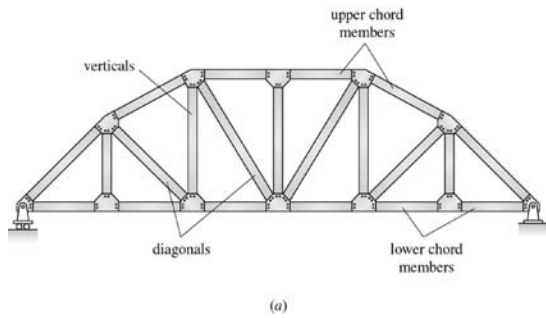
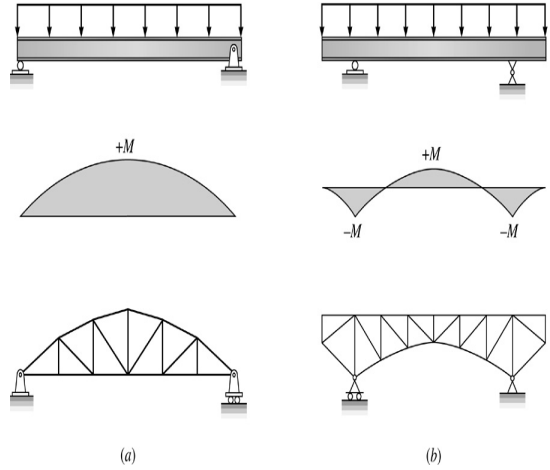


Truss Structures



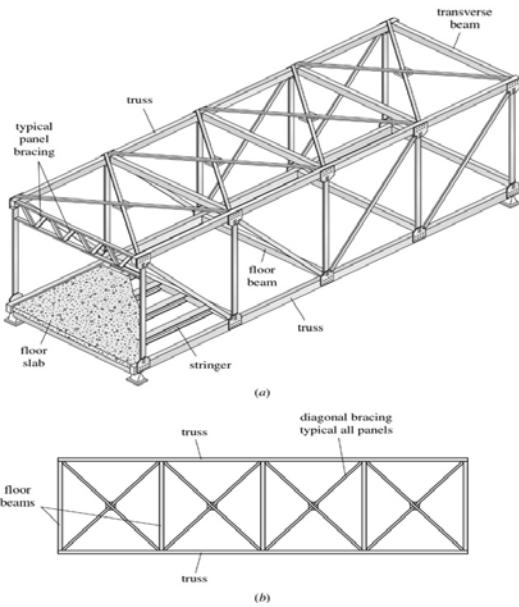
Truss Definitions and Details

1



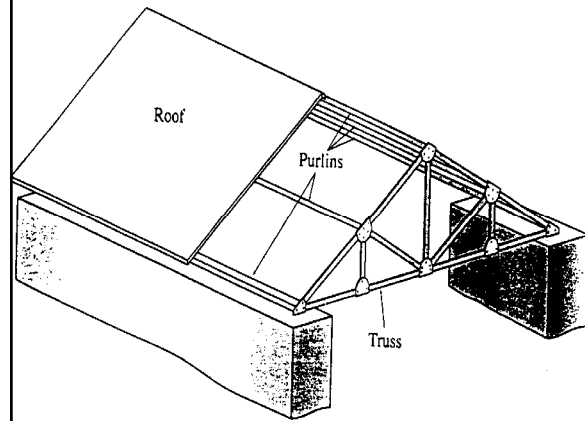
Truss: Mimic Beam Behavior

2



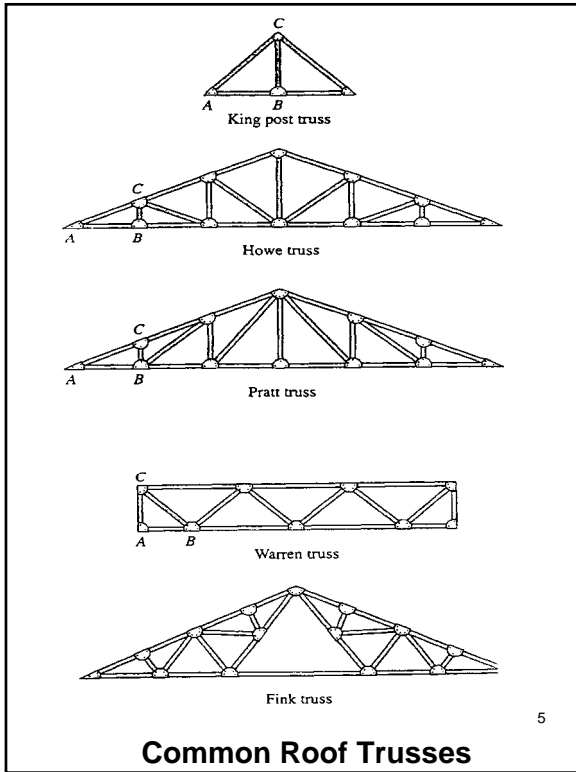
Bridge Truss Details

3

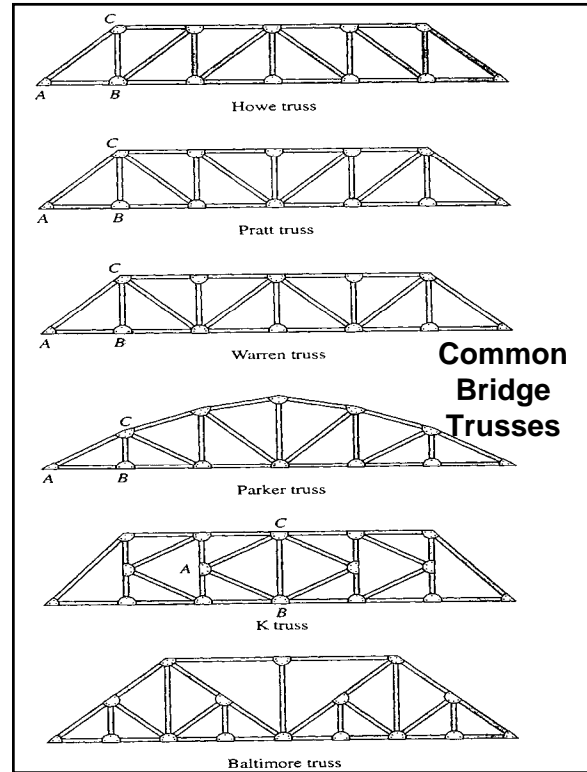


Framing of a Roof Supported Truss

4



5



Buckling Calculations

$$P_{cr} = \frac{\pi^2 EI_{weak}}{(kL)^2}$$

= buckling force

k = effective length factor

k = 1 for an ideal truss member

7

Types of Trusses

Basic Truss Element

≡ three member triangular truss

Simple Trusses – composed of basic truss elements

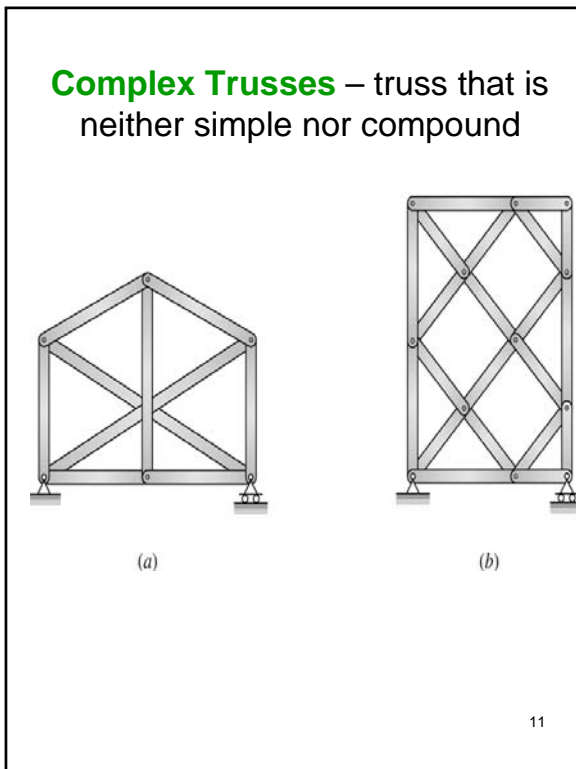
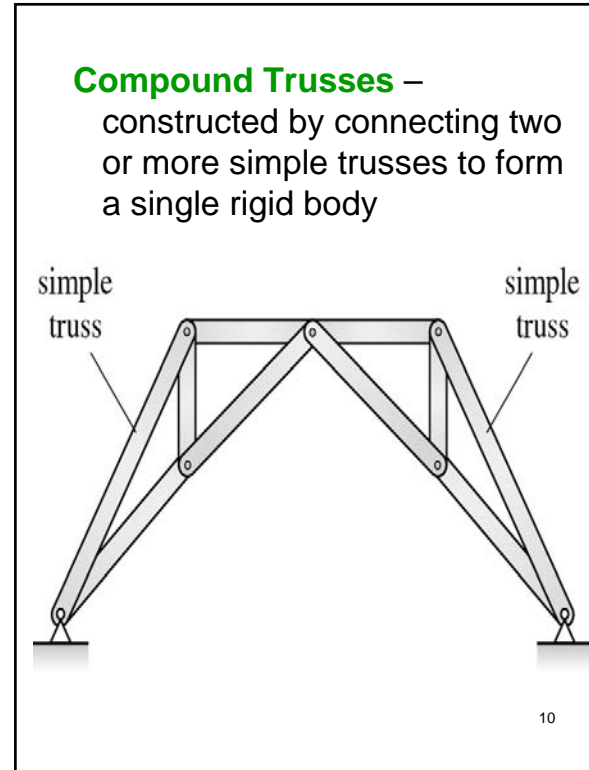
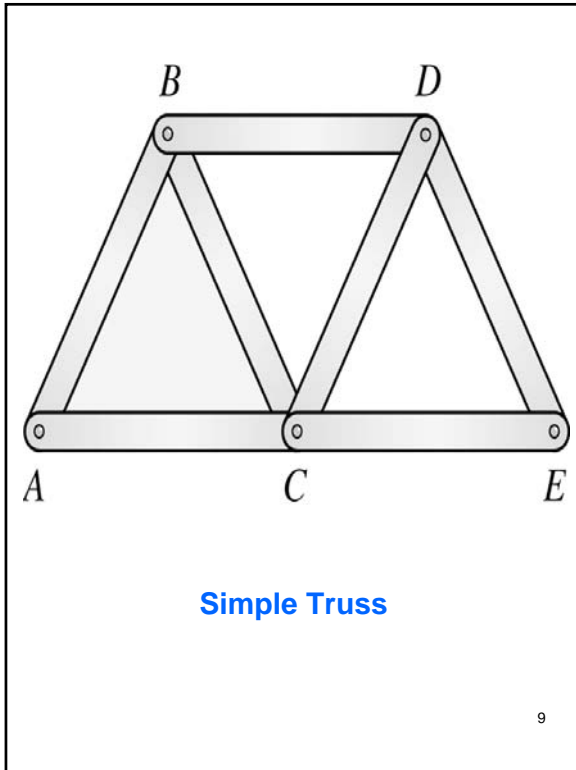
$$m = 3 + 2(j - 3) = 2j - 3$$

for a simple truss

m ≡ total number of members

j ≡ total number of joints

8



Analysis of Trusses

The analysis of trusses is usually based on the following simplifying assumptions:

- The centroidal axis of each member coincides with the line connecting the centers of the adjacent members and the members only carry axial force.
- All members are connected only at their ends by frictionless hinges in plane trusses.
- All loads and support reactions are applied only at the joints.

12

The reason for making these assumptions is to obtain an ideal truss, i.e., a truss whose members are subjected only to axial forces.

Primary Forces \equiv member axial forces determined from the analysis of an ideal truss

Secondary Forces \equiv deviations from the idealized forces, i.e., shear and bending forces in a truss member.

Our focus will be on primary forces. If large secondary forces are anticipated, the truss should be analyzed as a frame.

13

Method of Joints

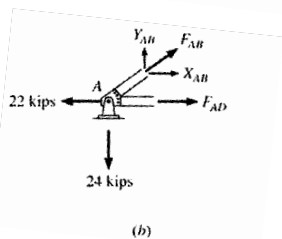
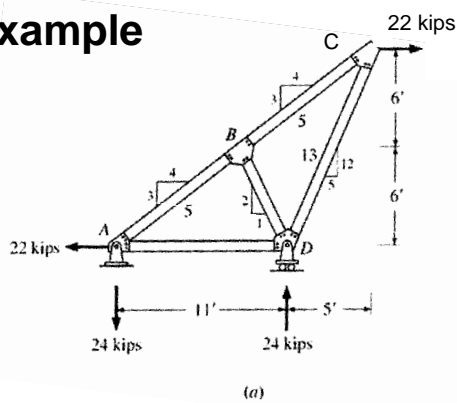
Method of Joints - the axial forces in the members of a statically determinate truss are determined by considering the equilibrium of its joints.

Tensile (T) axial member force is indicated on the joint by an arrow pulling away from the joint.

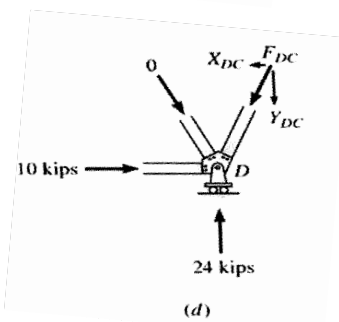
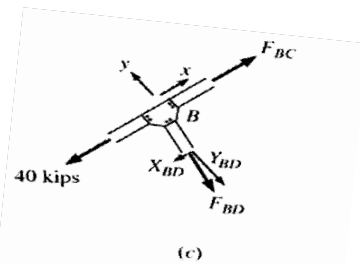
Compressive (C) axial member force is indicated by an arrow pushing toward the joint.

14

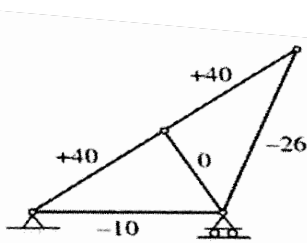
Method of Joints Example



15



16



(e)

Truss Solution

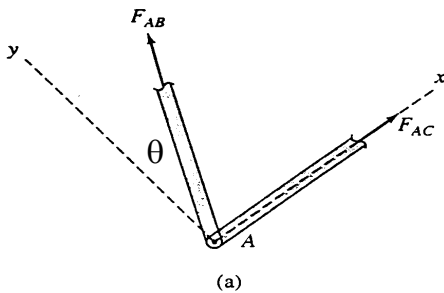
17

Zero Force Members:

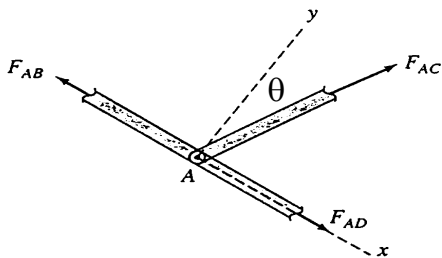
(a) If only two noncollinear members are connected to a joint that has no external loads or reactions applied to it, then the force in both members is zero.

(b) If three members, two of which are collinear, are connected to a joint that has no external loads or reactions applied to it, then the force in the member that is not collinear is zero.

18



(a)



(b)

Zero Force Members

19

Zero Member Force Calculations

Figure (a):

$$\sum F_y = 0 = F_{AB} \cos \theta$$

$$\therefore F_{AB} = 0$$

$$\sum F_x = 0 = F_{AC} + \cancel{F_{AB} \sin \theta}^0$$

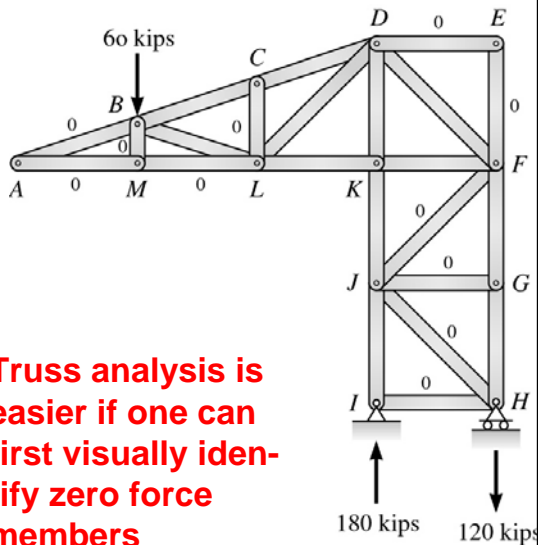
$$\therefore F_{AC} = 0$$

Figure (b):

$$\sum F_y = 0 = F_{AC} \cos \theta$$

$$\therefore F_{AC} = 0$$

20



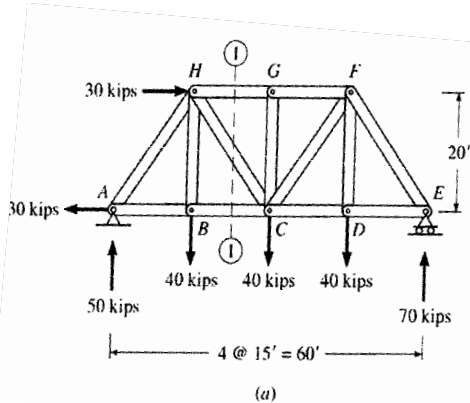
Truss analysis is easier if one can first visually identify zero force members

Method of Sections

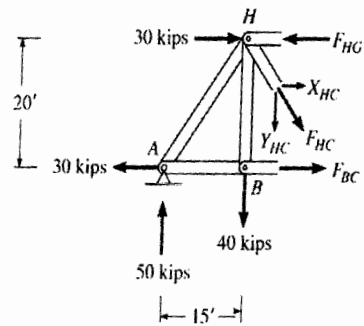
The method of sections enables one to determine forces in specific truss members directly.

Method of Sections \equiv involves cutting the truss into two portions (free body diagrams, FBD) by passing an imaginary section through the members whose forces are desired. Desired member forces are determined by considering equilibrium of one of the two FBD of the truss.

Method of sections can be used to determine three unknown member forces per FBD since all three equilibrium equations can be used.



(a)



(b)

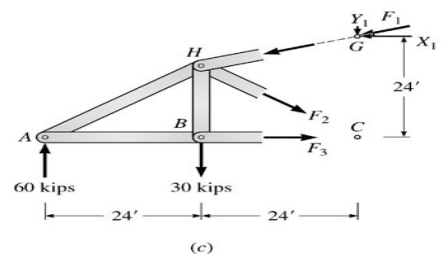
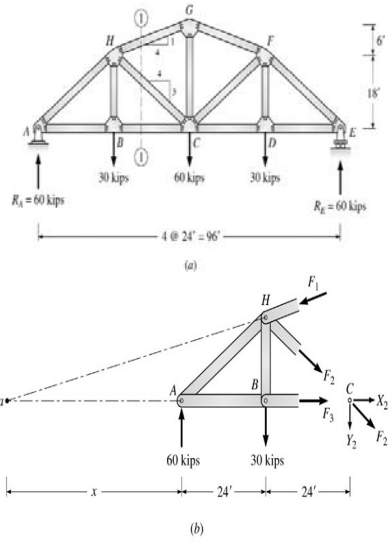
$F_{BC} = \underline{\hspace{2cm}}$

$F_{HG} = \underline{\hspace{2cm}}$

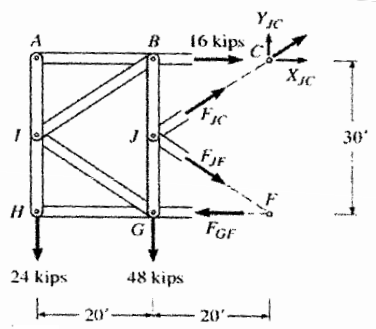
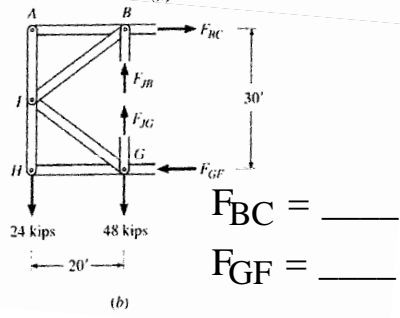
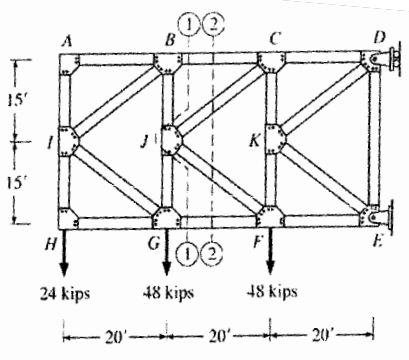
$F_{HC} = \underline{\hspace{2cm}}$

Method of Sections Example

Statics Principle of Transmissibility

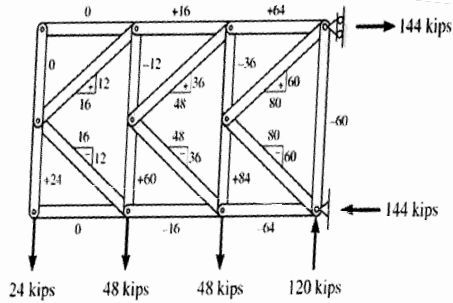


Transmissibility principle of statics states that a force can be applied at any point on its line of action without a change in the external effects



$F_{JC} = \underline{\hspace{2cm}}$

$F_{JF} = \underline{\hspace{2cm}}$



(d)

K-Truss Solution

29

Determinacy and Stability

Internal Stability \equiv number and arrangement of members is such that the truss does not change its shape when detached from the supports.

External Instability \equiv instability due to insufficient number or arrangement of external supports.

30

Internal Stability

$$m < 2j - 3$$

\Rightarrow truss is internally unstable

$$m \geq 2j - 3$$

\Rightarrow truss is internally stable provided it is geometrically stable

m \equiv total number of members

j \equiv total number of joints

Geometric stability in the second condition requires that the members be properly arranged.

31

Statically Determinate Truss \equiv

if all the forces in all its members as well as all the external reactions can be determined by using the equations of equilibrium.

Statically Indeterminate Truss \equiv

if all the forces in all its members as well as all the external reactions cannot be determined by using the equations of equilibrium.

External Indeterminacy \equiv excess number of support reactions

32

Internal Indeterminacy \equiv excess number of members

Redundants \equiv excess members or reactions

Number of redundants defines the degree of static indeterminacy **I**

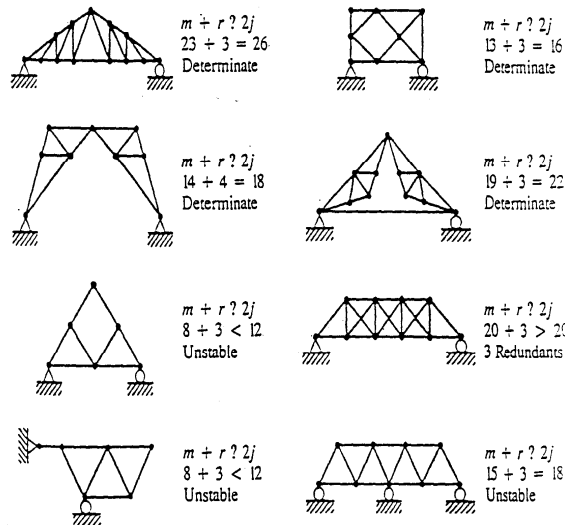
Summary

- $m + R < 2j$
 \Rightarrow statically unstable truss
- $m + R = 2j$
 \Rightarrow statically determinate truss
- $m + R \geq 2j$
 \Rightarrow statically indeterminate truss

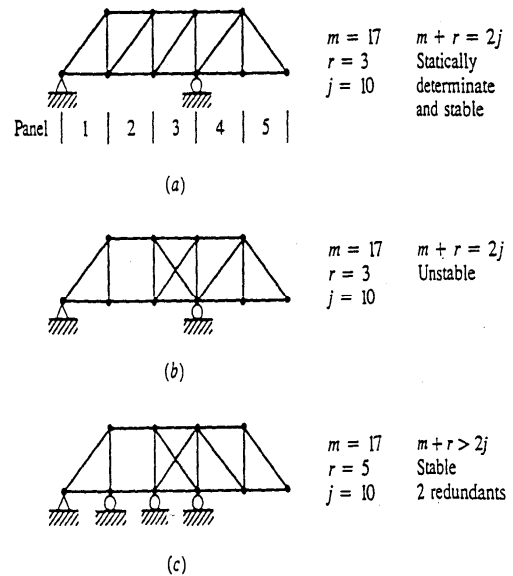
The first condition is always true.

But, the **last two conditions are true if and only if the truss is geometrically stable.**

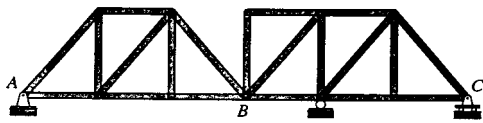
The analysis of unstable trusses will always lead to inconsistent, indeterminant, or infinite results.



Truss Determinacy Calculations

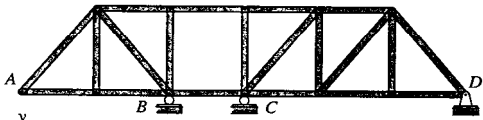


Truss Determinacy Calculations



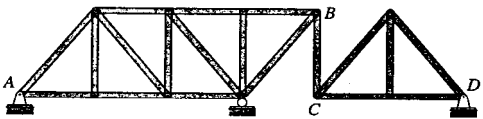
One equation of condition:
 $\Sigma M_B^{AB} = 0$ or $\Sigma M_B^{BC} = 0$

(a)



One equation of condition:
 $\Sigma F_y^{AB} = 0$ or $\Sigma F_y^{CD} = 0$

(b)



Two equations of condition:
 $\Sigma F_x^{AB} = 0$ or $\Sigma F_x^{CD} = 0$
 $\Sigma M_B^{AB} = 0$ or $\Sigma M_C^{CD} = 0$

(c)

**Equations of Condition:
 Plane Trusses**