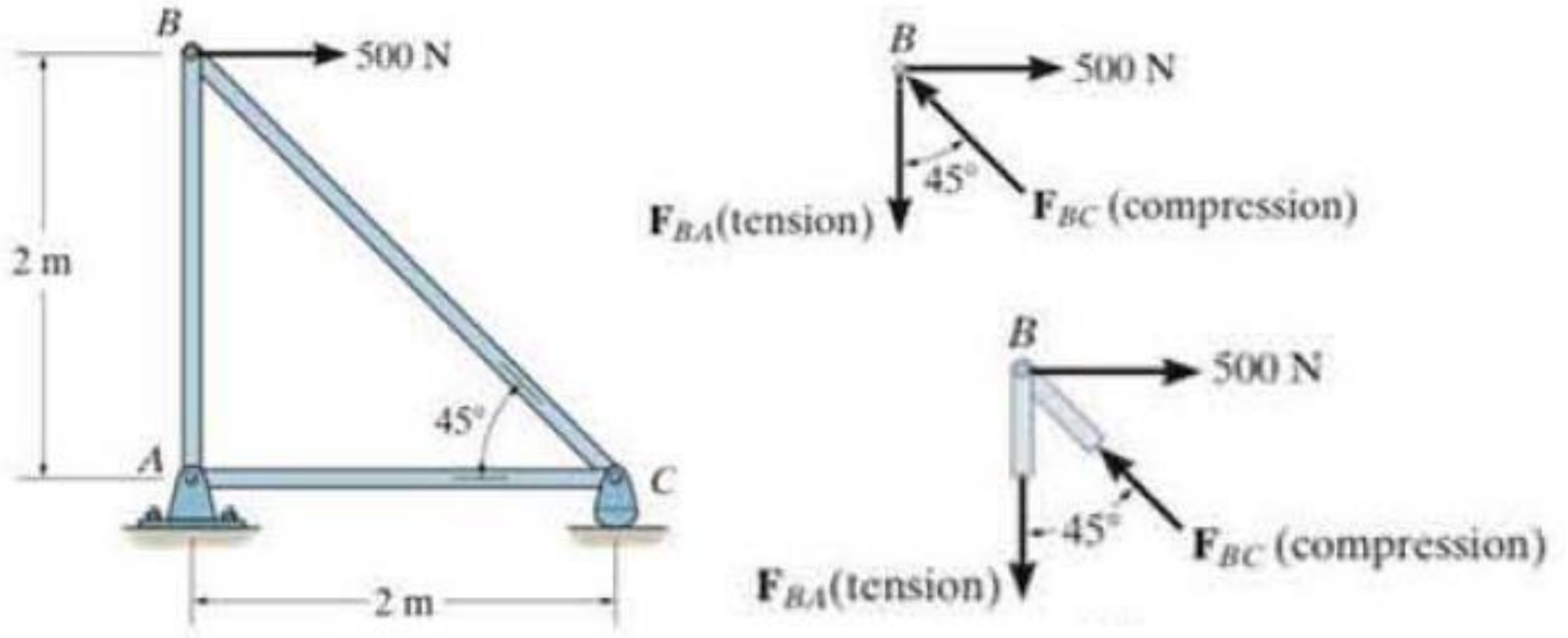
- If three members are pin connected at their ends they form a triangular truss that will be rigid
- If a truss is constructed by expanding the basic triangular truss, it is called as simple truss





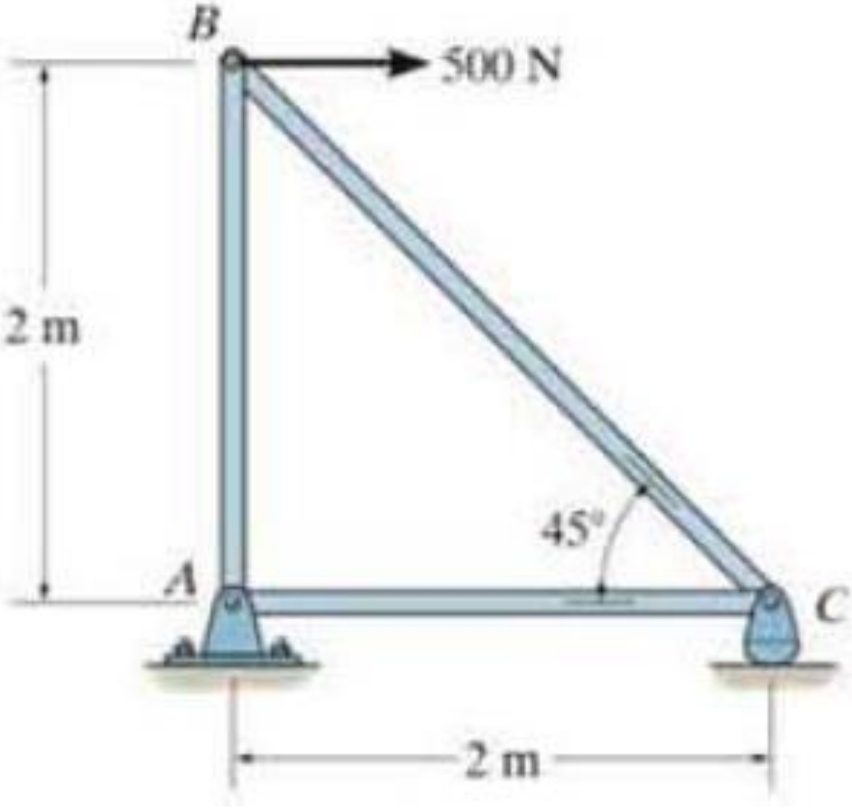
Method of Joints

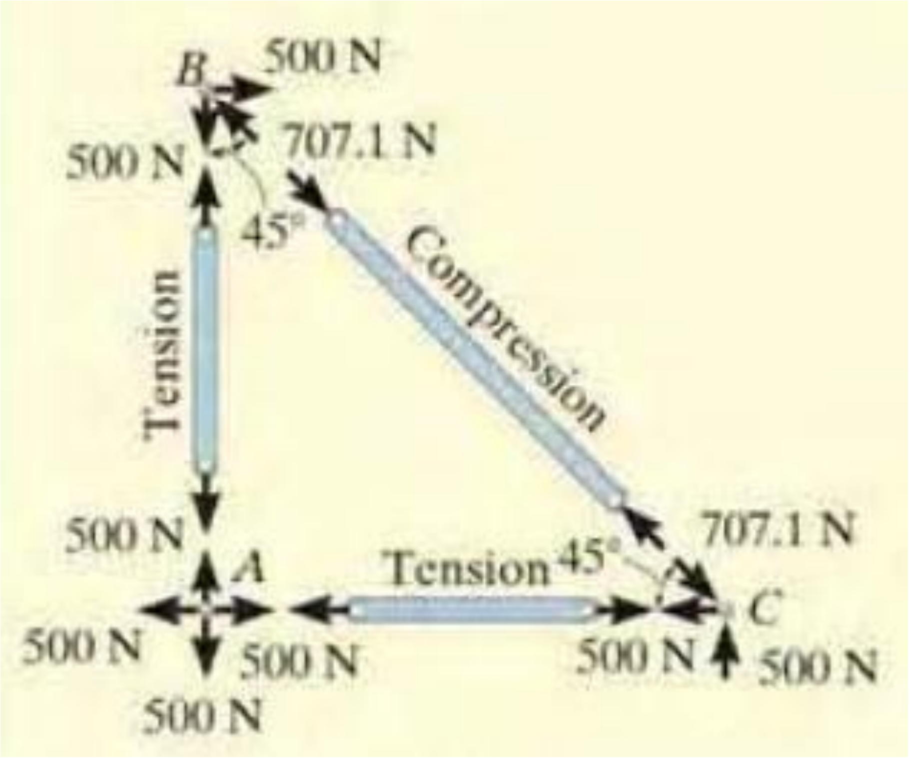
- This method is based on the fact that if the entire truss is in equilibrium, then each of its joints is also in equilibrium
- If the free body diagram of each joint is drawn, the force equilibrium equations can then be used to obtain the member forces acting on each joint



Problem 1

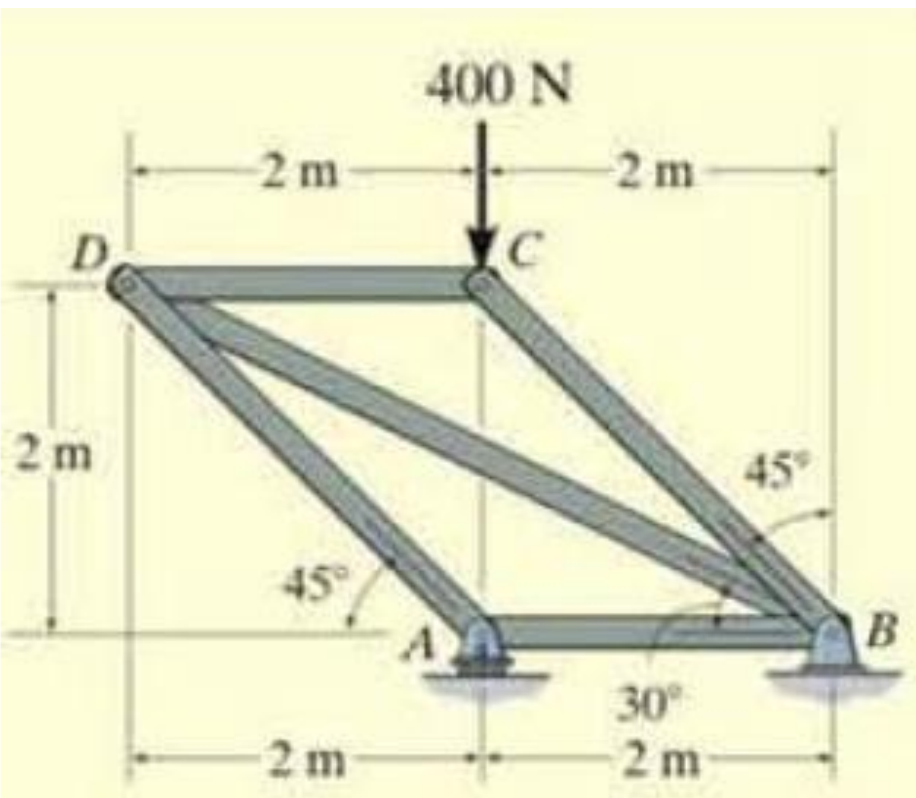
Determine the force in each member of the truss shown in figure and indicate whether the members are in tension or compression.

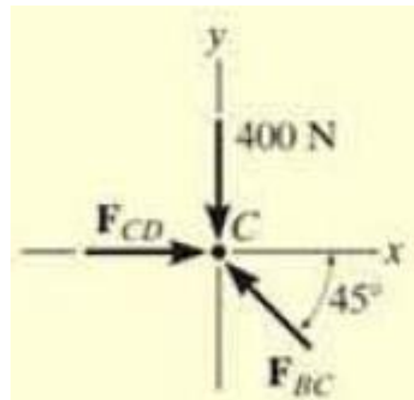


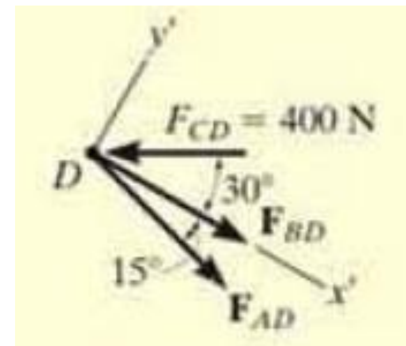


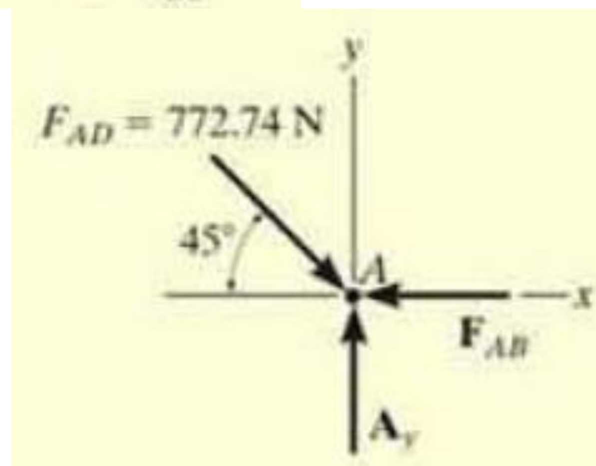
Problem 2

Determine the force in each member of the truss shown in figure and indicate whether the members are in tension or compression.



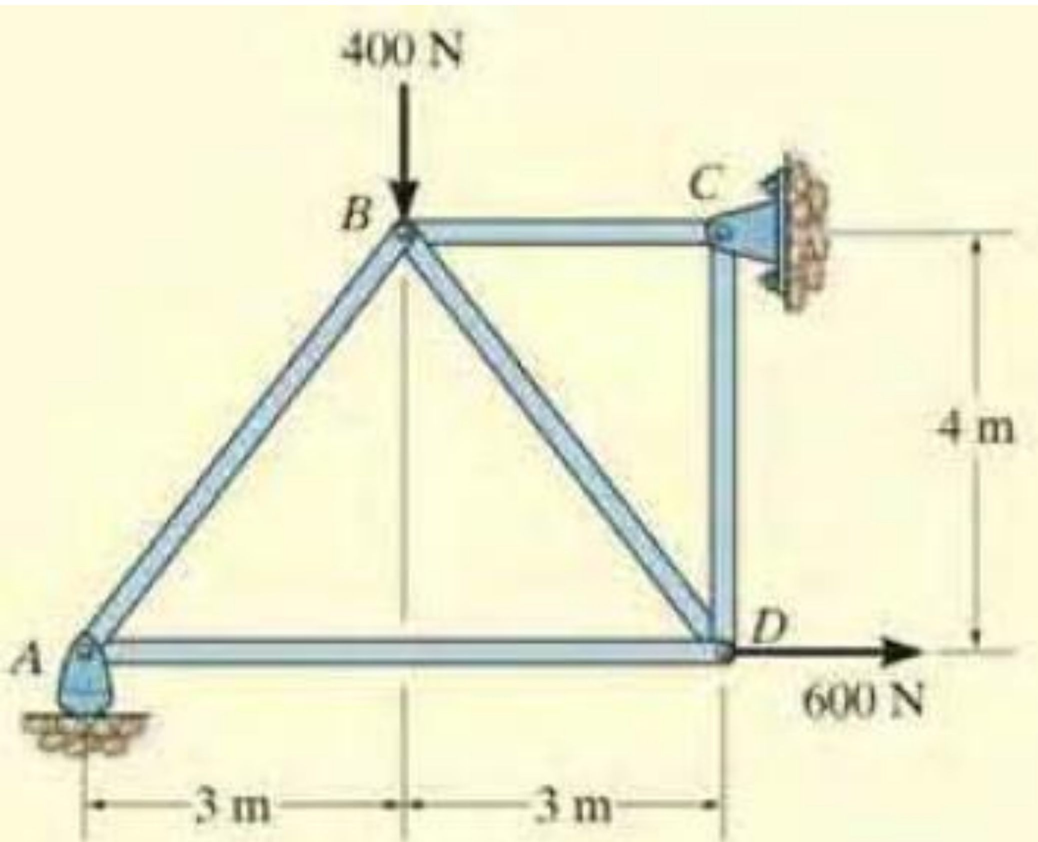


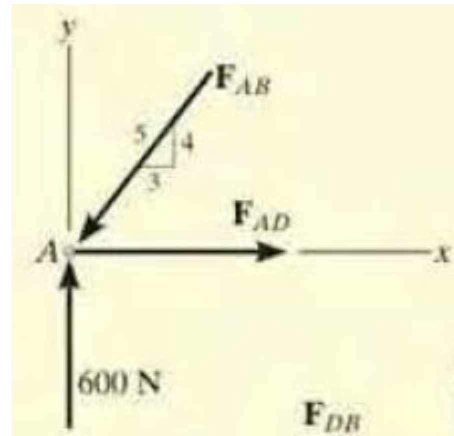


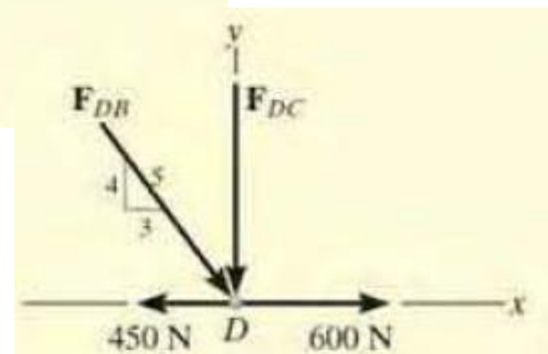


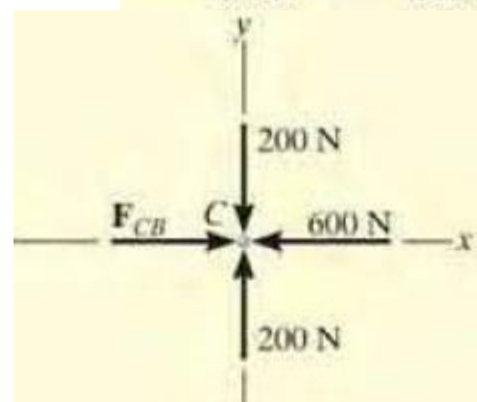
Problem 3

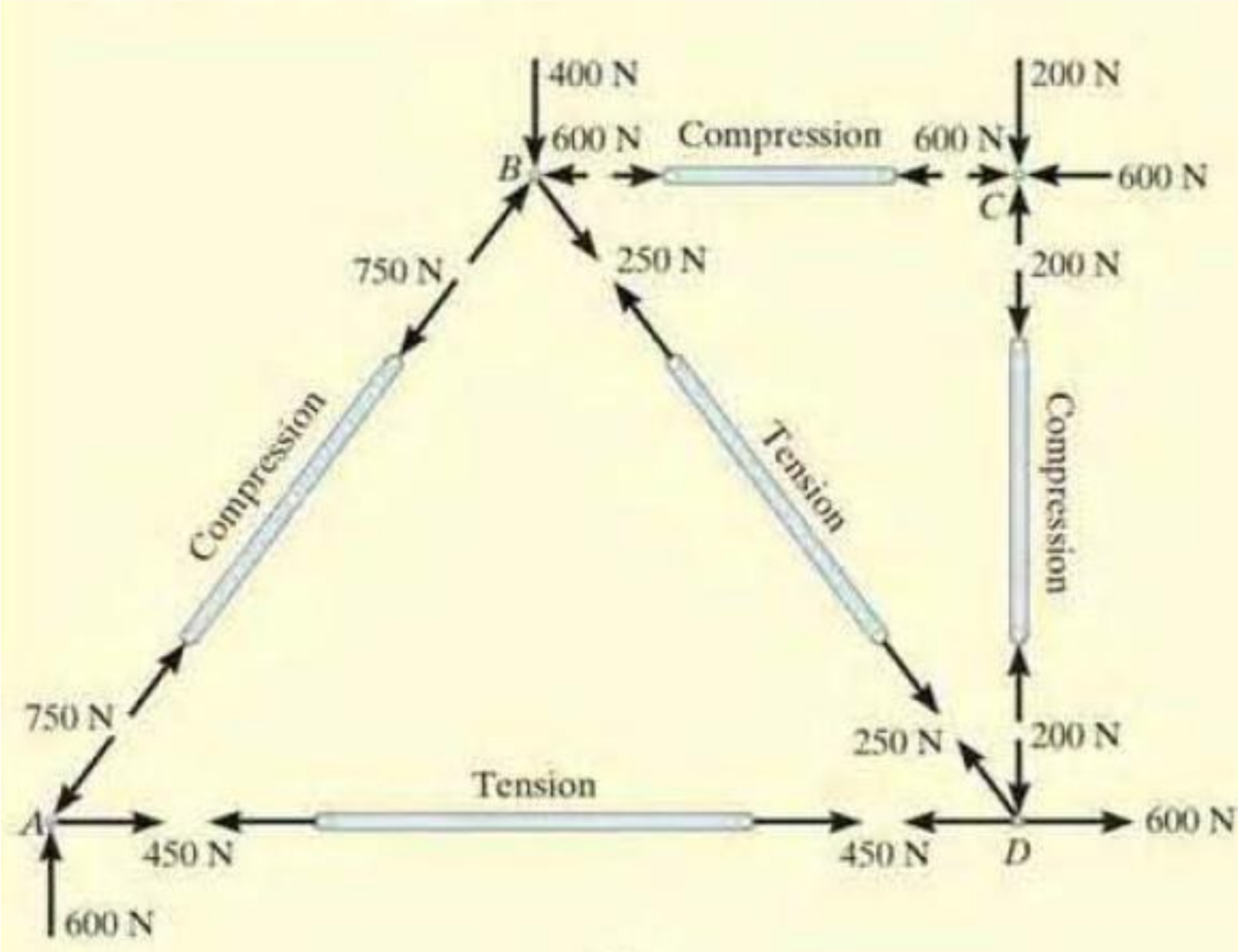
Determine the force in each member of the truss shown in figure and indicate whether the members are in tension or compression.









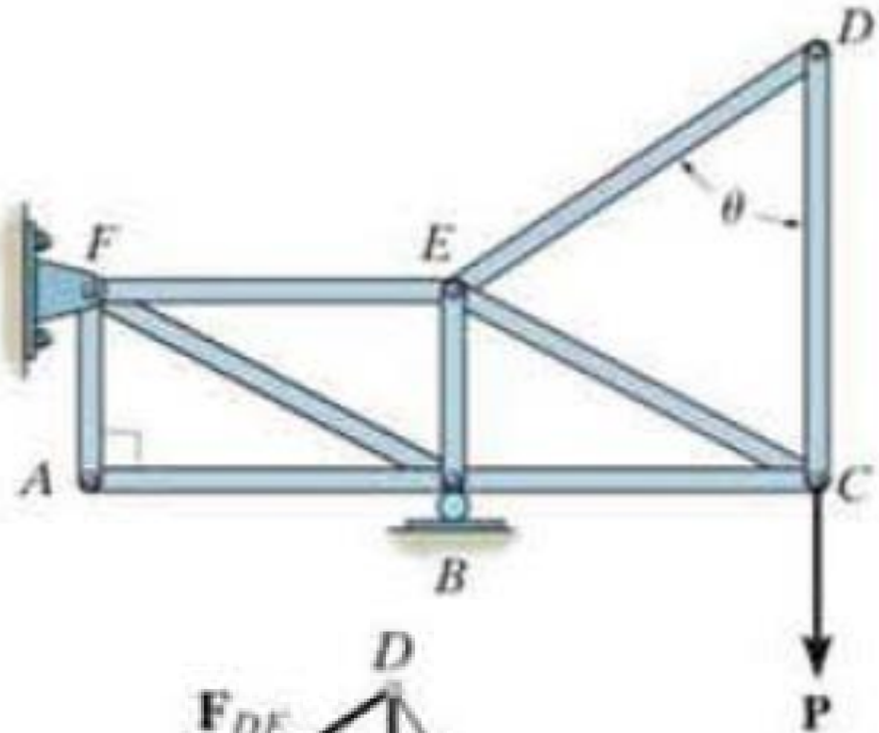

400 N
200 N
600 N
Compression
600 N
600 N
B
C
750 N
250 N
200 N
Compression
Tension
Compression
750 N
250 N
200 N
Tension
A
450 N
450 N
D
600 N
600 N

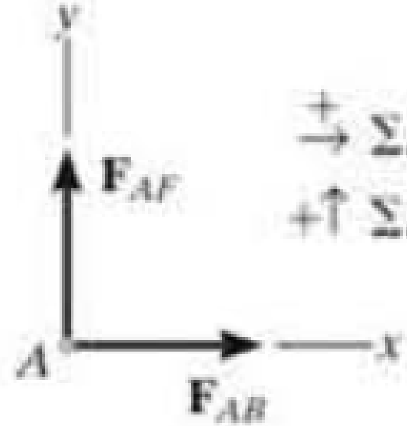
Zero-Force Members

- The members which support no loading are zero-force members
- These members are added to increase stability and to provide added support

How to Identify:

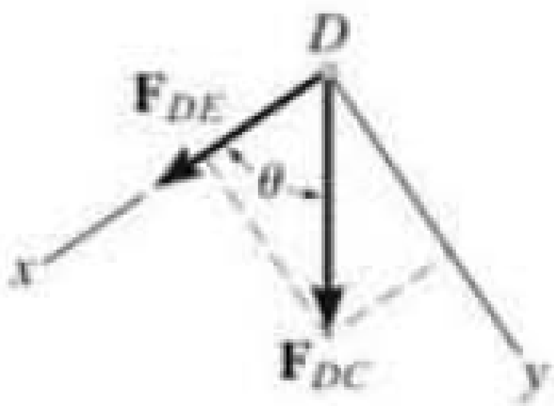
If only two members form a truss joint and no external load or support reaction is applied to the joint, the members must be zero-force members.

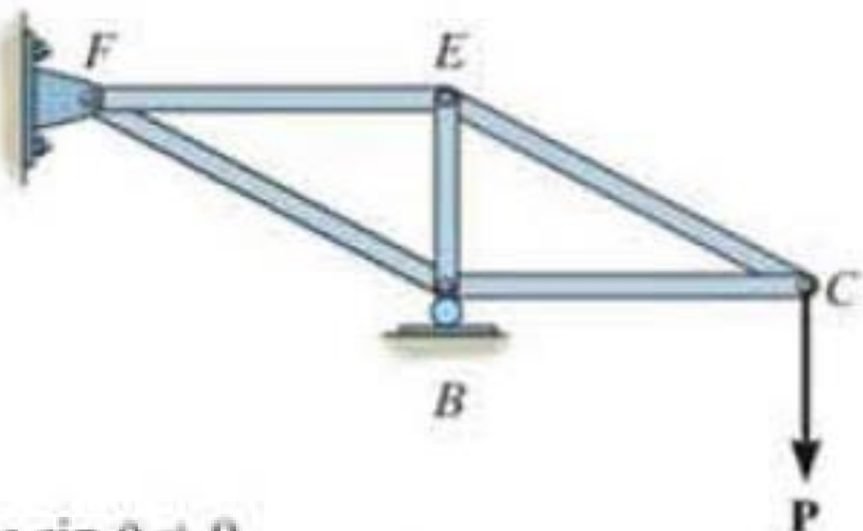




$\overset{+}{\rightarrow} \Sigma F_x = 0;\ F_{AB} = 0$

$+\uparrow \Sigma F_y = 0;\ F_{AF} = 0$

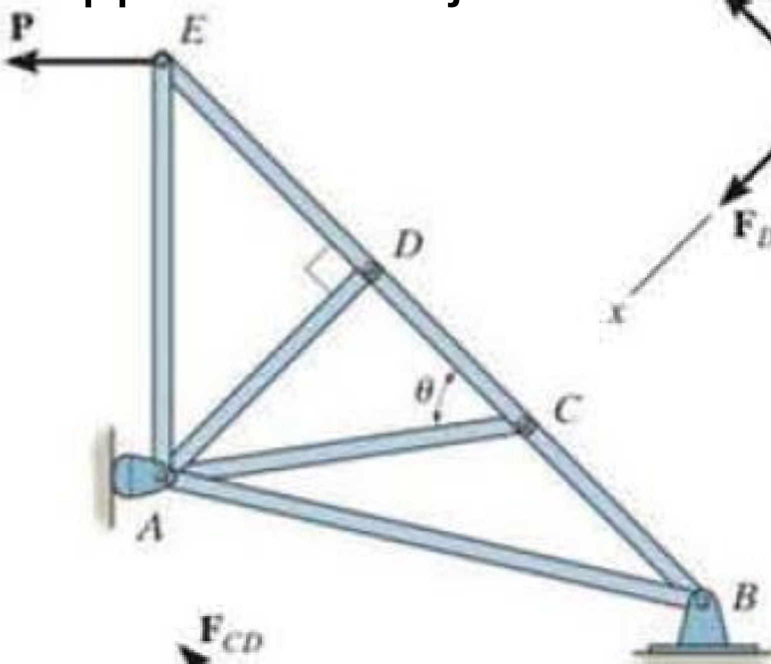


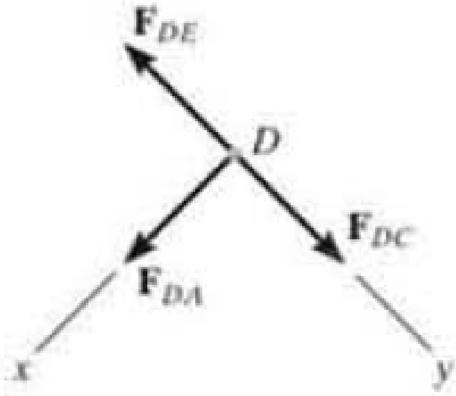


$+\searrow \Sigma F_y = 0;\ F_{DC} \sin\theta = 0;\quad F_{DC} = 0 \text{ since } \sin\theta \neq 0$

$+\swarrow \Sigma F_x = 0;\ F_{DE} + 0 = 0;\quad F_{DE} = 0$

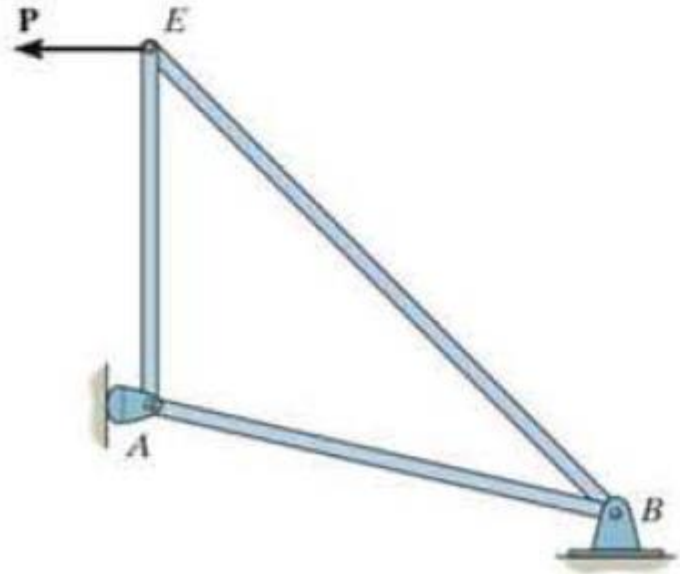
If three members form a truss joint for which two of the members are collinear, the third member is a zero-force member provided no external force or support reaction is applied to the joint.

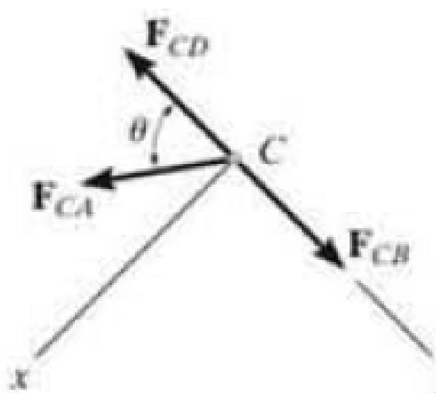




$$+\swarrow \Sigma F_x = 0; \quad F_{DA} = 0$$

$$+\searrow \Sigma F_y = 0; \quad F_{DC} = F_{DE}$$



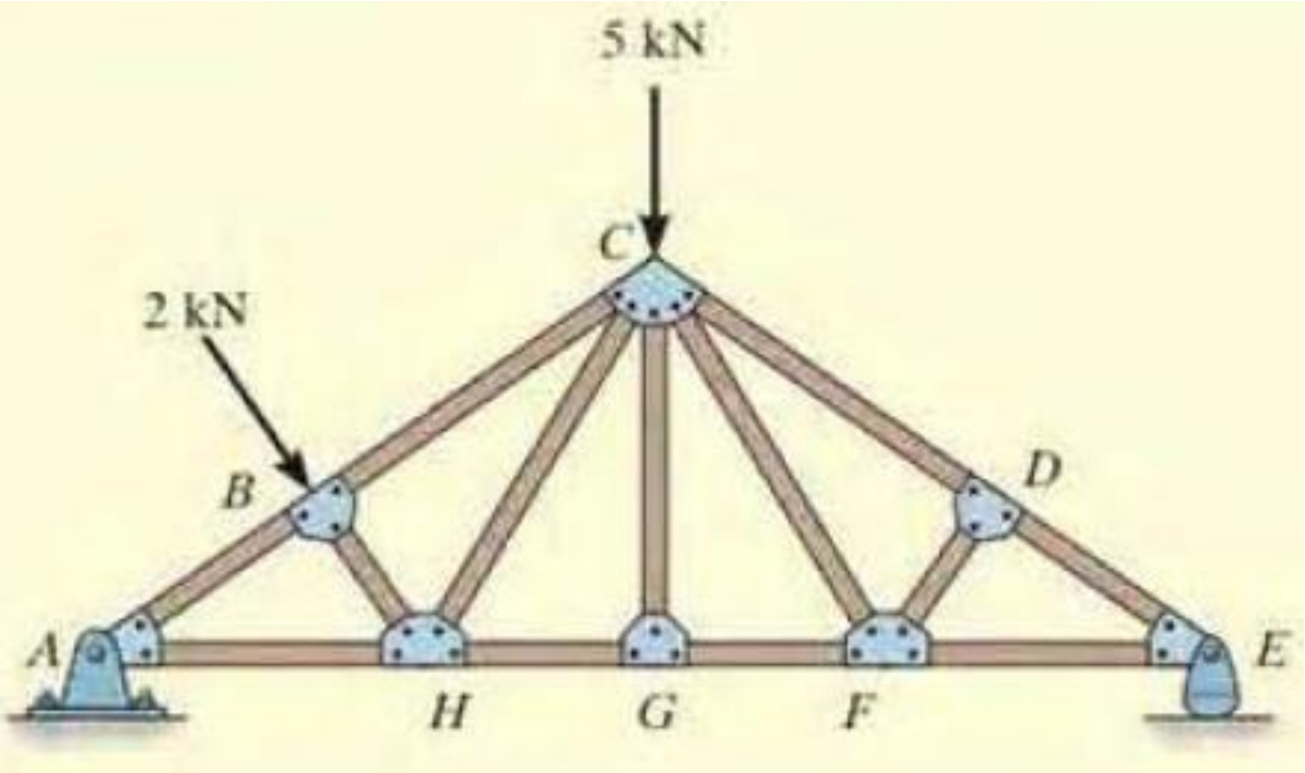


$$+\swarrow \Sigma F_x = 0; \quad F_{CA} \sin\theta = 0; \quad F_{CA} = 0 \text{ since } \sin\theta \neq 0;$$

$$+\searrow \Sigma F_y = 0; \quad F_{CB} = F_{CD}$$

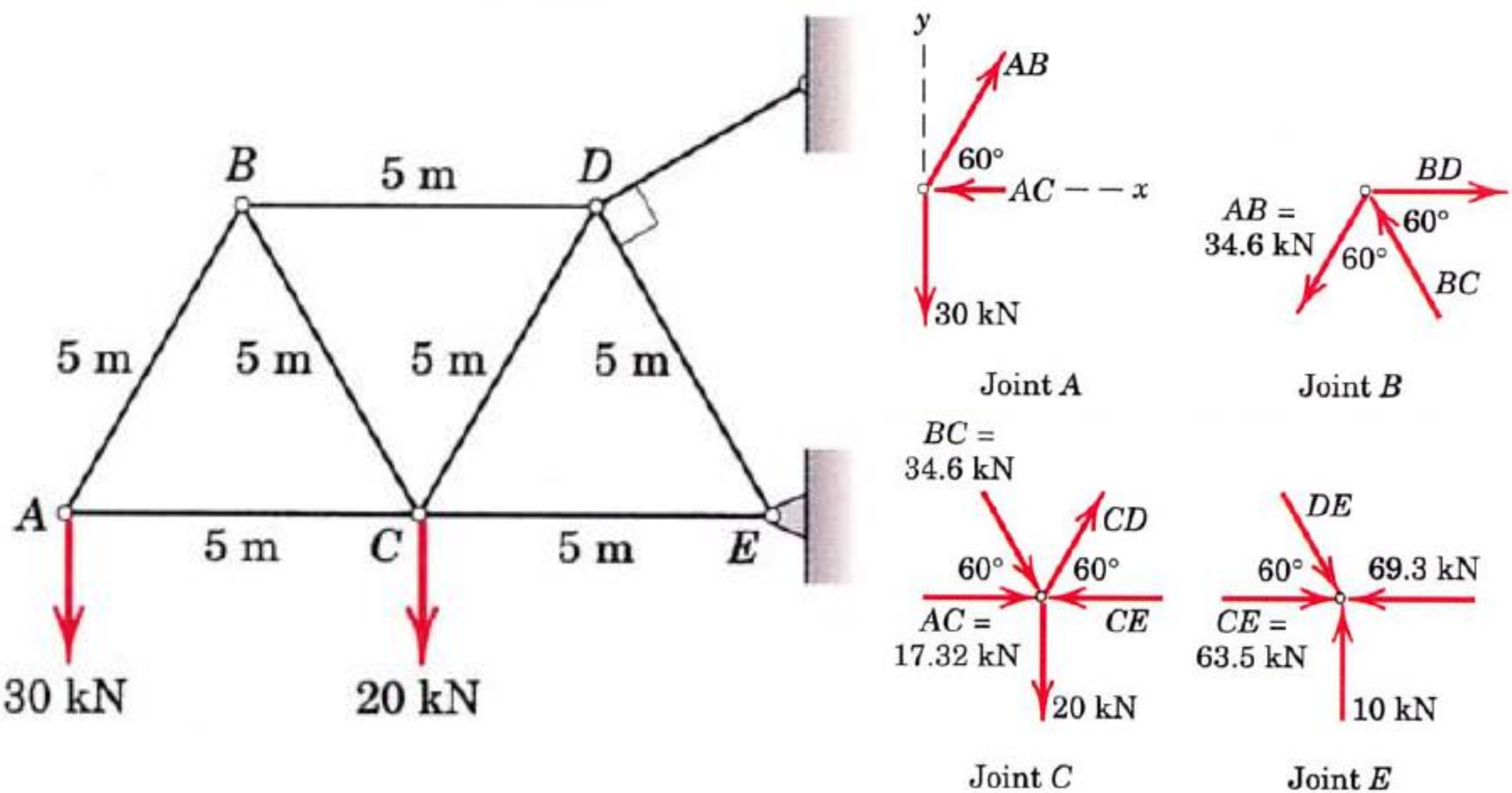
Problem 4

Using the method of joints, determine all the zero-force members of the Fink roof truss shown in figure assume all the joints are pin connected.



Problem 5

Using the method of joints, compute the force in each member of the loaded cantilever truss.



Problem 5
ANSWER

$$T = 80 \text{ kN}$$
$$E_x = 69.3 \text{ kN}$$
$$E_y = 10 \text{ kN}$$

$$BC = 34.6 \text{ kN } C$$
$$BD = 34.6 \text{ kN } T$$

$$CD = 57.7 \text{ kN } T$$

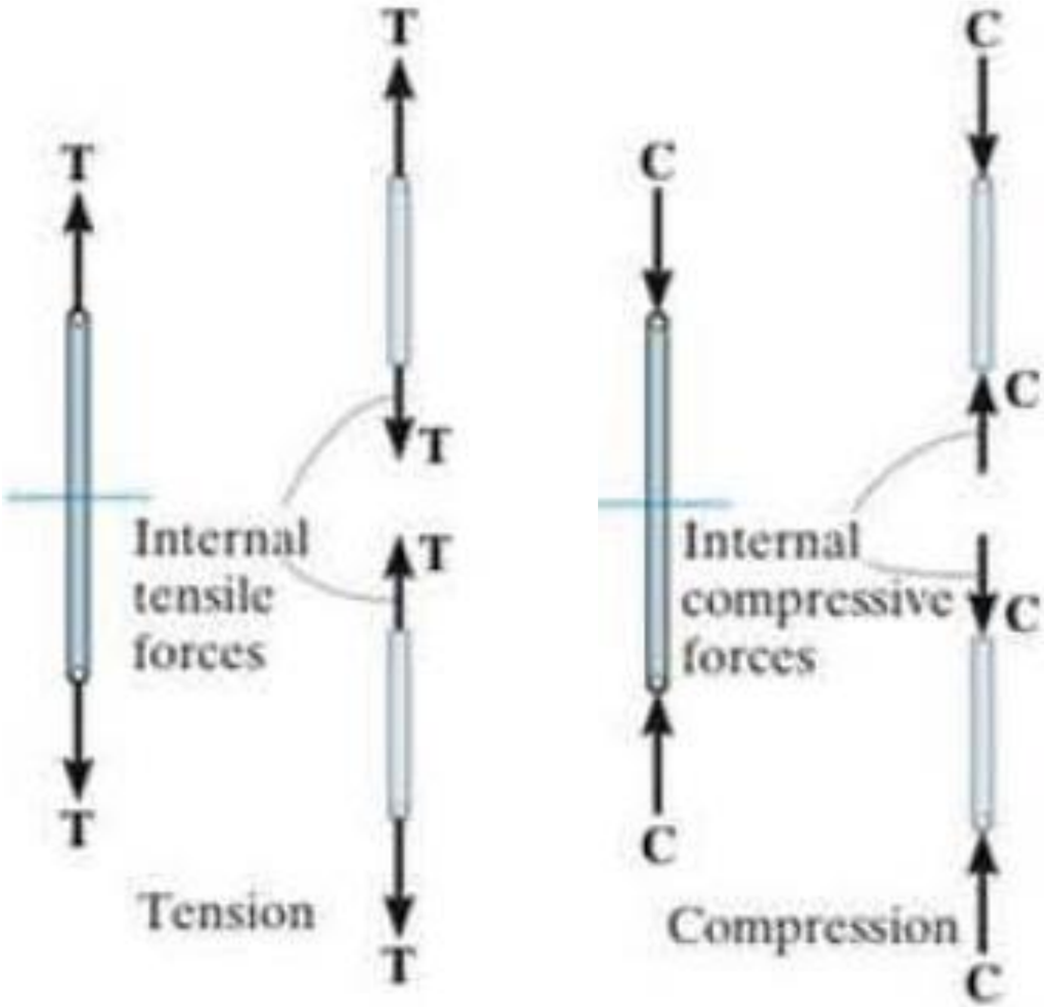
$$AB = 34.6 \text{ kN } T$$
$$AC = 17.32 \text{ kN } C$$

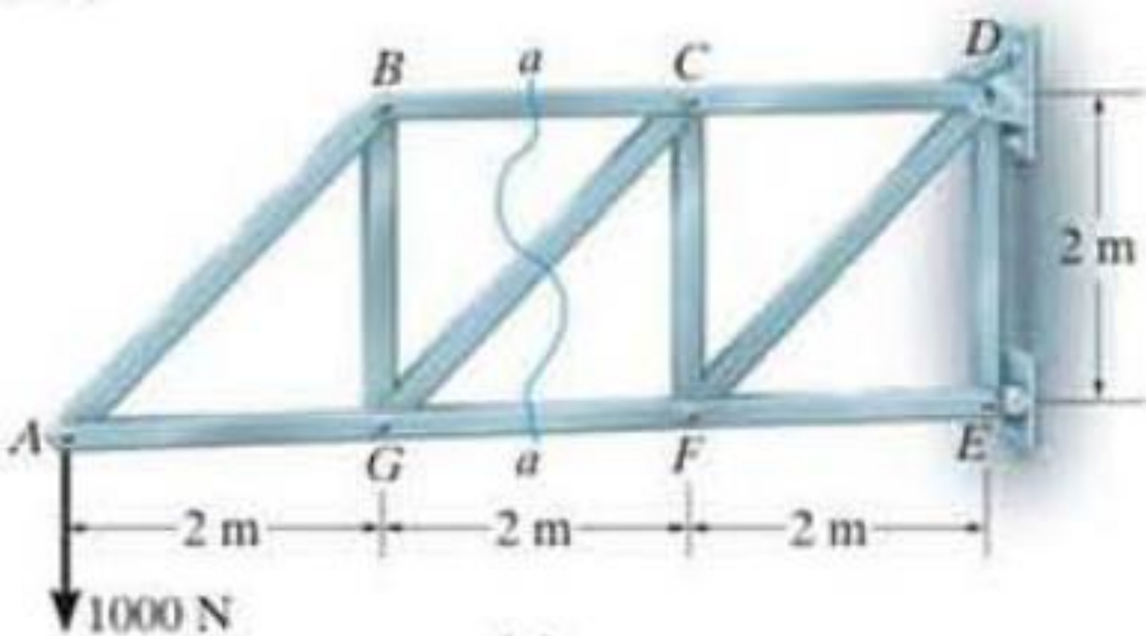
$$CE = 63.5 \text{ kN } C$$

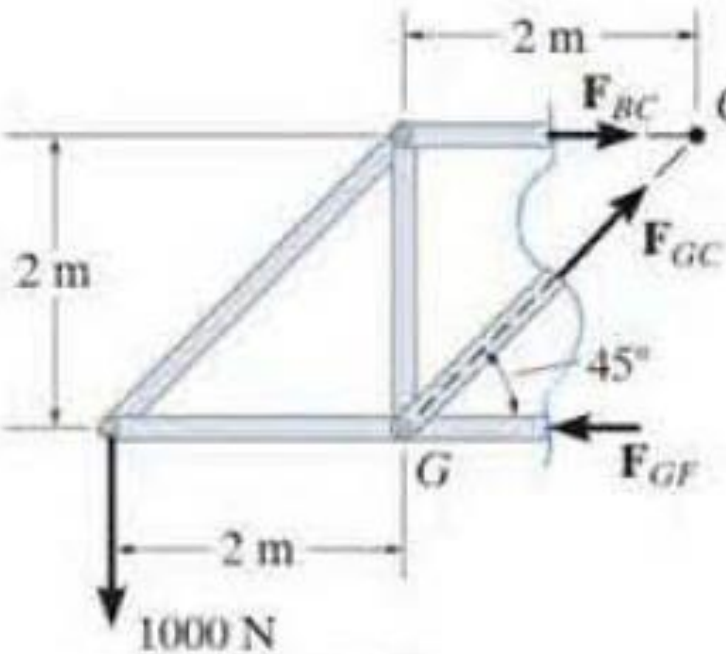
$$DE = 11.55 \text{ kN } C$$

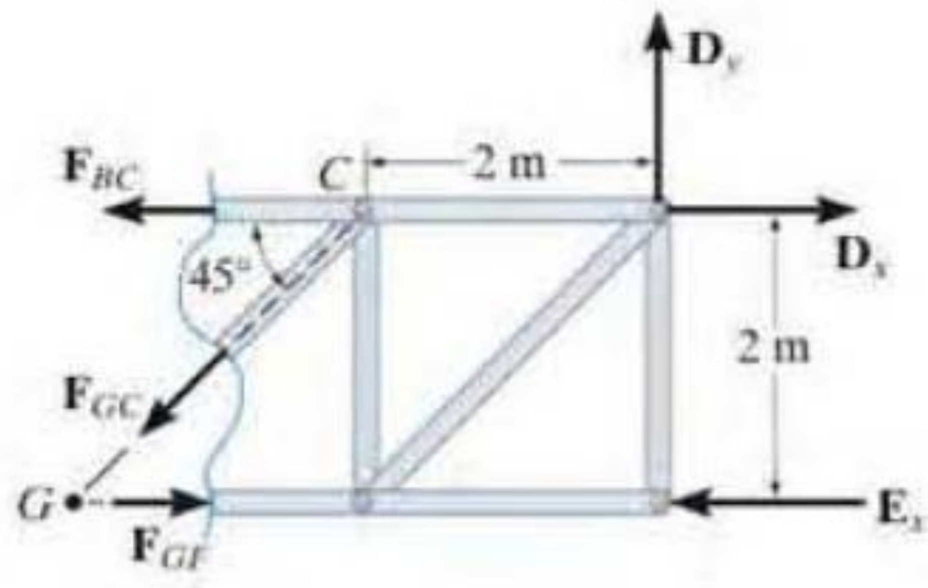
Method of Sections

- This method is used to find force in only a few members of a truss




B
a
C
D
2 m
A
G
a
F
E
2 m
2 m
2 m
1000 N

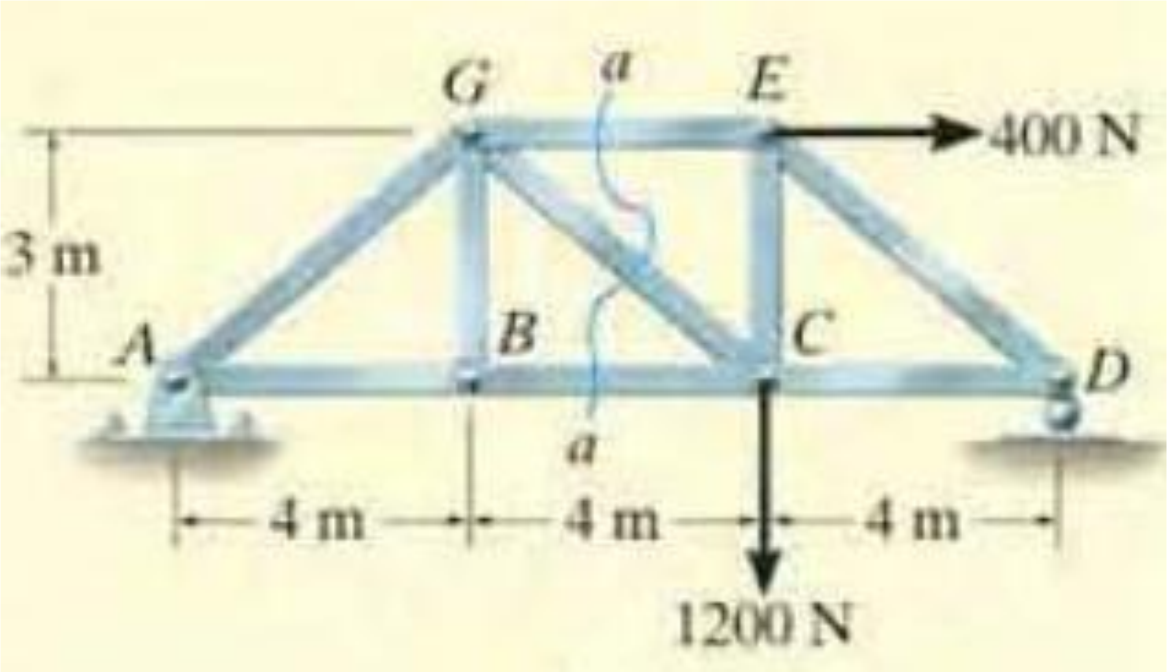

2 m
F_{BC}
C
F_{GC}
2 m
45°
G
F_{GF}
2 m
1000 N


D_y
F_{BC}
C
2 m
D_x
45°
2 m
F_{GC}
G
F_{GF}
E_x

(c)

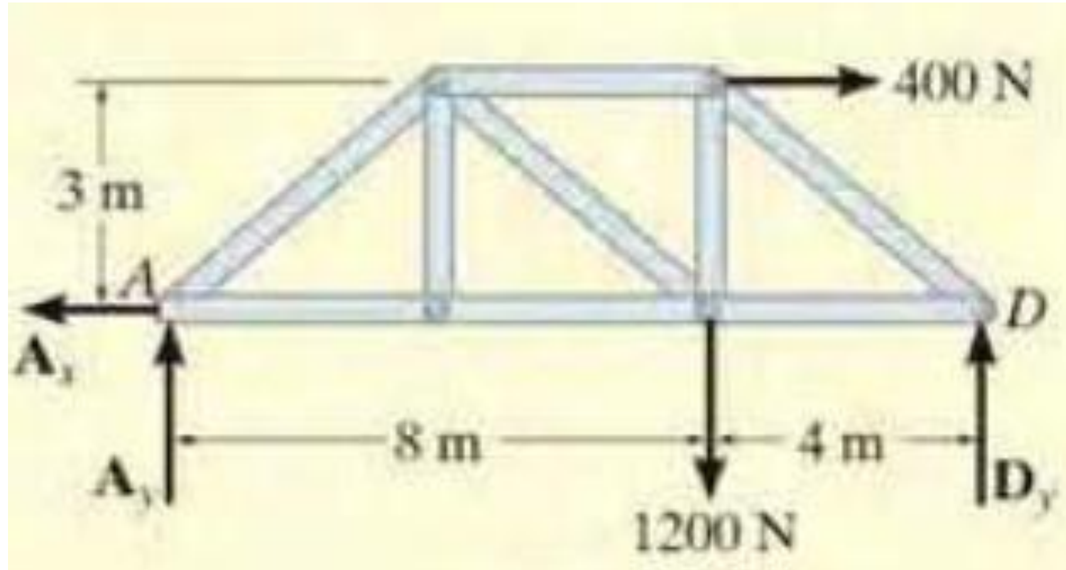
Problem 6

Determine the force in members *GE*, GC and *BC* of the truss shown in Figure and indicate whether the members arc in tension or compression.



Solution

FBD



Applying equations of equilibrium,

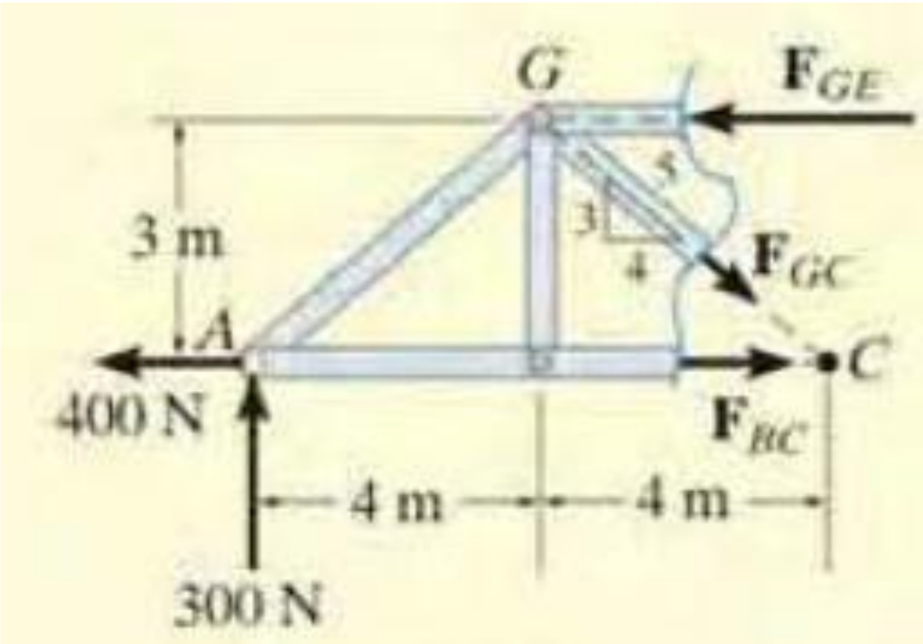
$$\stackrel{+}{\rightarrow} \Sigma F_x = 0; \qquad 400\text{ N} - A_x = 0 \qquad A_x = 400\text{ N}$$

$$\circlearrowleft + \Sigma M_A = 0; \qquad -1200\text{ N}(8\text{ m}) - 400\text{ N}(3\text{ m}) + D_y(12\text{ m}) = 0$$

$$D_y = 900\text{ N}$$

$$+\uparrow \Sigma F_y = 0; \qquad A_y - 1200\text{ N} + 900\text{ N} = 0 \qquad A_y = 300\text{ N}$$

FBD of left portion of the sectioned truss is considered as this portion involves the least number of forces



Applying equations of equilibrium,

$$\circlearrowleft + \Sigma M_G = 0; \qquad -300\,\text{N}(4\,\text{m}) - 400\,\text{N}(3\,\text{m}) + F_{BC}(3\,\text{m}) = 0$$

$$F_{BC} = 800\,\text{N} \quad (\text{T}) \qquad \textit{Ans.}$$

$$\zeta + \Sigma M_C = 0; \qquad -300\text{ N}(8\text{ m}) + F_{GE}(3\text{ m}) = 0$$

$$F_{GE} = 800\text{ N} \quad (\text{C}) \qquad \textit{Ans.}$$

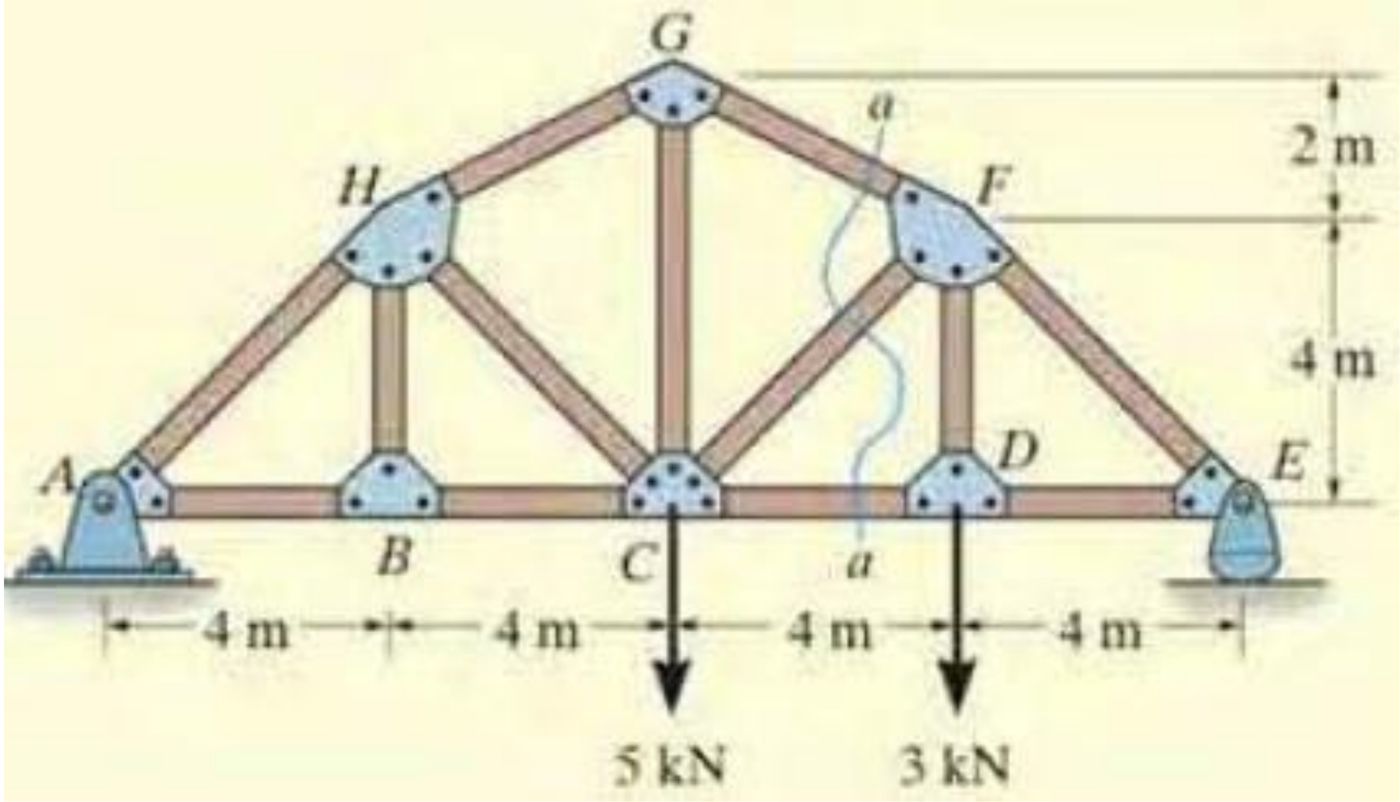
Since $\mathbf{F}_{BC}$ and $\mathbf{F}_{GE}$ have no vertical components, summing forces in the y direction directly yields F_{GC}, i.e.,

$$+\uparrow \Sigma F_y = 0; \qquad 300\text{ N} - \tfrac{3}{5}\text{F}_{GC} = 0$$

$$F_{GC} = 500\text{ N} \quad (\text{T}) \qquad \textit{Ans.}$$

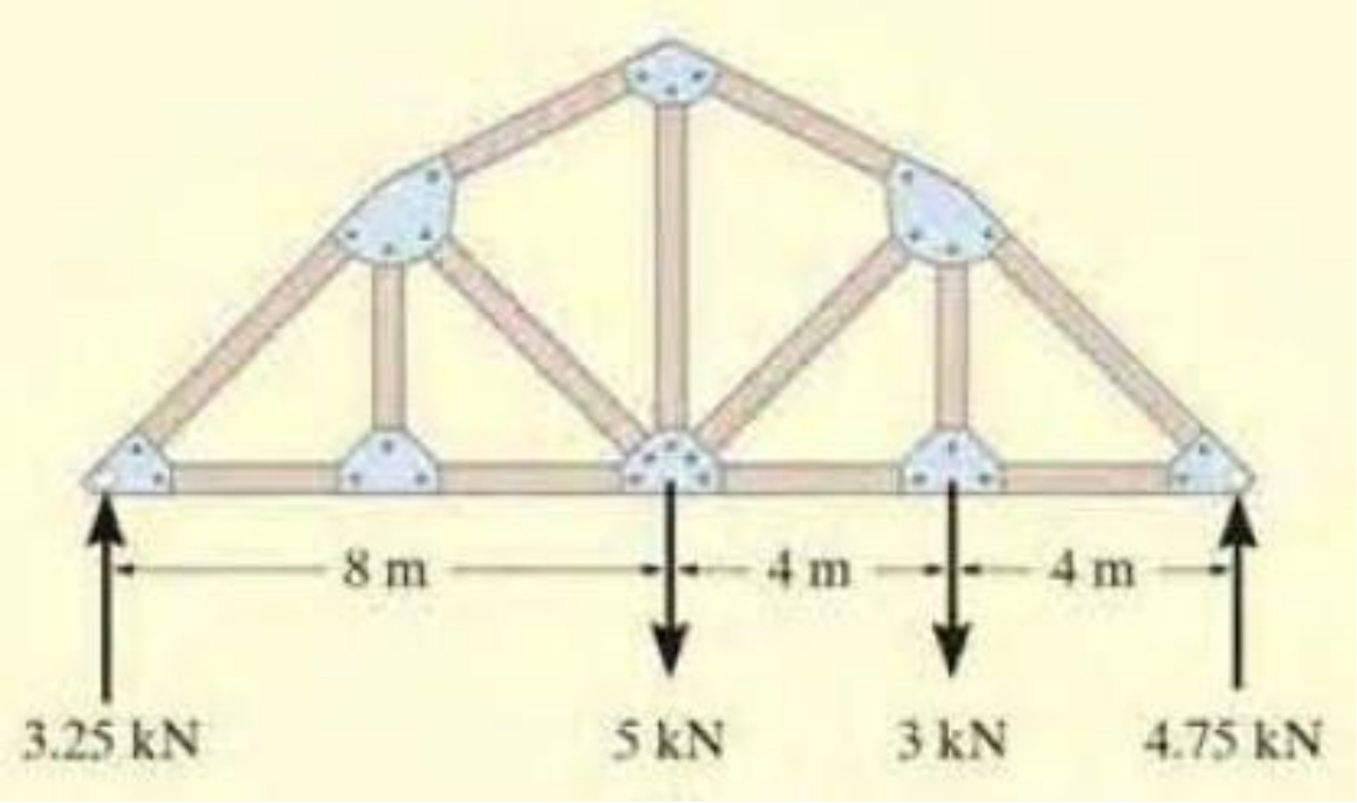
Problem 7

Determine the force in member *CF* of the truss shown in Figure and Indicate whether the member is in tension or compression. Assume each member is pin connected.

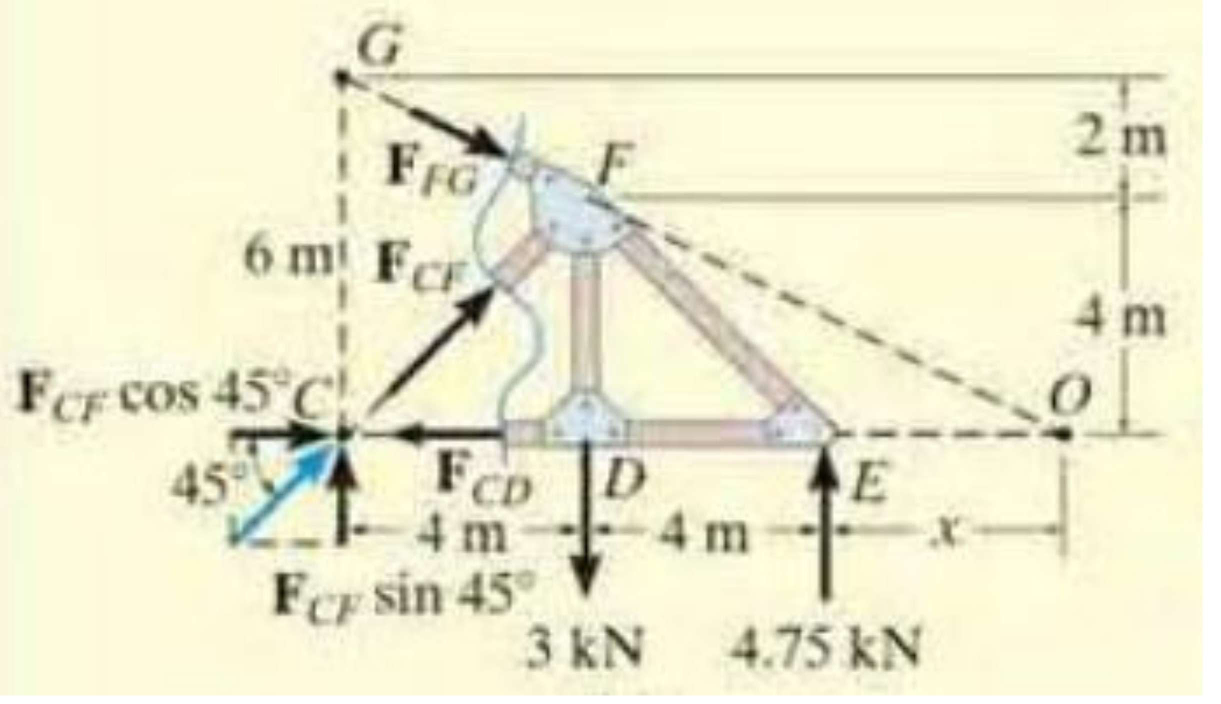


Solution

Applying equations of equilibrium find out reactions,



Solution



Using similar triangles method, it is found that x = 4 m.

$$\circlearrowleft + \Sigma M_O = 0;$$

$$-F_{CF}\sin 45°(12\text{ m}) + (3\text{ kN})(8\text{ m}) - (4.75\text{ kN})(4\text{ m}) = 0$$

$$F_{CF} = 0.589\text{ kN} \quad (\text{C})$$