TD N°02:

Truss Analysis

”Analysis of Statically Determinate Trusses”

1- Determinacy (statically determinate or indeterminate)

$b + r = 2j$	statically determinate
$b + r > 2j$	statically indeterminate

Where:

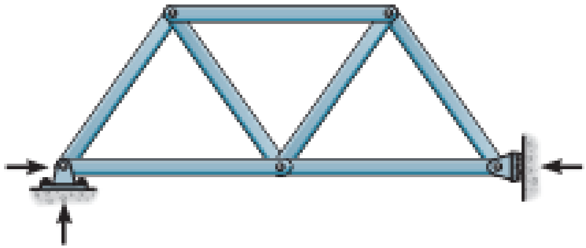
r is the number of force and moment reaction components

b is the number of bars of the truss

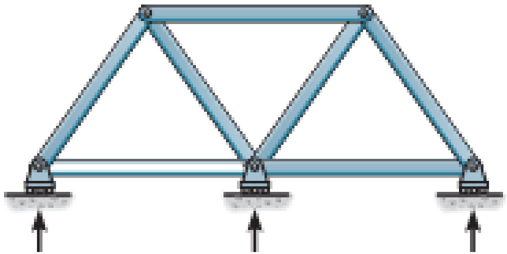
j number of joints

2. Stability (Stable or unstable):

$b + r < 2j$	unstable
$b + r \geq 2j$	unstable if truss support reactions are concurrent or parallel or if some of the components of the truss form a collapsible mechanism



unstable concurrent reactions

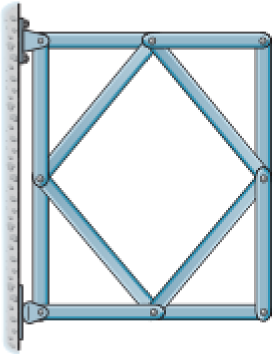


unstable parallel reactions

Example N°01:

Classify each of the trusses in Figure a & d as stable, unstable, statically determinate, or statically indeterminate


(a)


(d)

Solution:

Figure (a): stable, since the reactions are not concurrent or parallel. Since

$b = 9$, $r = 3$, $j = 11$, then $b + r = 2j$ or $22 = 22$

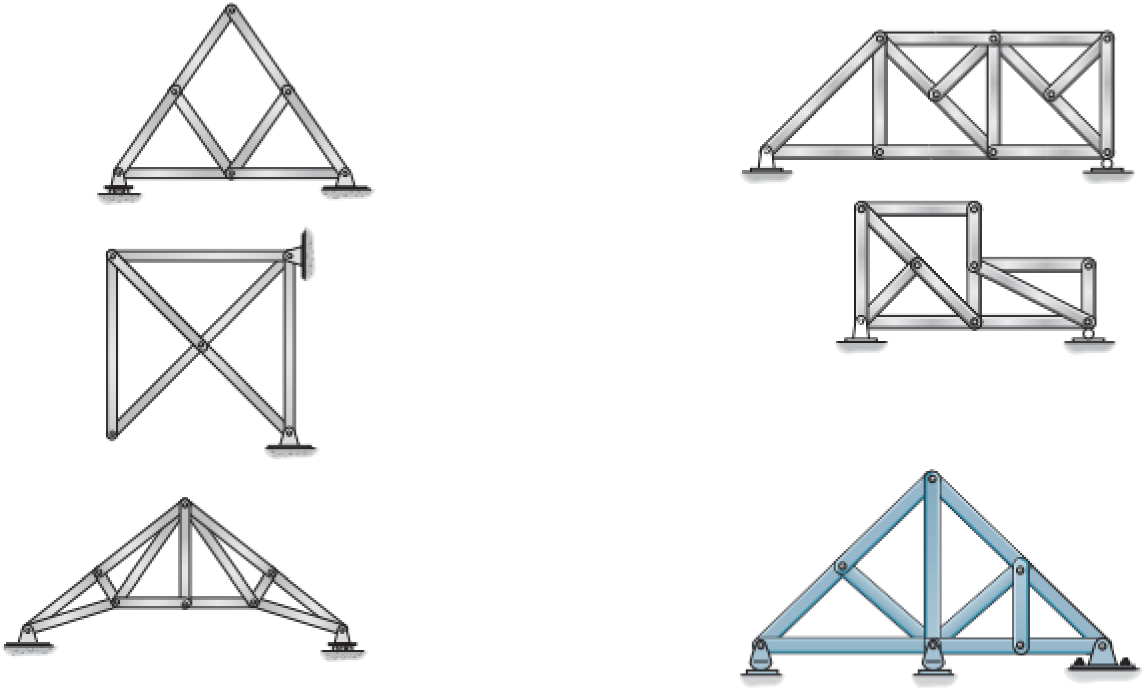
Therefore, the truss is statically determinate.

Figure (d): Since $b = 12$, $r = 3$, and $j = 8$ then $b + r < 2j$ or $15 < 16$

The truss is unstable.

<u>Exercise</u>:

Classify each of the trusses in bellow Figures as stable, unstable, statically determinate, or statically indeterminate



To find the forces in each member of a ***simple truss***, we have two methods:

1. Method of Joints

2. Method of Sections

We will study just one method which is:

1. Method of Joints

If a truss is in equilibrium, then each of its joints must also be in equilibrium. This method is done by selecting each joint in sequence, having at most one known force and at least two unknowns. The free-body diagram of each joint is constructed and two force equations of equilibrium, $\sum F_x = 0$ and $\sum F_y = 0$, when applying these equations, the correct sense of an unknown member force can be determined using one of two possible methods:

1. Always assume the unknown member forces acting on the joint's free-body diagram to be in tension,i.e.,"pulling"on the pin. If this is done, then

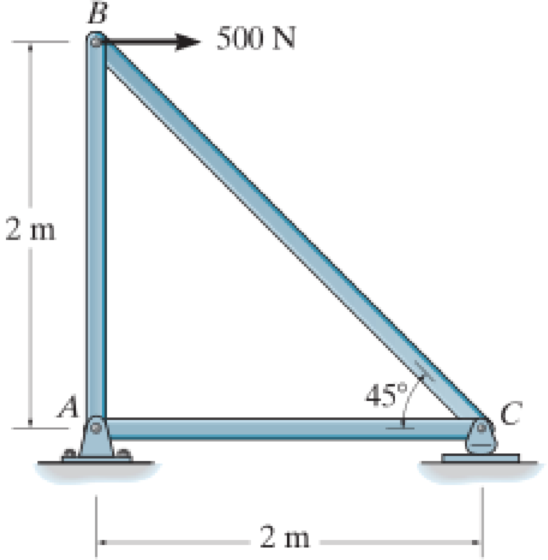
numerical solution of the equilibrium equations will yield positive scalars for members in tension and negative scalars for members in compression. Once an unknown member force is found, use its correct magnitude and sense (T or C) on subsequent joint free-body diagrams.

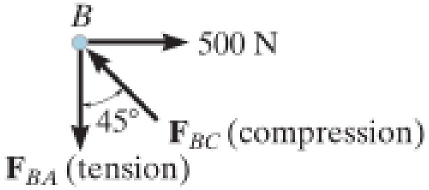
2. The correct sense of direction of an unknown member force can, in many cases, be determined "by inspection".

For example, in Figure below must push on the pin (compression) since its horizontal component, sin 45°, must balance the 500-N force.

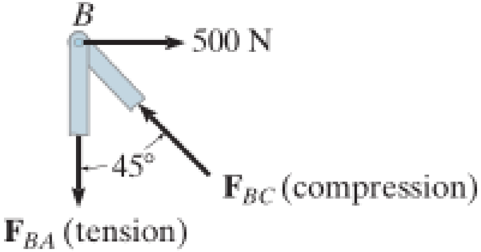
Likewise, is a tensile force since it balances the vertical component, cos 45°

In more complicated cases, the sense of an unknown member force can be assumed; then, after applying the equilibrium equations, the assumed sense can be verified from the numerical results. A positive answer indicates that the sense is correct, whereas a negative answer indicates that the sense shown on the free-body diagram must be reversed.


B
500 N
2 m
A
45°
C
2 m

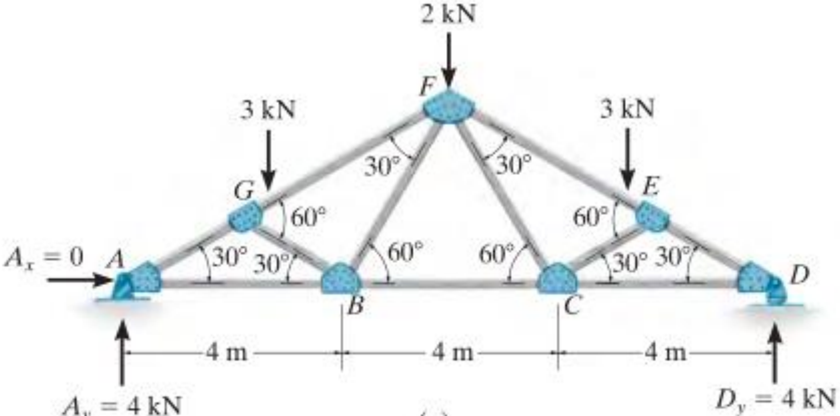

B
500 N
45°
F_{BC} (compression)
F_{BA} (tension)

(b)


B
500 N
45°
F_{BC} (compression)
F_{BA} (tension)

Example N°01:

Determine the force in each member of the roof truss shown in the photo. The dimensions and loadings are shown in Figure a. State whether the members are in tension or compression.



(a)

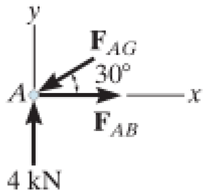
Solution:

Only the forces in half the members have to be determined, since the truss is symmetric with respect to both loading and geometry.

Joint A:

$$+\uparrow \Sigma F_y = 0; \quad 4 - F_{AG} \sin 30^\circ = 0 \qquad F_{AG} = 8 \text{ kN (C)}$$

$$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AB} - 8 \cos 30^\circ = 0 \qquad F_{AB} = 6.928 \text{ kN (T)}$$



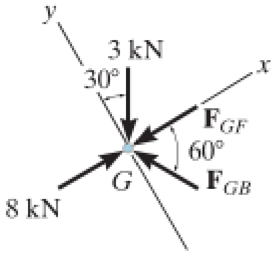
Joint G:

$$+\nwarrow \Sigma F_y = 0; \quad F_{GB} \sin 60^\circ - 3 \cos 30^\circ = 0$$

$$F_{GB} = 3.00 \text{ kN (C)}$$

$$+\nearrow \Sigma F_x = 0; \quad 8 - 3 \sin 30^\circ - 3.00 \cos 60^\circ - F_{GF} = 0$$

$$F_{GF} = 5.00 \text{ kN (C)}$$



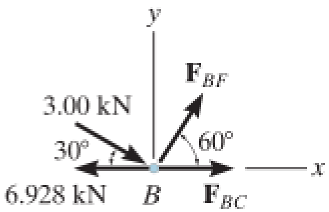
Joint B:

$$+\uparrow \Sigma F_y = 0; \quad F_{BF} \sin 60^\circ - 3.00 \sin 30^\circ = 0$$

$$F_{BF} = 1.73 \text{ kN (T)}$$

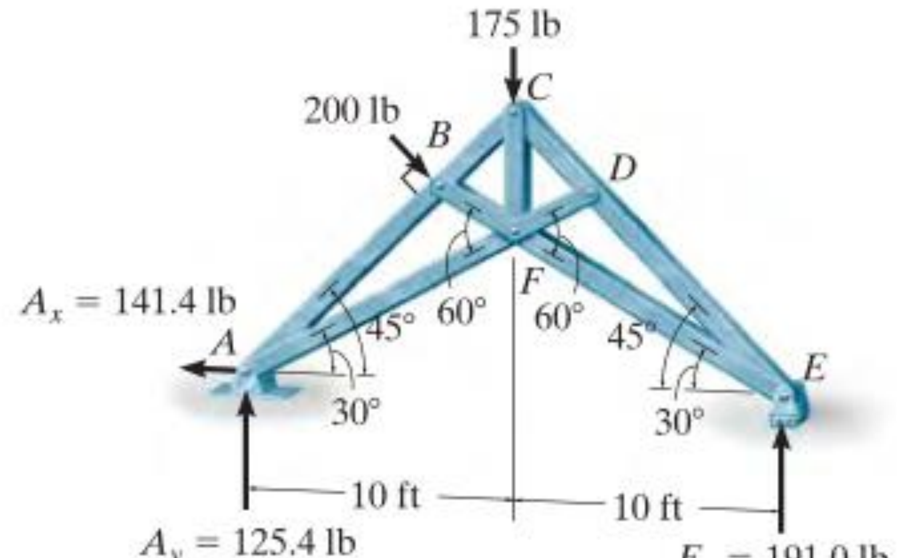
$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_{BC} + 1.73 \cos 60^\circ + 3.00 \cos 30^\circ - 6.928 = 0$$

$$F_{BC} = 3.46 \text{ kN (T)}$$



Example N°02:

Determine the force in each member of the truss shown in Figure a. State whether the members are in tension or compression. The reactions at the supports are given.



(a)

Solution:

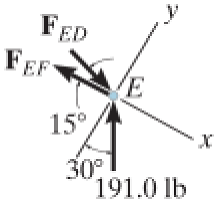
Joint E:

$$+\nearrow \Sigma F_y = 0; \qquad 191.0 \cos 30° - F_{ED} \sin 15° = 0$$

$$F_{ED} = 639.1 \text{ lb (C)}$$

$$+\searrow \Sigma F_x = 0; \qquad 639.1 \cos 15° - F_{EF} - 191.0 \sin 30° = 0$$

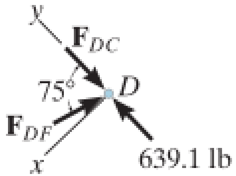
$$F_{EF} = 521.8 \text{ lb (T)}$$



Joint D:

$$+\swarrow \Sigma F_x = 0; \qquad -F_{DF} \sin 75° = 0 \qquad F_{DF} = 0$$

$$+\nwarrow \Sigma F_y = 0; \qquad -F_{DC} + 639.1 = 0 \qquad F_{DC} = 639.1 \text{ lb (C)}$$



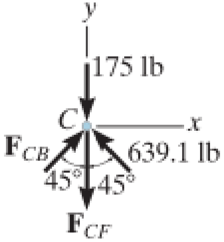
Joint C:

$$\xrightarrow{+} \Sigma F_x = 0; \qquad F_{CB} \sin 45° - 639.1 \sin 45° = 0$$

$$F_{CB} = 639.1 \text{ lb (C)}$$

$$+\uparrow \Sigma F_y = 0; \qquad -F_{CF} - 175 + 2(639.1) \cos 45° = 0$$

$$F_{CF} = 728.8 \text{ lb (T)}$$

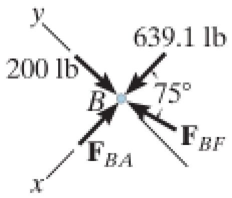


Joint B:

$+\nwarrow \Sigma F_y = 0; \quad F_{BF} \sin 75° - 200 = 0 \quad F_{BF} = 207.1 \text{ lb (C)}$

$+\swarrow \Sigma F_x = 0; \quad 639.1 + 207.1 \cos 75° - F_{BA} = 0$

$$F_{BA} = 692.7 \text{ lb (C)}$$

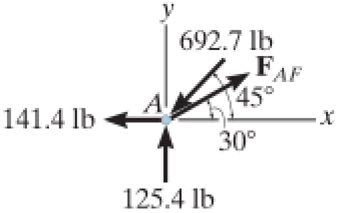


Joint A:

$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad F_{AF} \cos 30° - 692.7 \cos 45° - 141.4 = 0$

$$F_{AF} = 728.9 \text{ lb (T)}$$

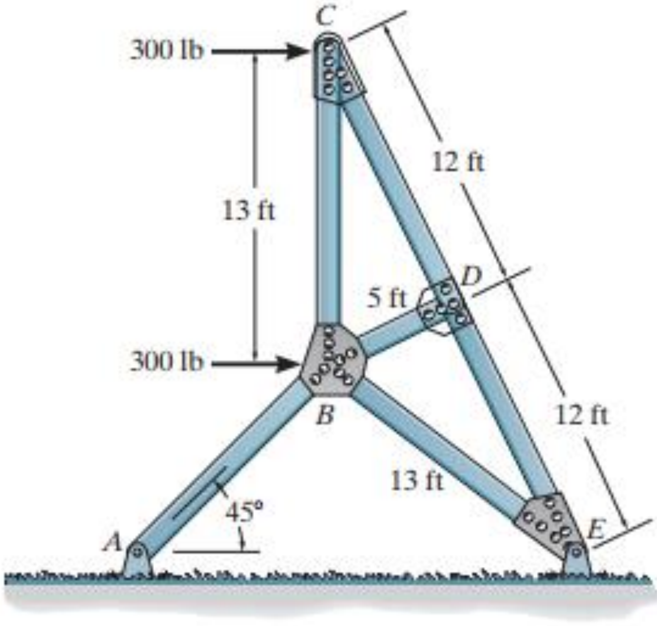
$+\uparrow \Sigma F_y = 0; \quad 125.4 - 692.7 \sin 45° + 728.9 \sin 30° = 0$



Notice that since the reactions have been calculated, a further check of the calculations can be made by analyzing the last joint F. Try it and find out.

Example N°03:

A sign is subjected to a wind loading that exerts horizontal forces of 300 lb on joints B and C of one of the side supporting trusses. Determine the force in each member of the truss and state if the members are in tension or compression.



Solution:

$$F_{CD} = 780 \text{ lb (C)}$$
$$F_{CB} = 720 \text{ lb (T)}$$
$$F_{DB} = 0$$
$$F_{DE} = 780 \text{ lb (C)}$$
$$F_{BE} = 297 \text{ lb (T)}$$
$$F_{BA} = 722 \text{ lb (T)}$$

References

1. Hibbeler, R C. 2012. Structural Analysis. Eighth Edition, Pearson Prentice Hall, New Jersey.