CHAPTER 4

STRUCTURES

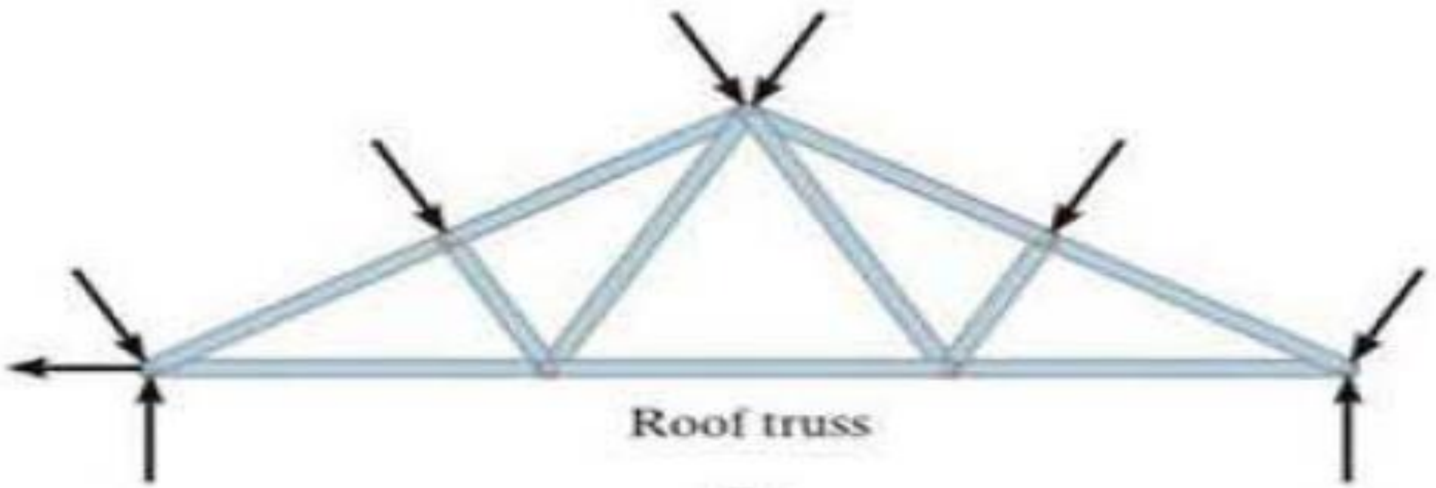
Introduction

- In this chapter, we shall analyze the *internal forces* acting in several types of structures, namely, *trusses*, *frames*, and *machines*.

Trusses

- A *truss* is a structure composed of *slender members* that are connected at their ends by *joints*. The *truss* is one of the most *important* structures in *engineering applications*.

(a)



(b)

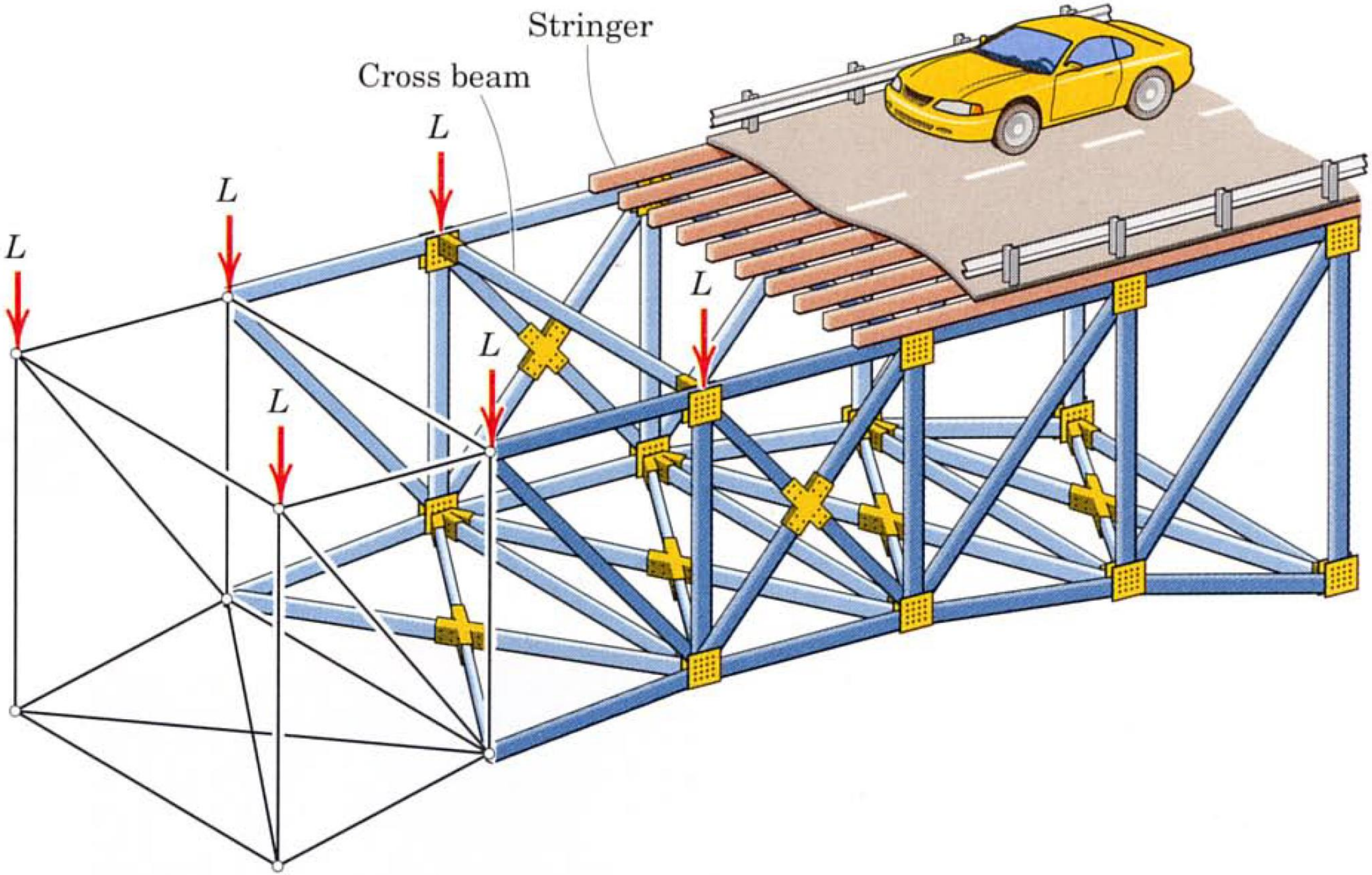
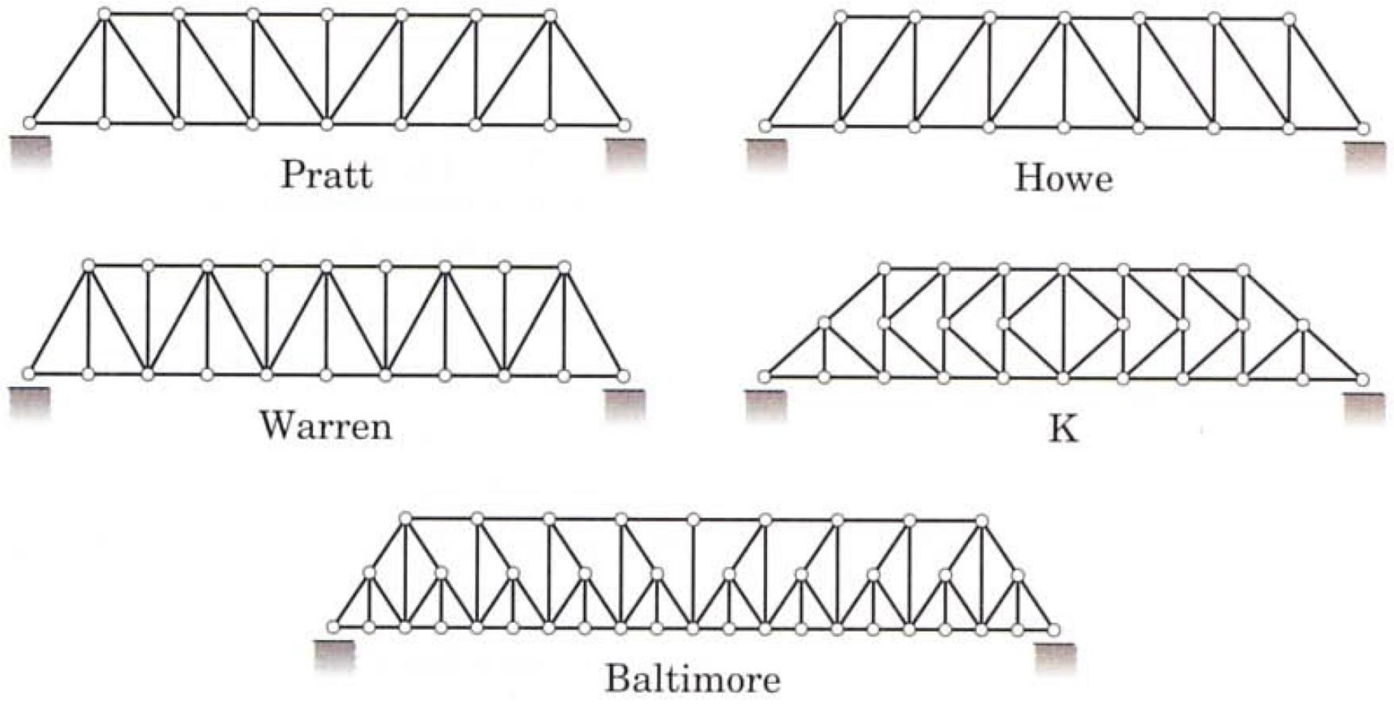
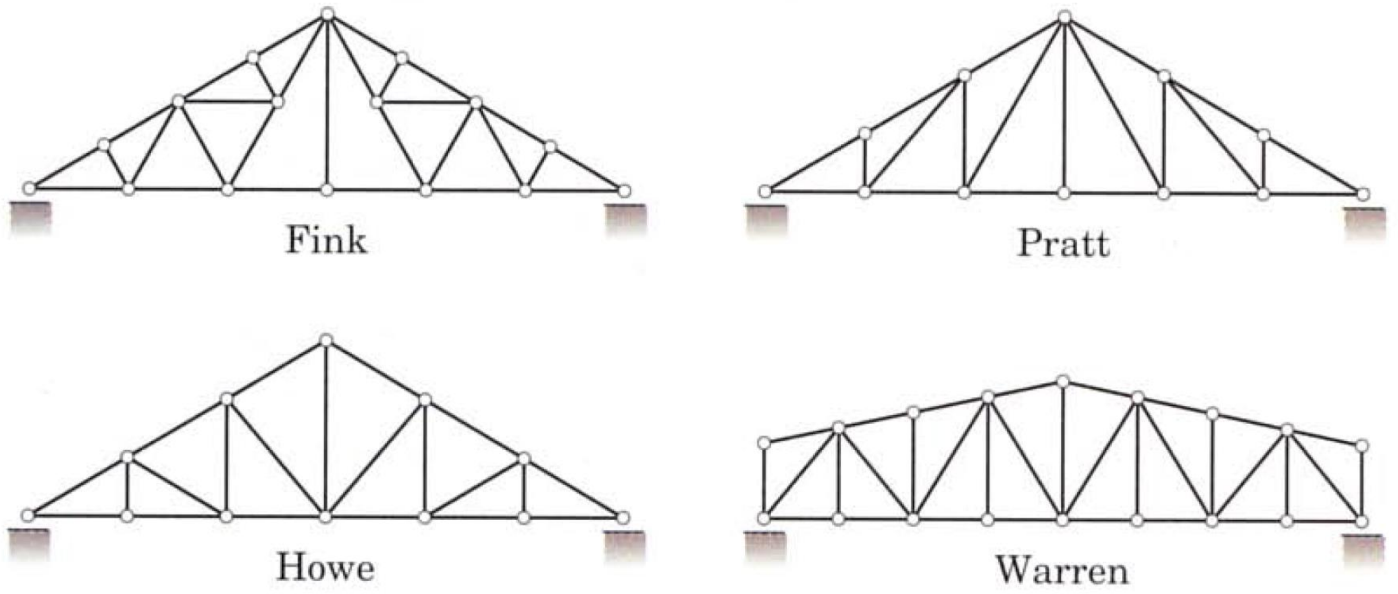


Figure 4/1



Commonly Used Bridge Trusses

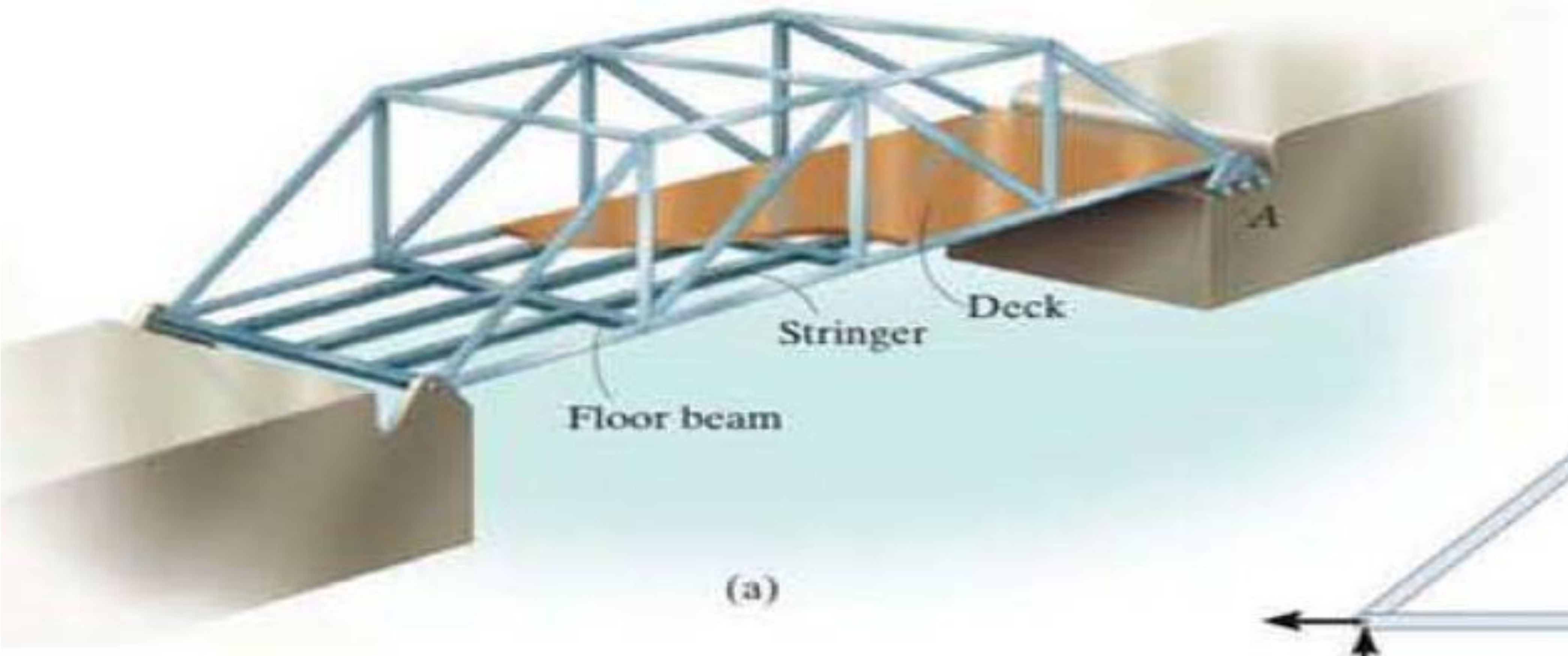


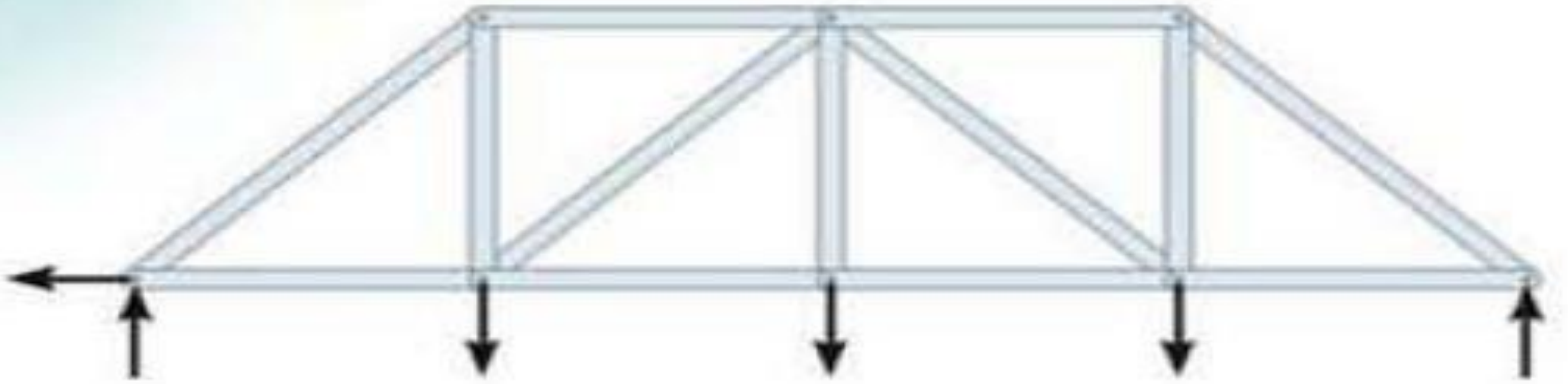
Commonly Used Roof Trusses

Figure 4/2

Plane Trusses

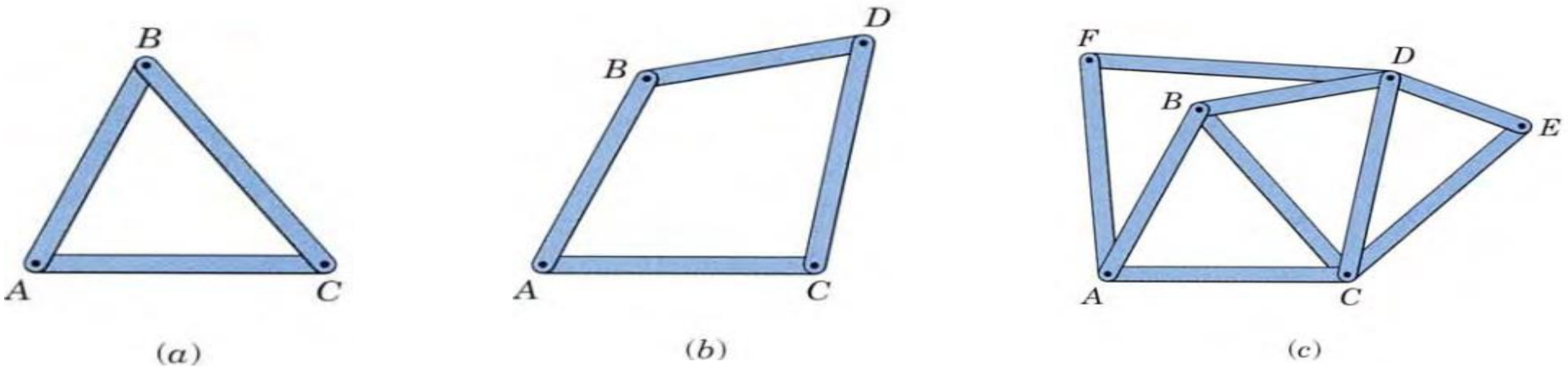
- When the *members* of the truss lie essentially in a *single plane*, the truss is known as a *plane truss*.





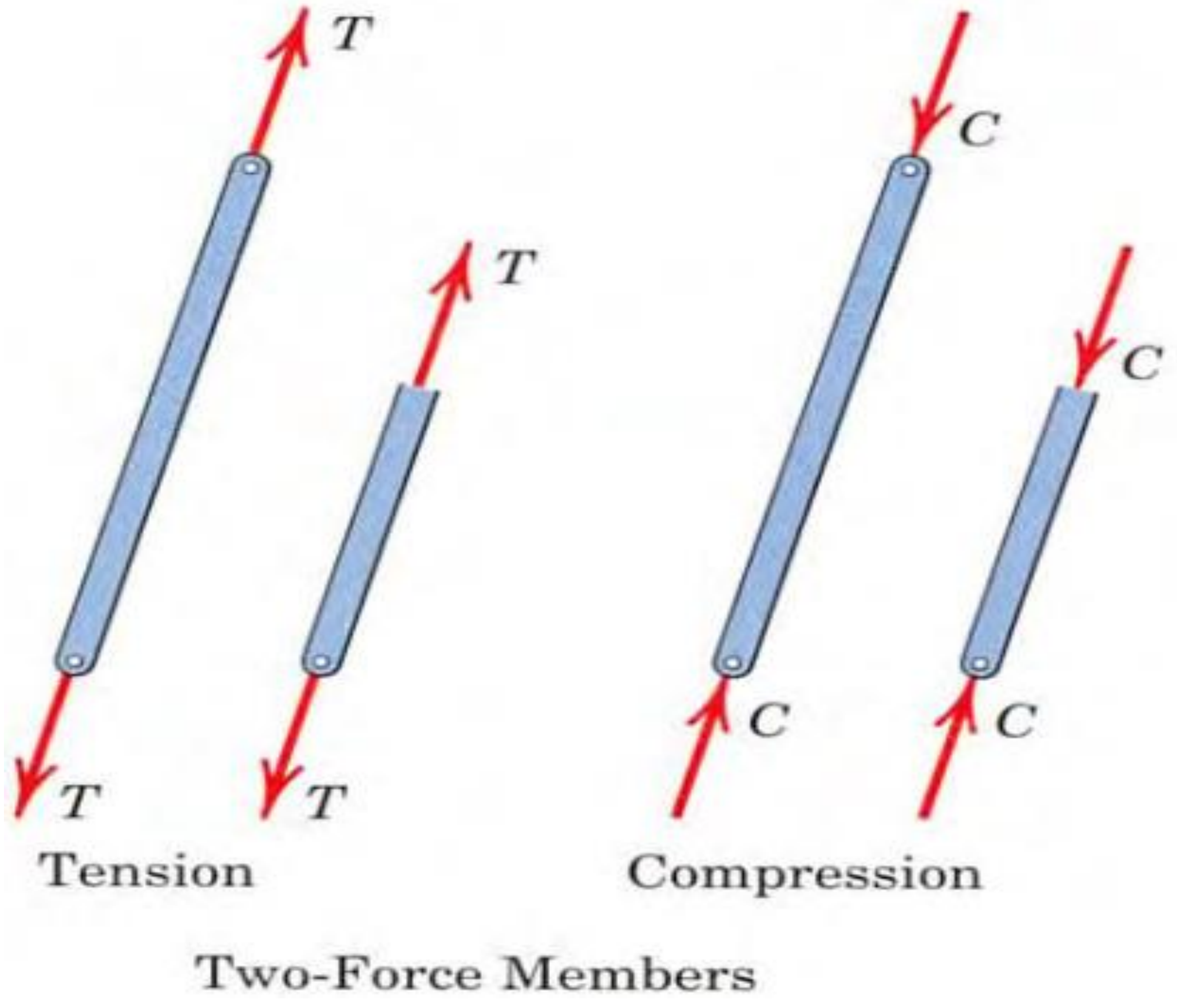
Bridge truss

- The *basic element* of a plane truss is the *triangle*. Three *bars joined* by pins at their ends, constitute a *rigid frame*. On the other hand, *four or more bars* pin-jointed to form a polygon of as many sides constitute a *non-rigid frame*.



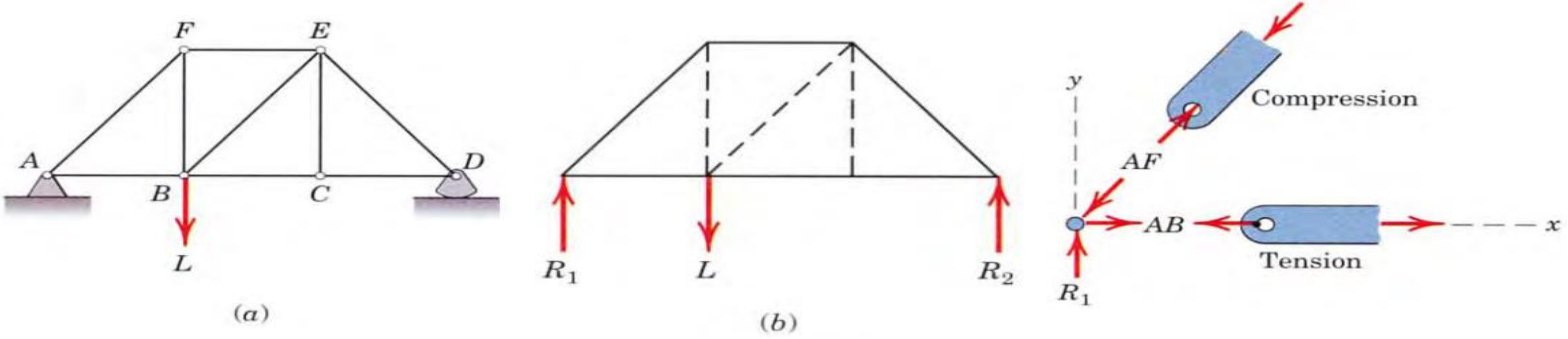
Assumptions for Design

- We assume all members to be *two-force members*.
- All *loadings* are *applied* at the *joints*. If the *weight* of the members are *small* compared with the forces, they can be *neglected*. If not, half of their magnitude applied at each end of the member.
- The members are *joined* together by *smooth pins*.

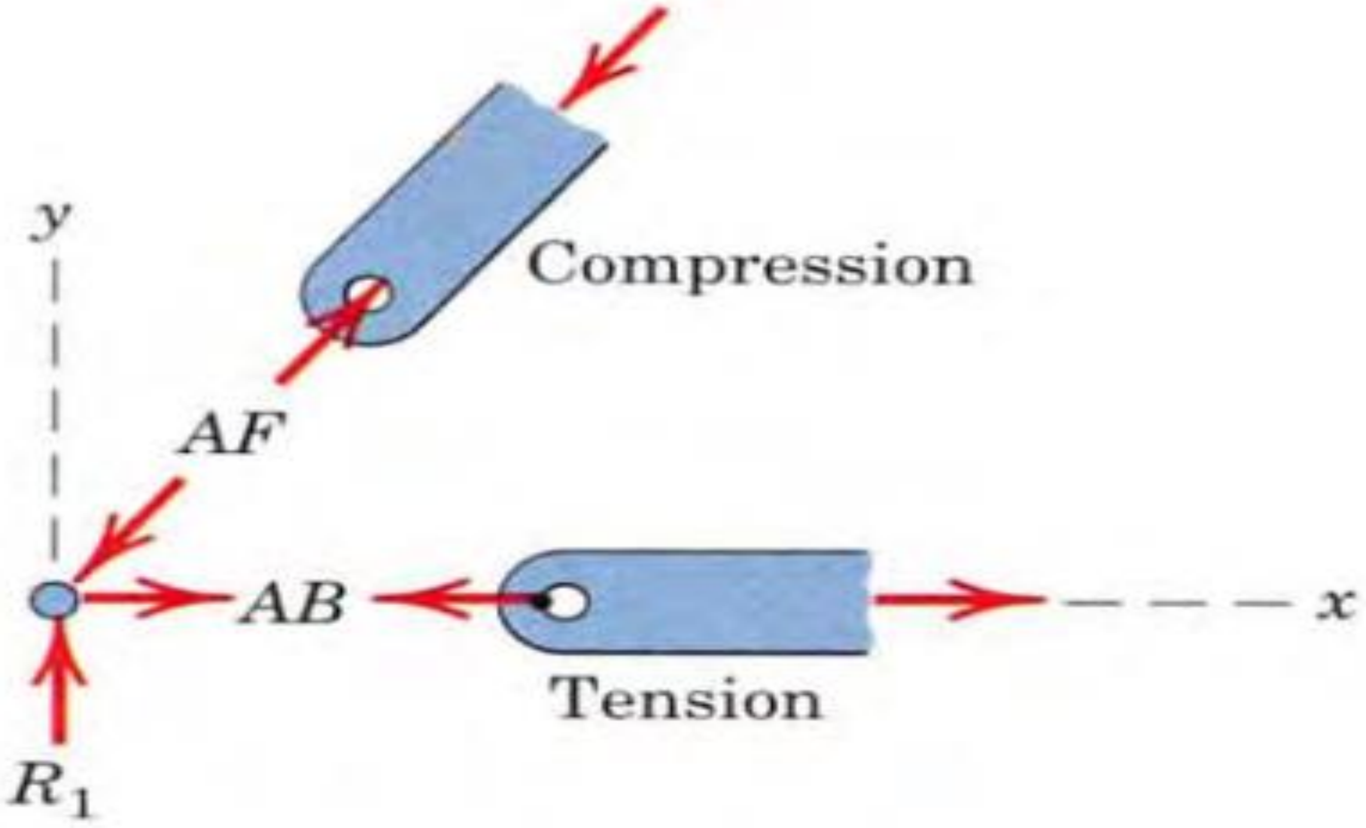

T
T
T
T
C
C
C
C
Tension
Compression
Two-Force Members

Method of Joints

- The *method of joints* consists of applying the equilibrium conditions to the *free-body diagram* of *each joint* of the truss.

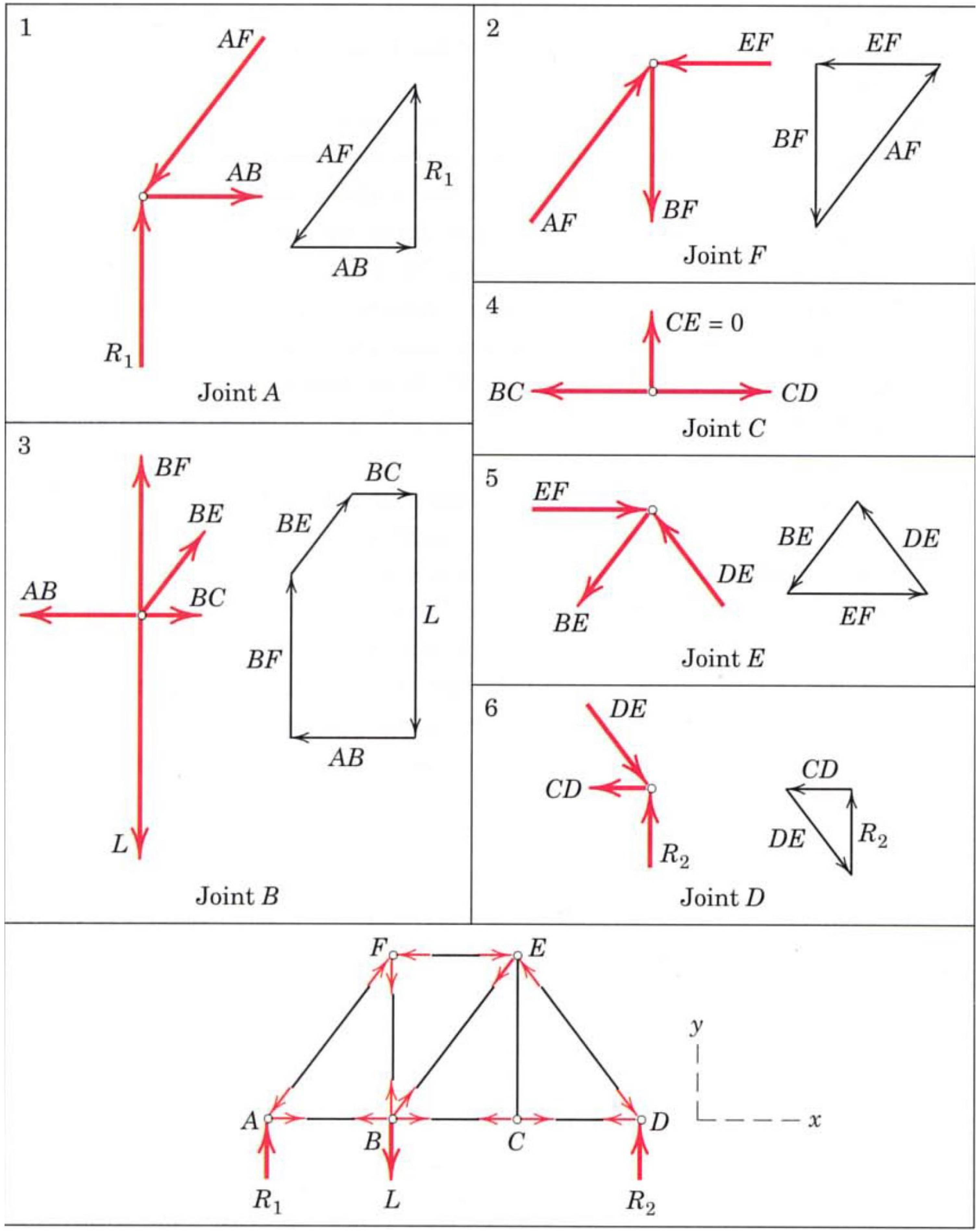


- After drawing free-body diagram, we *apply equilibrium equations for each joints.*



$$\sum F_x = 0$$

$$\sum F_y = 0$$


1
AF
AB
AF
R_1
AB
R_1
Joint A
2
EF
EF
BF
AF
AF
BF
Joint F
3
BF
BC
BE
BE
AB
BC
L
BF
AB
L
Joint B
4
CE = 0
BC
CD
Joint C
5
EF
BE
DE
DE
BE
EF
Joint E
6
DE
CD
CD
DE
R_2
R_2
Joint D
F
E
y
A
B
C
D
x
R_1
L
R_2

Special Conditions

- Firstly, we must *define* the *zero-force members*.

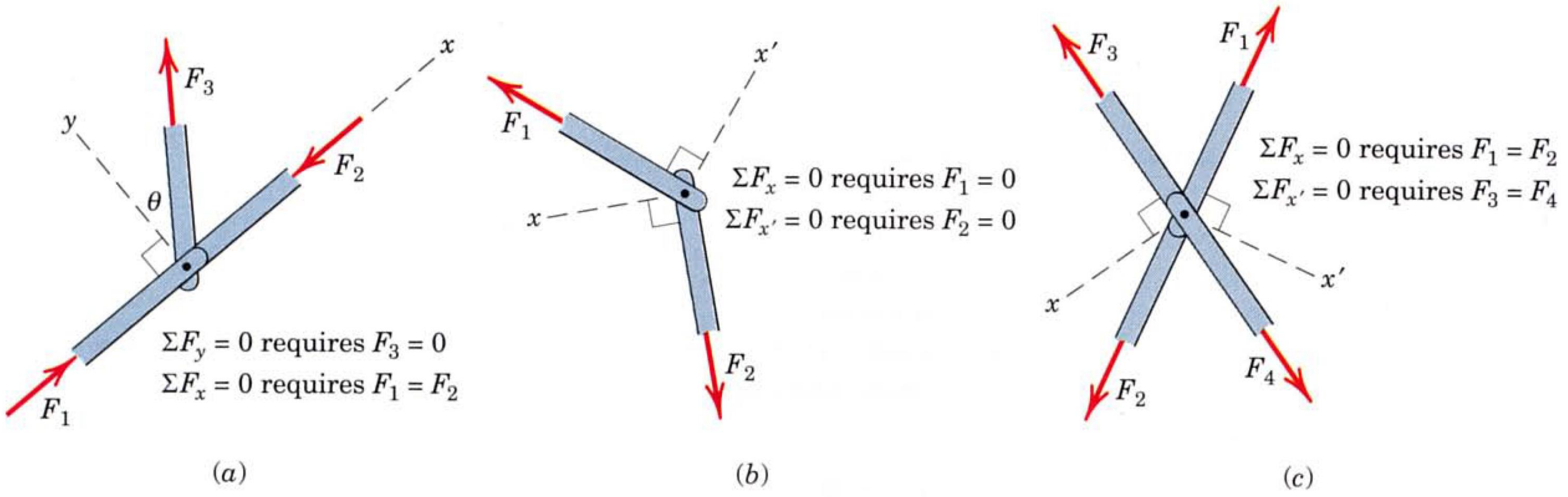
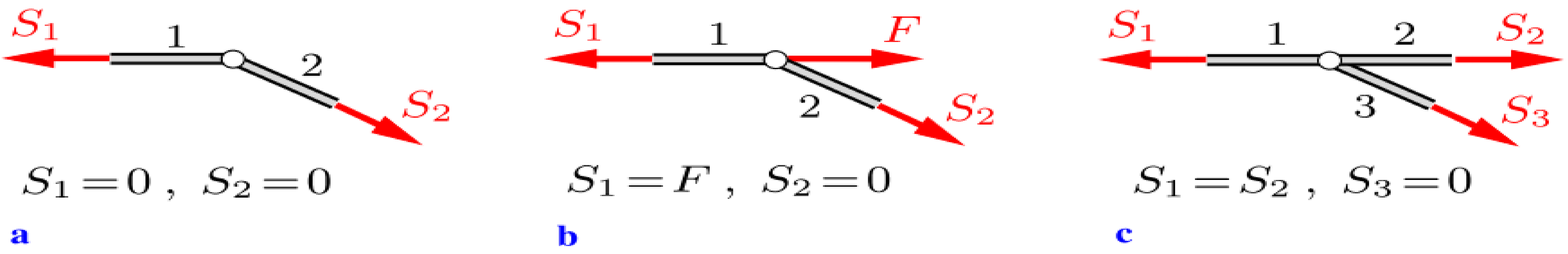
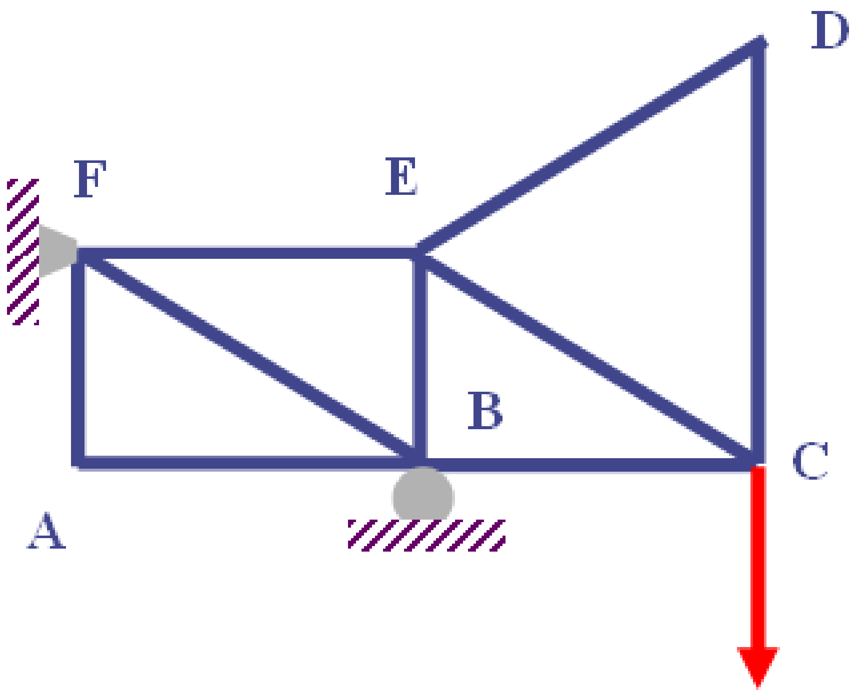
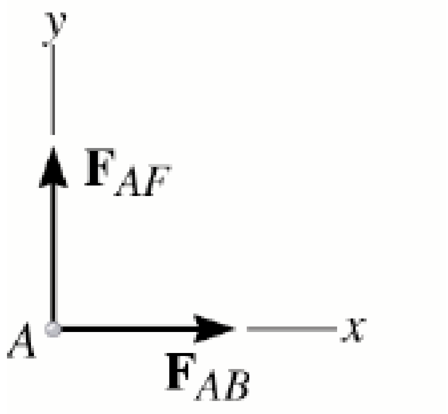


Figure 4/9

Special Conditions

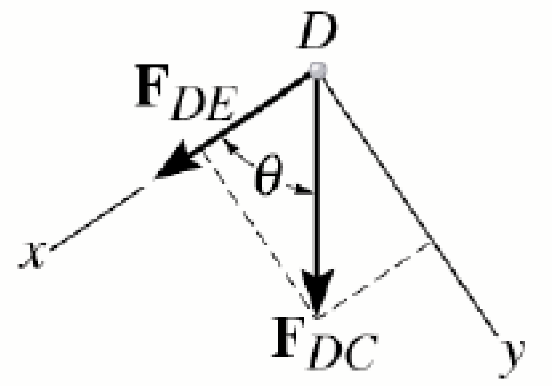






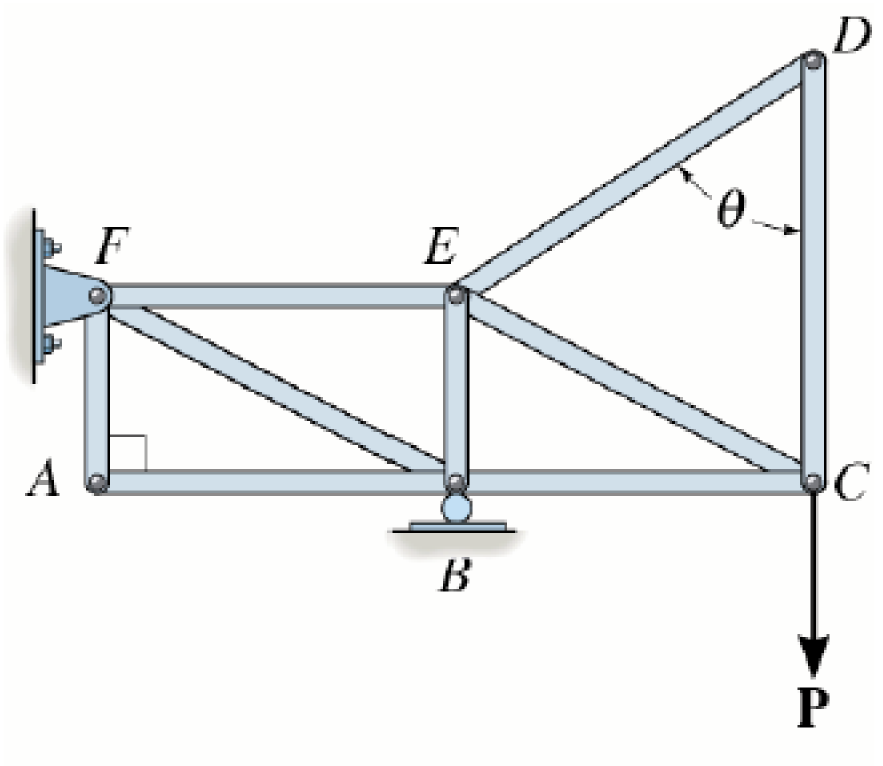
$\xrightarrow{+} \Sigma F_x = 0; \quad F_{AB} = 0$

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



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

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



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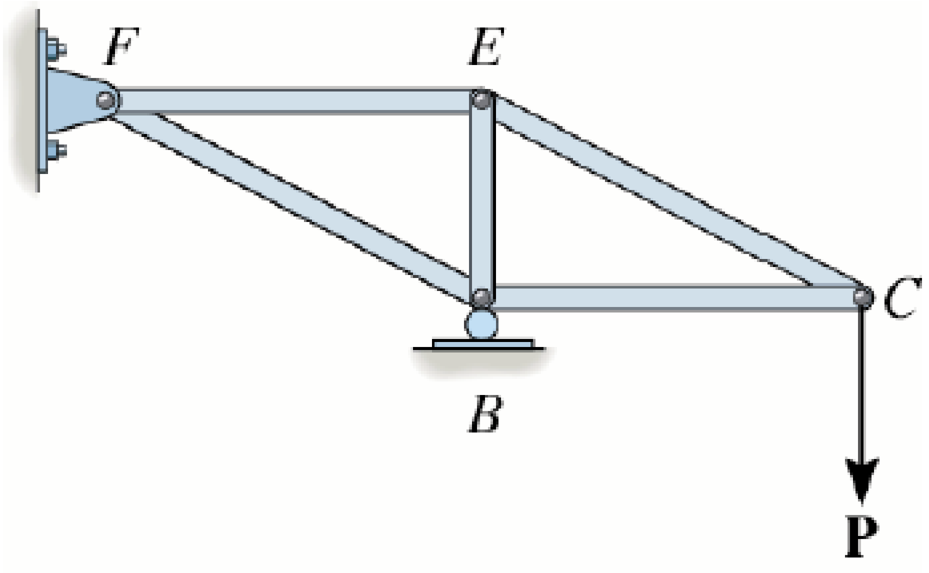
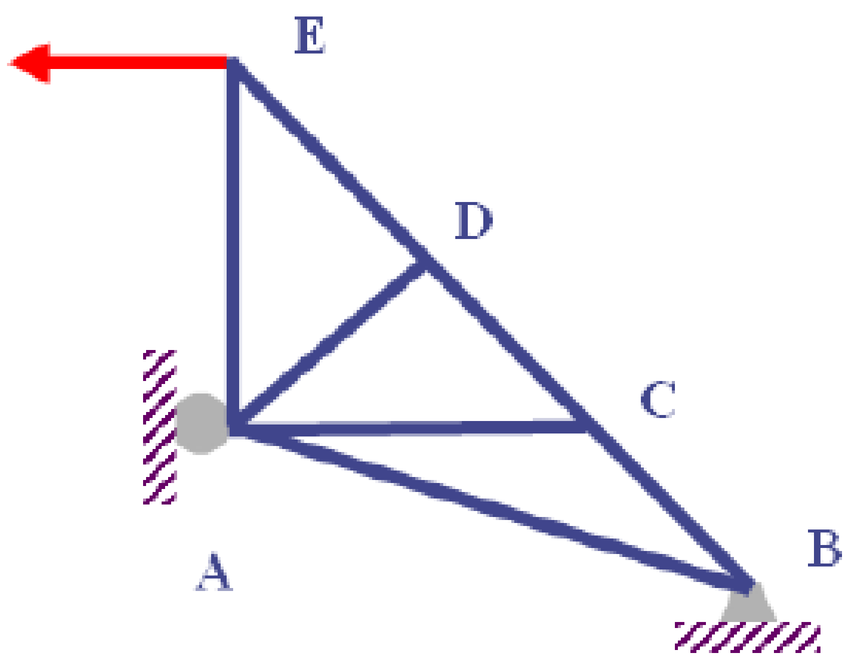
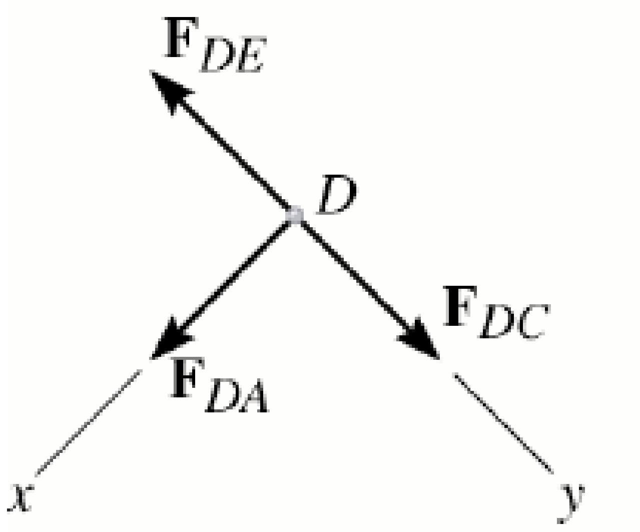
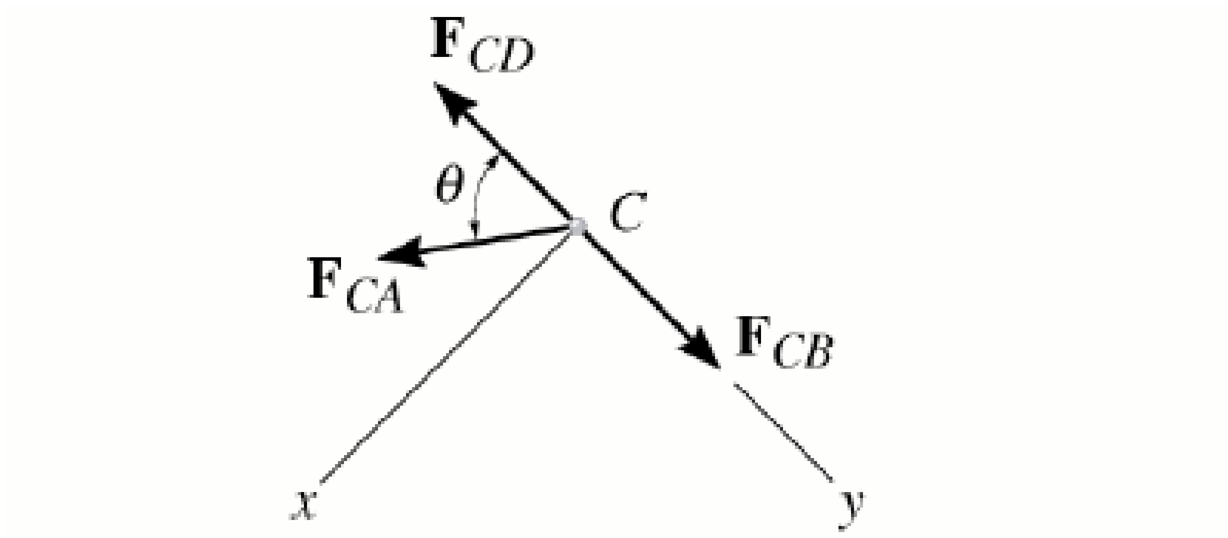






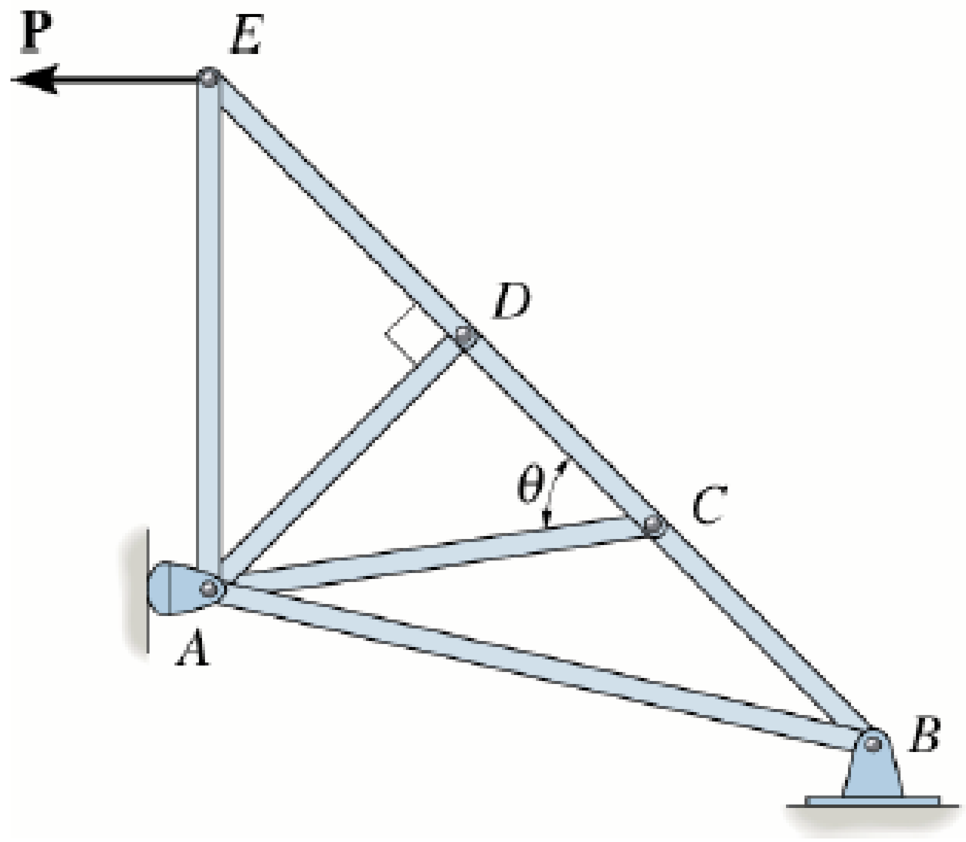
$+\swarrow \Sigma F_x = 0;\; F_{DA} = 0$

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



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

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



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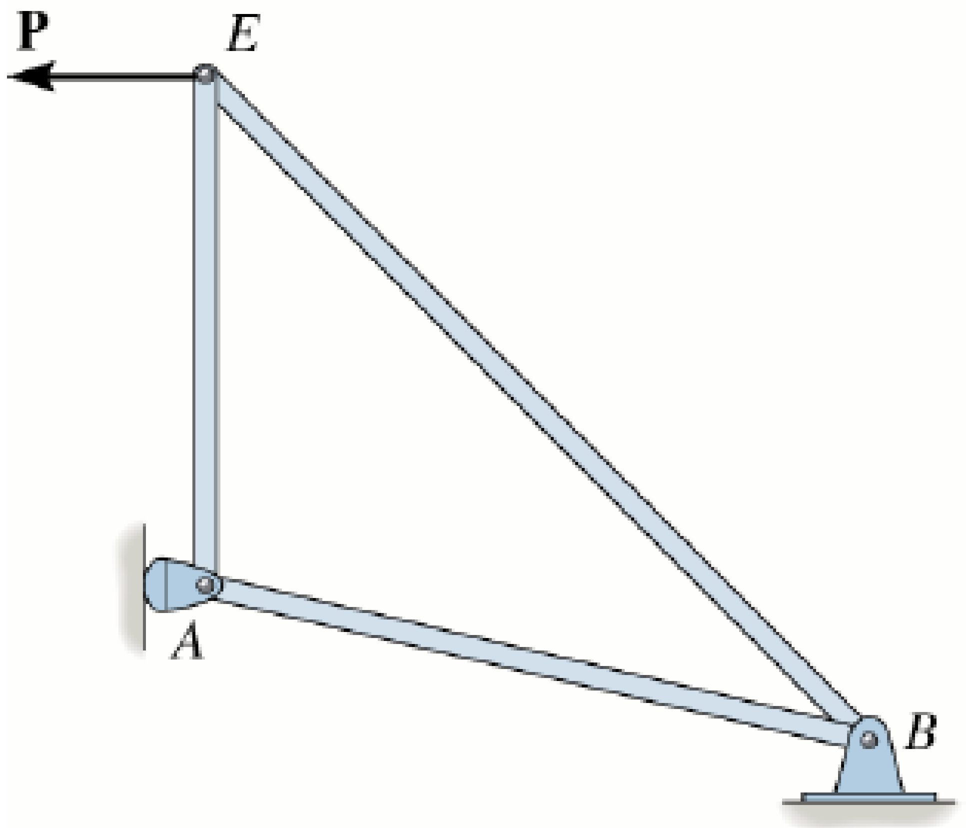
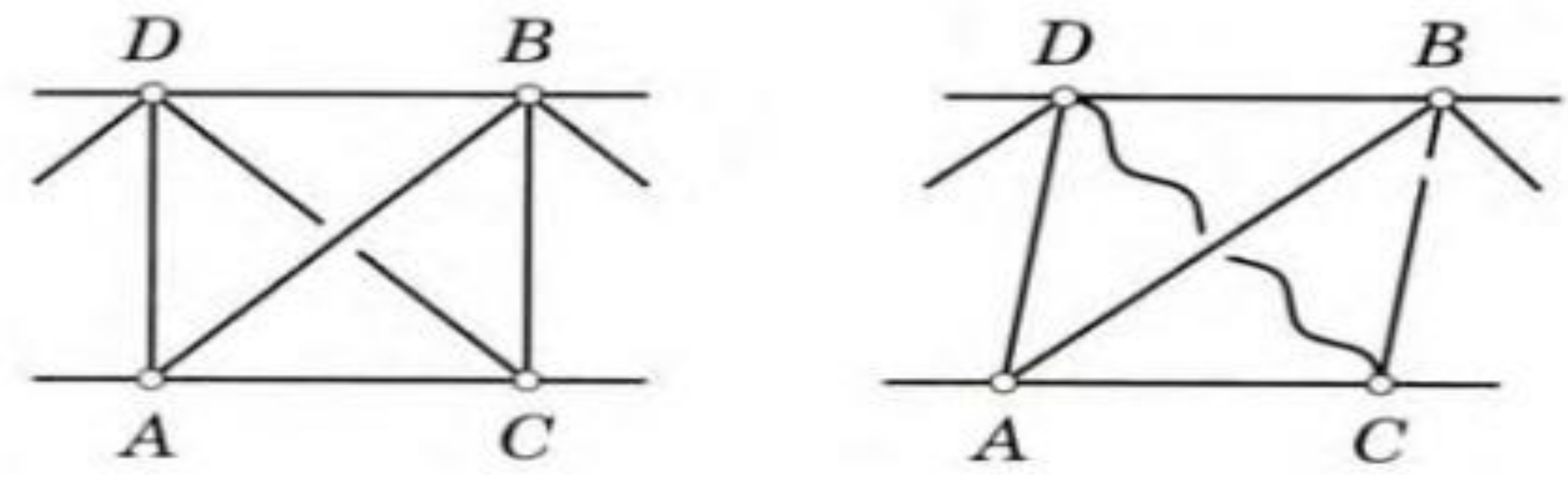


- An other special condition is the *cross-braced*. Such a panel is *statically indeterminate* if each brace can support either *tension* or *compression*. However, when the braces are *flexible* members *cannot* support *compression*.



Procedure of application of Method of Joints

1. **Draw free Body diagram (FBD) of whole truss and find reactions at joints.**
2. **Draw free Body diagram of each joint (don’t forget to start the joint which have maximum two unknown since you have only two equilubrium equations)**

$$\sum F_x = 0 \qquad \sum F_y = 0$$

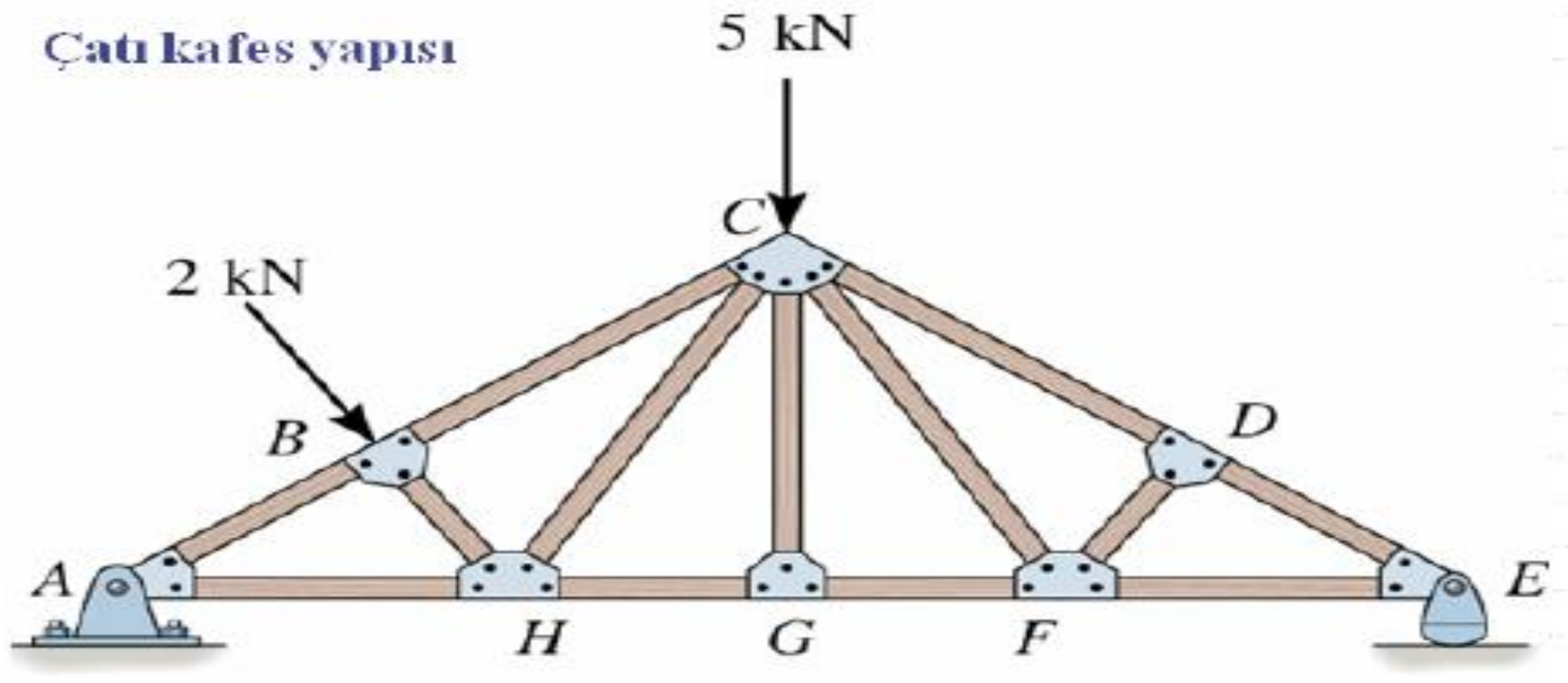
3. **Put known forces at its direction, for unknown forces put in the directions of out of from joints (tension). After calculation of unkown forces, if result is positive, then force is tension. Else if result is negative, then force is compression.**

Examples

Method of Joints

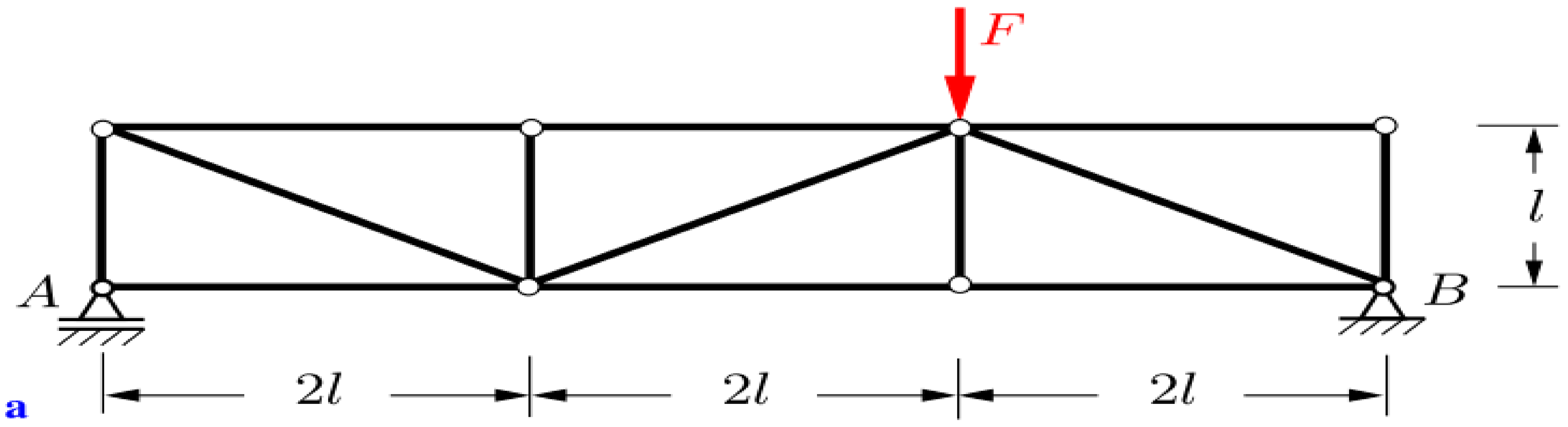
Example 1

- Find the zero force members.



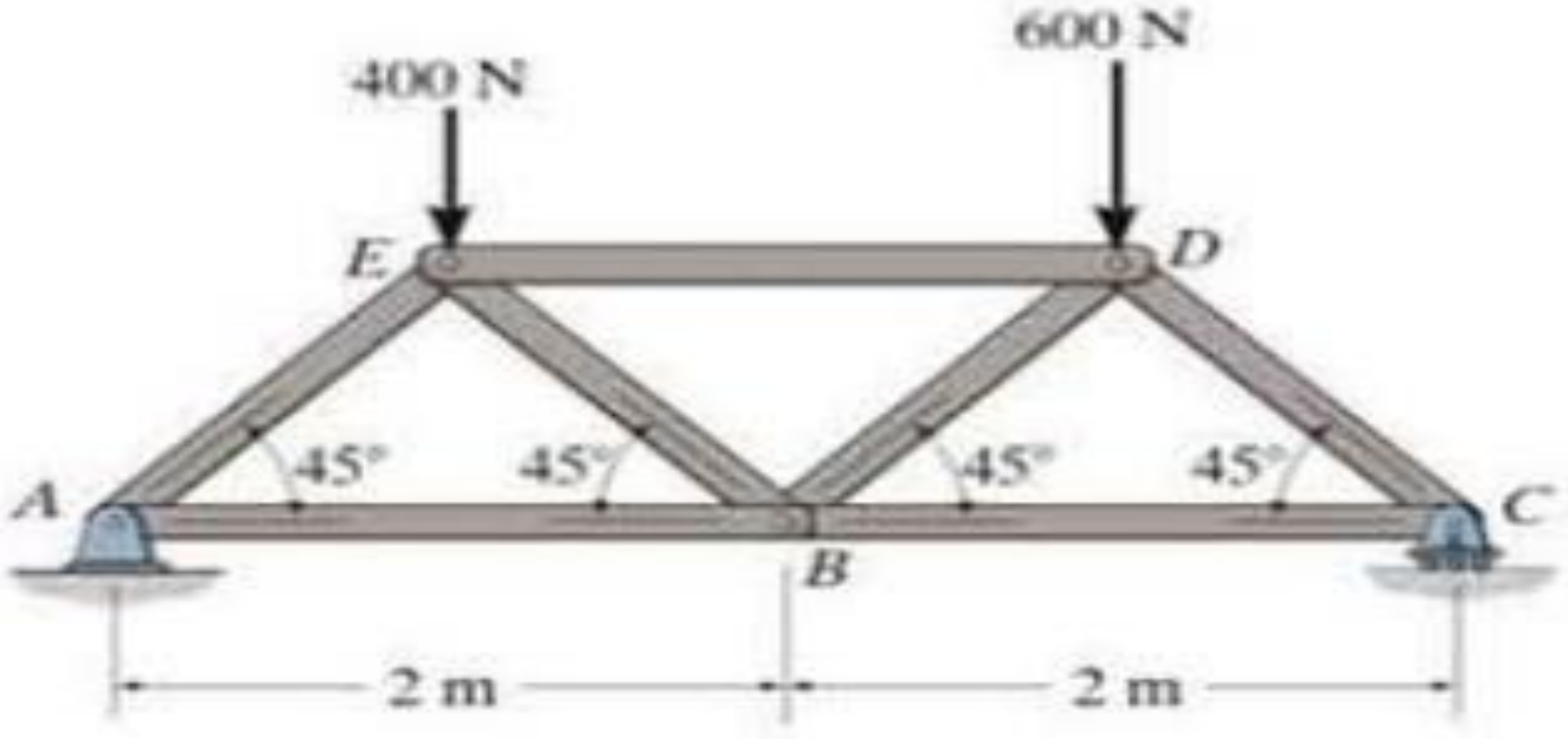
Example 3

- The truss shown in the figure is loaded by an external force F. Determine the forces at the supports and in the members of the truss.



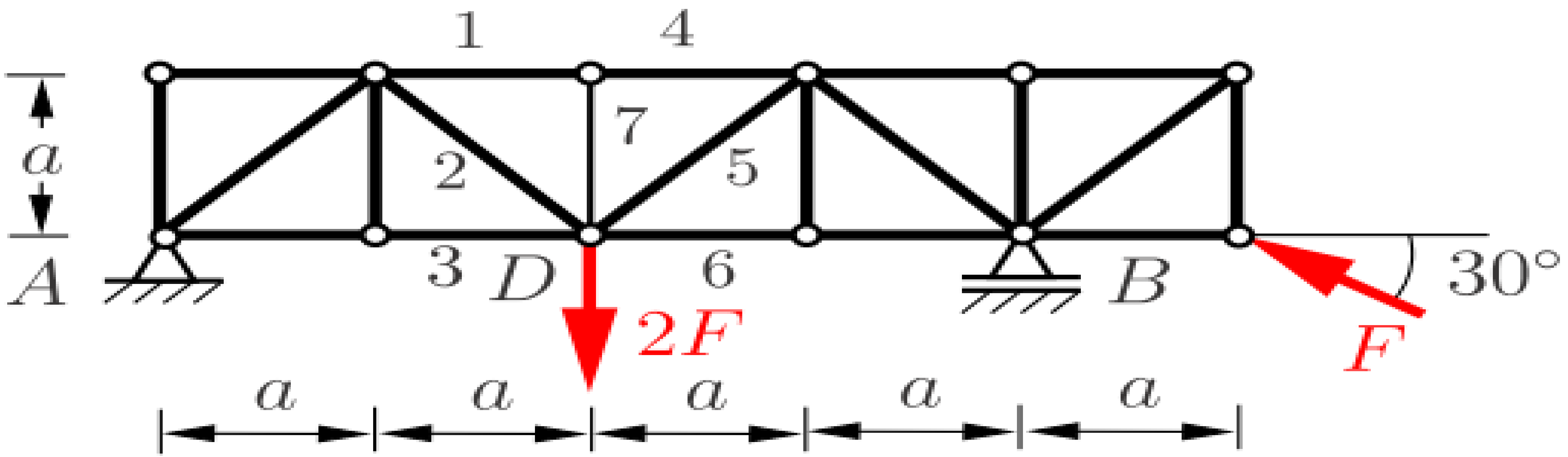
Example 4

- Determine the forces at the supports and in the members of the truss.



Review Problems

- Determine the forces in the members 1-7 of the truss shown, also find the zero force members.



4/7 Determine the force in each member of the loaded truss. Make use of the symmetry of the truss and of the loading.

Ans. $AB = DE = 96.0$ kN C
$AH = EF = 75$ kN T, $BC = CD = 75$ kN C
$BH = CG = DF = 60$ kN T
$CH = CF = 48.0$ kN C, $GH = FG = 112.5$ kN T