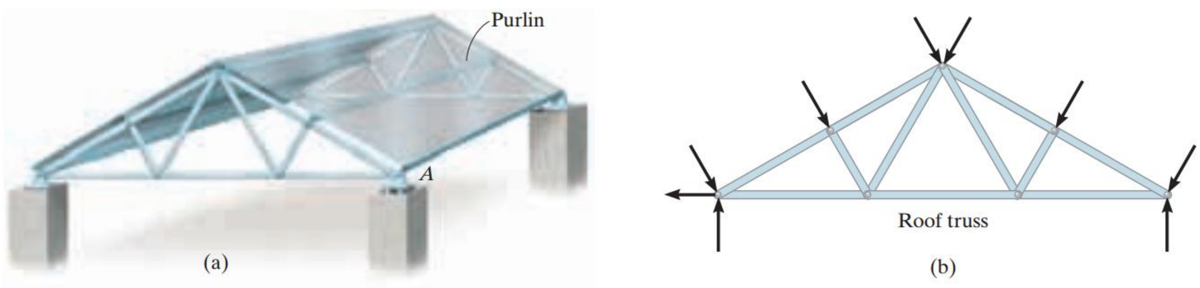
4. Chapter four: Structural Analysis

A ***truss*** is a structure composed of slender members joined together at their end points. The members commonly used in construction consist of wooden struts or metal bars.



Simple trusses are composed of **triangular** elements. The members are assumed to be **pin connected** at their ends and loads applied at the joints.

Assumptions for Design

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

4.1. Analysis of trusses:

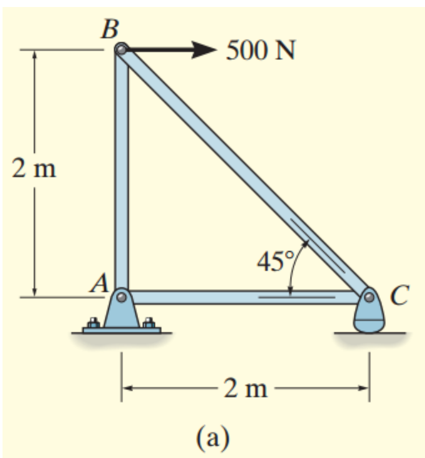
In order to analyze or design a truss, it is necessary to determine the force in each of its members. There are two main methods:

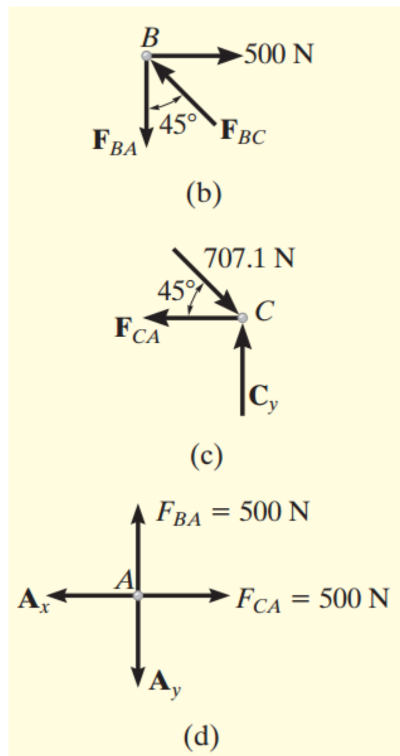
1. Method of joints.
2. Method of sections.

4.1.1. The 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. Therefore, 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.

Example: Determine the force in each member of the truss shown in Fig. *a* and indicate whether the members are in tension or compression.





Solution:

Since we should have no more than two unknown forces at the joint and at least one known force acting there, we will begin our analysis at joint B.

Joint B. The free-body diagram of the joint at B is shown in Fig. b. applying the equations of equilibrium, we have:

$$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad 500\text{ N} - F_{BC}\sin 45^\circ = 0 \qquad F_{BC} = 707.1\text{ N (C)} \qquad \textit{Ans.}$$

$$+\uparrow\Sigma F_y = 0; \qquad F_{BC}\cos 45^\circ - F_{BA} = 0 \qquad F_{BA} = 500\text{ N (T)} \qquad \textit{Ans.}$$

Since the force in member BC has been calculated, we can proceed to analyze joint C to determine the force in member CA and the support reaction at the rocker.

Joint C. From the free-body diagram of joint C, Fig. c, we have:

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad -F_{CA} + 707.1 \cos 45^\circ \text{ N} = 0 \quad F_{CA} = 500 \text{ N (T)} \qquad \textit{Ans.}$$

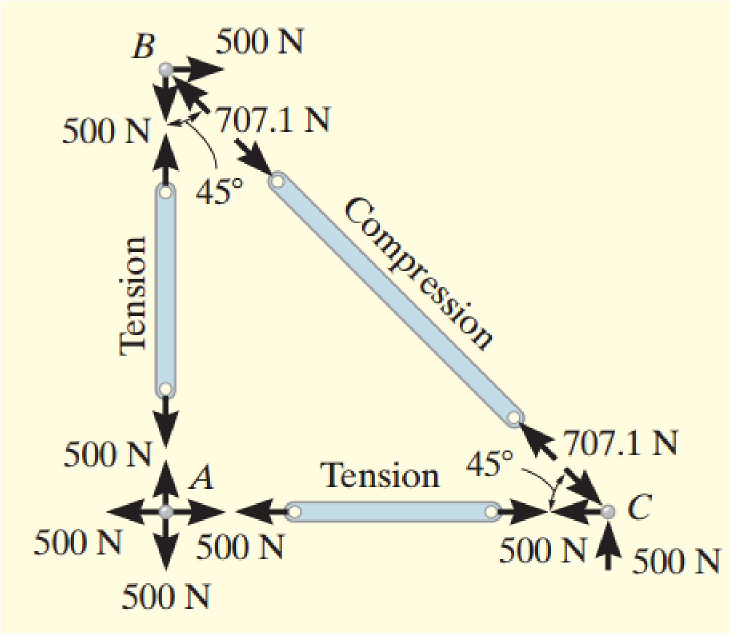
$$+\uparrow \Sigma F_y = 0; \quad C_y - 707.1 \sin 45^\circ \text{ N} = 0 \quad C_y = 500 \text{ N} \qquad \textit{Ans.}$$

Joint A. Although it is not necessary, we can determine the components of the support reactions at joint A using the results of F_{CA} and F_{BA}. From the free-body diagram, Fig. d, we have:

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad 500 \text{ N} - A_x = 0 \quad A_x = 500 \text{ N}$$

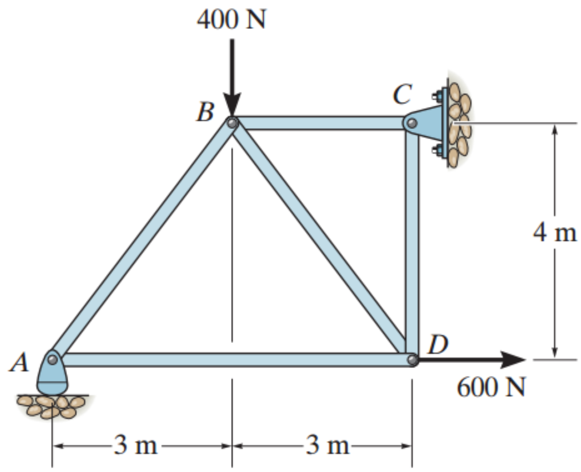
$$+\uparrow \Sigma F_y = 0; \quad 500 \text{ N} - A_y = 0 \quad A_y = 500 \text{ N}$$

The results of the analysis are summarized in Fig. e below:



(e)

HW: Determine the force in each member of the truss shown in Fig. below. Indicate whether the members are in tension or compression.

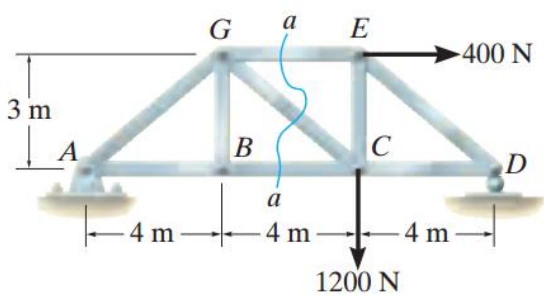


(a)

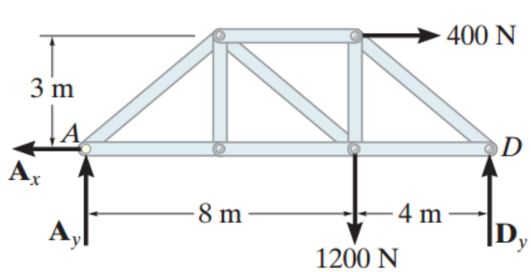
4.1.2. **The Method of Sections**

When we need to find the force in only a few members of a truss, we can analyze the truss using ***the method of sections***. It is based on the principle that if the truss is in equilibrium then any segment of the truss is also in equilibrium.

Example: Determine the force in members GE, GC, and BC of the truss shown in Fig. a. Indicate whether the members are in tension or compression.



(a)



(b)

Solution:

Section a a in Fig. a has been chosen since it cuts through the three members whose forces are to be determined. In order to use the method of sections, however, it is first necessary to determine the external reactions at A or D. Why? A free-body diagram of the entire truss is shown in Fig. b. applying the equations of equilibrium, we have:

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

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

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

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