TRUSSES

Learning Objectives

1). To identify *zero-force members* in a structure.

2). To recognize *planar* and *space* (i.e., three-dimensional) *truss structures*.

3). To understand the *assumptions* made in modeling trusses.

4). To understand *why* structures are often designed as trusses.

Definitions

Zero-Force Members: structural members that support **No** loading but aid in the stability of the truss.

Two-Force Members: structural members that are: a) subject to no applied or reaction **moments**, and b) are loaded only at **2** pin joints along the member.

Multi-Force Members: structural members that have a) applied or reaction moments, or b) are loaded at more than two points along the member.

Truss: a rigid framework of straight, lightweight **2-force** members that are joined together at their ends.

Frame: a rigid framework of straight and/or curved members intended to be a stationary structure for supporting a load.

Machine: an assembly of rigid members designed to do mechanical work by transmitting a given set of input loading forces into another set of output forces (Dynamics).

Simple and Compound Trusses

Simple Truss: a truss whose number of members is given by m = 2j – 3, where m = no. of members and j = no. of joints. (For simple space trusses the relationship is given by m = 3j – 6).

Compound Truss: a truss formed from two or more simple trusses.

Newton's Third Law

For each action there is an **equal** and **opposite** reaction (i.e., $F_{A_{Body\,1}} = -F_{A_{Body\,2}}$).

Assumptions for Modeling

1). All members are **straight**.

2). All connections are modeled as **pin joints**.

3). The centerlines of all members must be **concurrent** at the joint.

4). External loads act only at the **joints**.

5). Weight of members is **negligible** compared with external loads.

Advantage of Truss Structures

Truss structures can span *long* distances without intermediate supports (e.g., bridge and roof trusses) and can carry *heavy* loads with lightweight members.

Applications

See text book.

Two Methods of Solutions

- Method of Joints
- Method of Sections

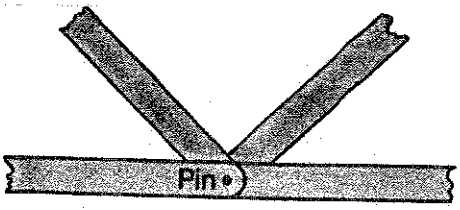
Static Indeterminacy/Partial Constraint

A truss is *internally indeterminate* if:

$m > 2j - 3$ (for planar trusses) where m = no. of members
$m > 3j - 6$ (for space trusses) where j = no. of joints

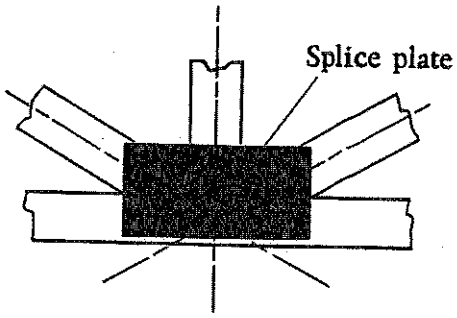
A truss is *improperly constrained* if:

$m < 2j - 3$ (for planar trusses) where m = no. of members
$m < 3j - 6$ (for space trusses) where j = no. of joints



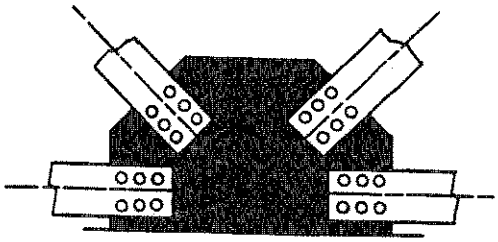
Model connection

FIGURE 4b



(a) Roof truss connection.

Figure 4.8



(b) Gusset plate connection.

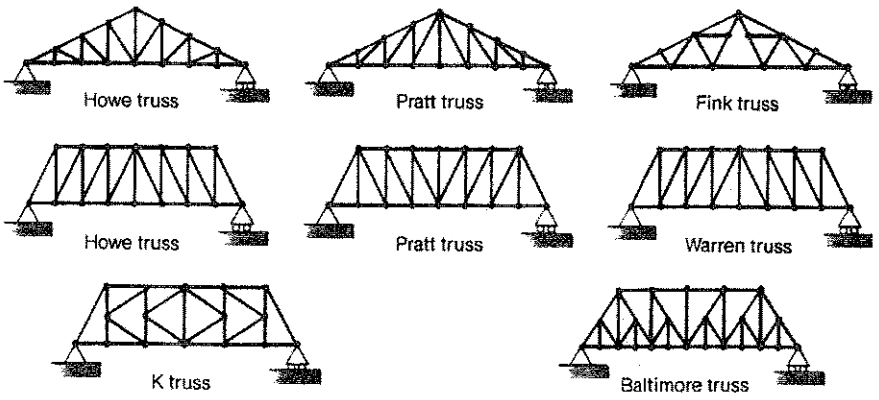


FIGURE 3

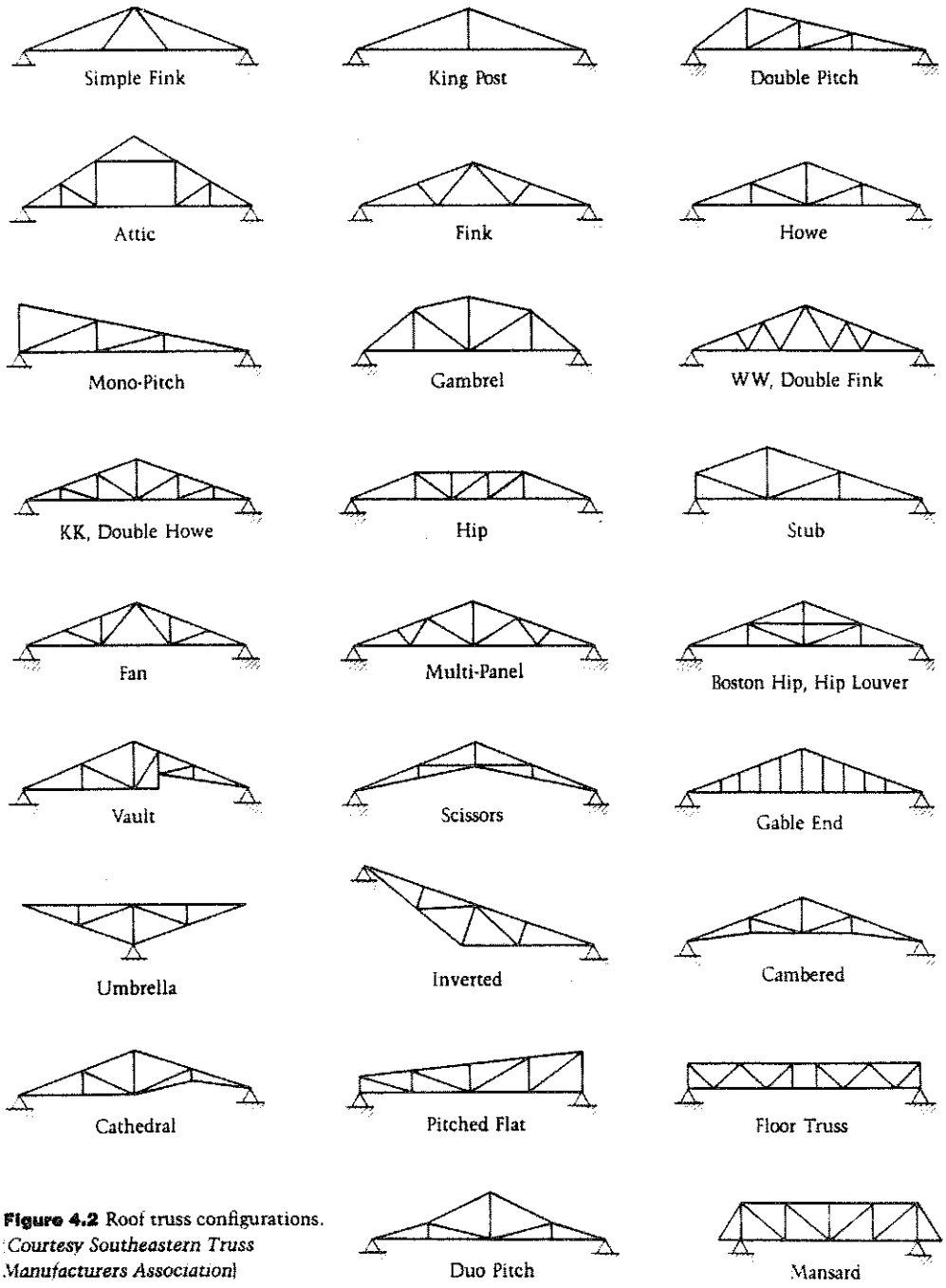
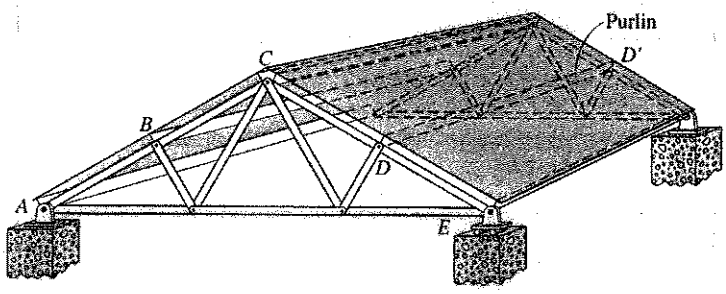


Figure 4.2 Roof truss configurations. *Courtesy Southeastern Truss Manufacturers Association*



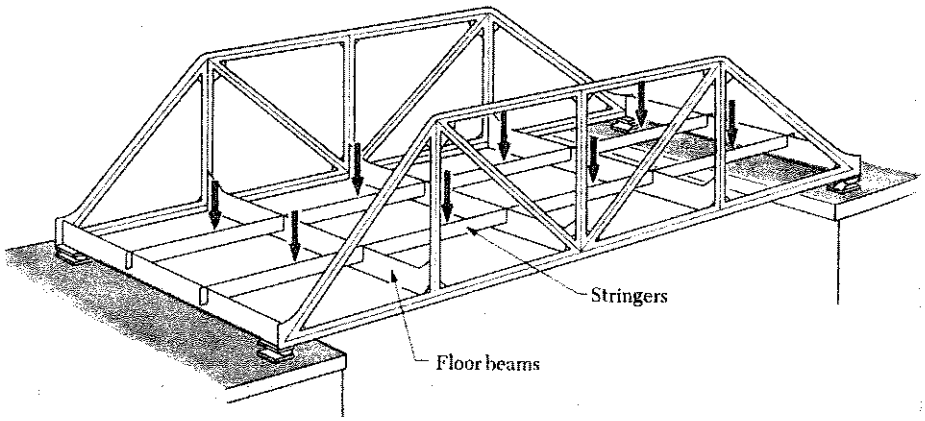
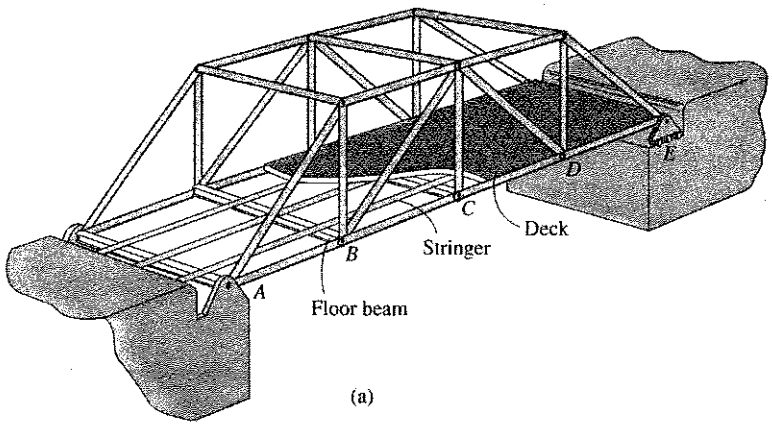


Fig. 6.3

Fig. 6–3



(a)

METHOD OF JOINTS

Learning Objectives

1). To employ the *methods of joints* to evaluate the axial force carried by each member in a truss.

2). To identify *zero-force members* in a truss.

3). To do an *engineering estimate* of the load distribution in a truss.

Procedure

1). Draw a FBD of the *entire truss* showing the *reaction forces* at the supports and the *external loads*. Write the equilibrium equations and solve for as many unknowns as possible.

2). Identify any *zero-force members* and any members that carry the same load as other members or external loads.

3). Draw a FBD of *each joint* in the truss. Be sure to abide by Newton's Third Law (reactions between interacting members are equal and opposite).

4). Make a *plan* for solving the member loads. Start with the joint with the least number of unknowns (this frequently occurs at the supports). In solving the equilibrium equations, avoid joints that have more than two unknowns acting on it. Remember that since the forces at each joint are concurrent (i.e., they intersect at the joint), *only two equilibrium equations* can be utilized ($\sum F_x = 0$ and $\sum F_y = 0$, no moment equation exists).

5). When through solving, go back and state whether each member is in *tension* or *compression*. (That is, if a negative value is found for a member. Then you assumed the wrong direction).

HINT: When drawing the FBDs of the joints, assume all members are initially in **tension** (i.e., show all member forces acting *away from the joint*). Then,

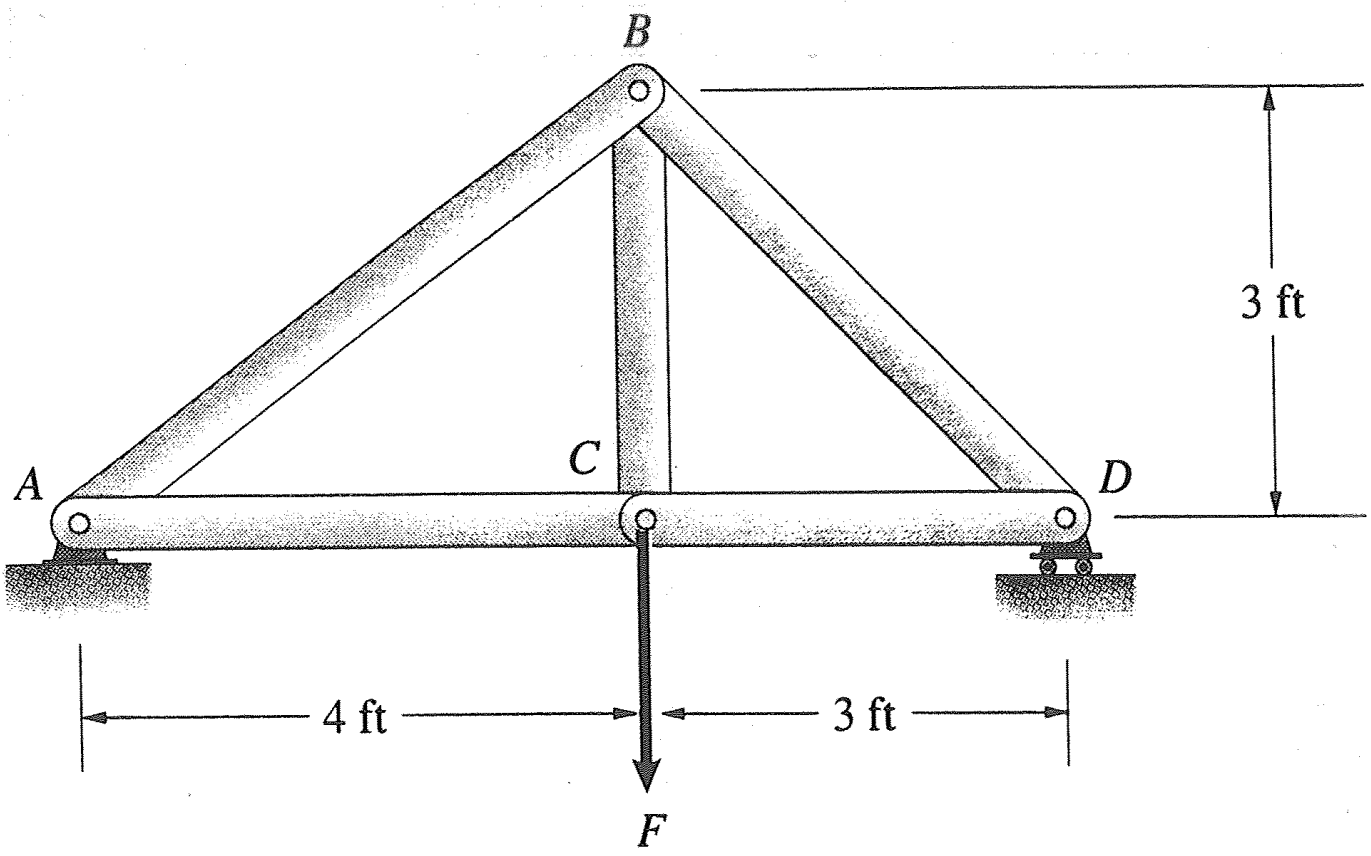
- if load is *positive* $\Rightarrow$ member is in **tension**.
- if load is *negative* $\Rightarrow$ member is in **compression**.

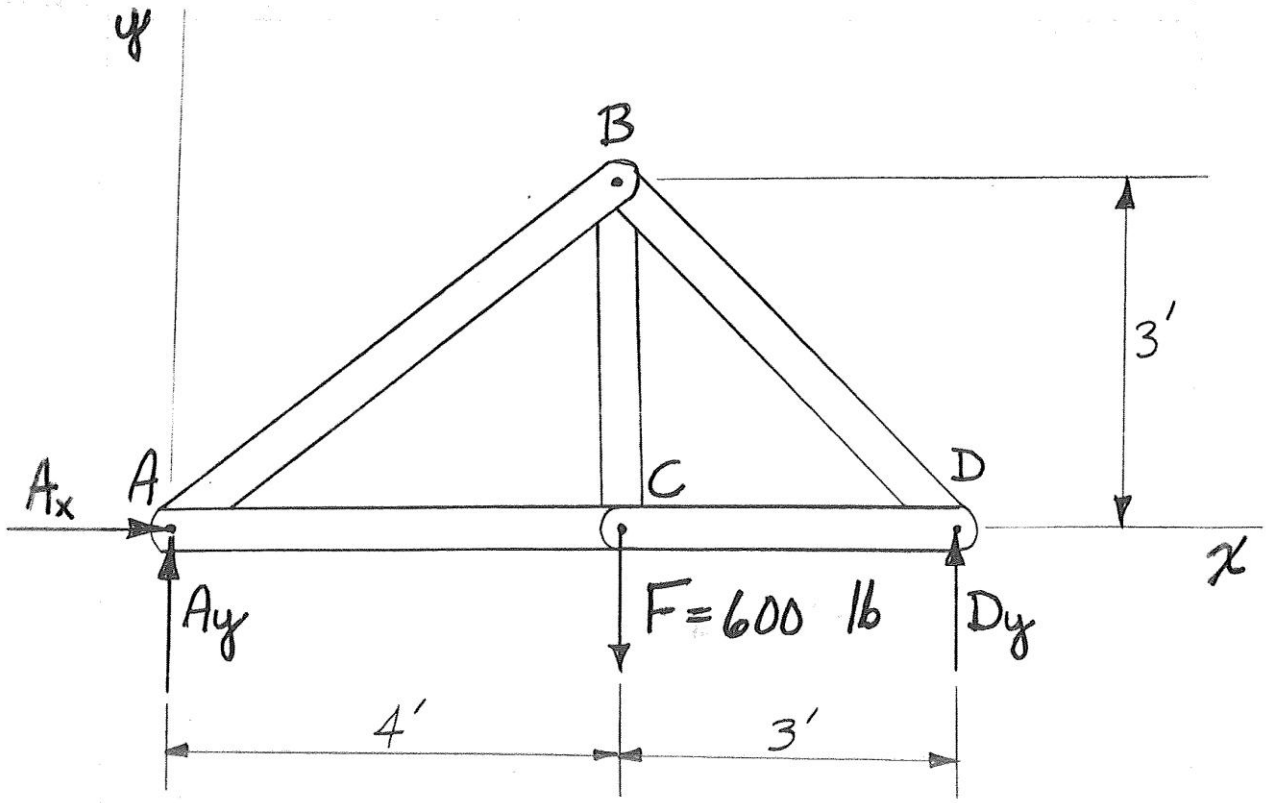
Method of Joints
Example 1

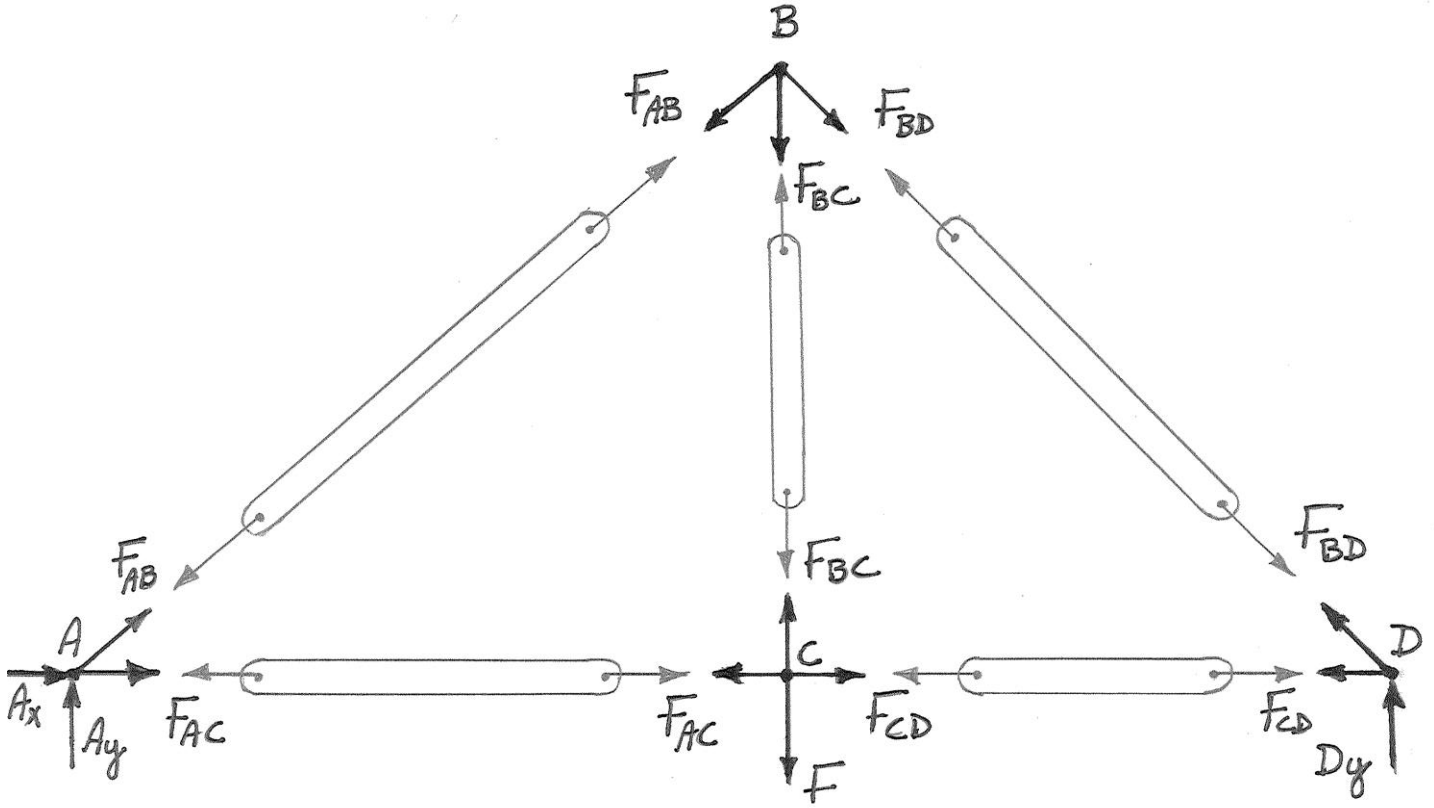
Given Truss ABCD is supported by a pin joint at A and a roller support at D. The truss is loaded with a 600 lb force as shown and is in static equilibrium.

Find:

a) Draw the overall free body diagrams.
b) Calculate the reaction forces at supports A and D.
c) Predict the sense (tension or compression) of each member in the truss.
d) Using the method of joints, determine the load carried in each member. State whether each member is in tension or compression.



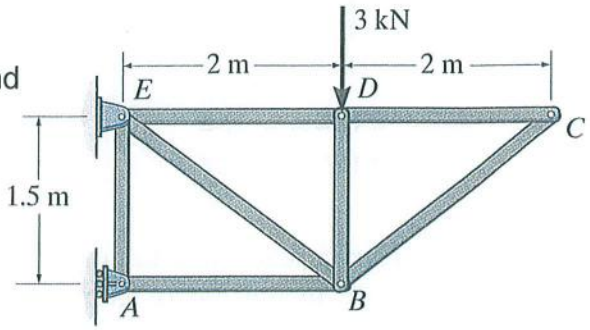

y
B
3′
A
A_x
C
D
x
A_y
F = 600 lb
D_y
4′
3′


B
F_{AB}
F_{BD}
F_{BC}
F_{BC}
F_{AB}
F_{BD}
A
C
D
A_x
A_y
F_{AC}
F_{AC}
F_{CD}
F_{CD}
D_y
F

Trusses – Method of Joints

Example 2

Given: Truss A-E is loaded with a 3 kN force as shown and is held in static equilibrium by a pin support at E a roller support at A.

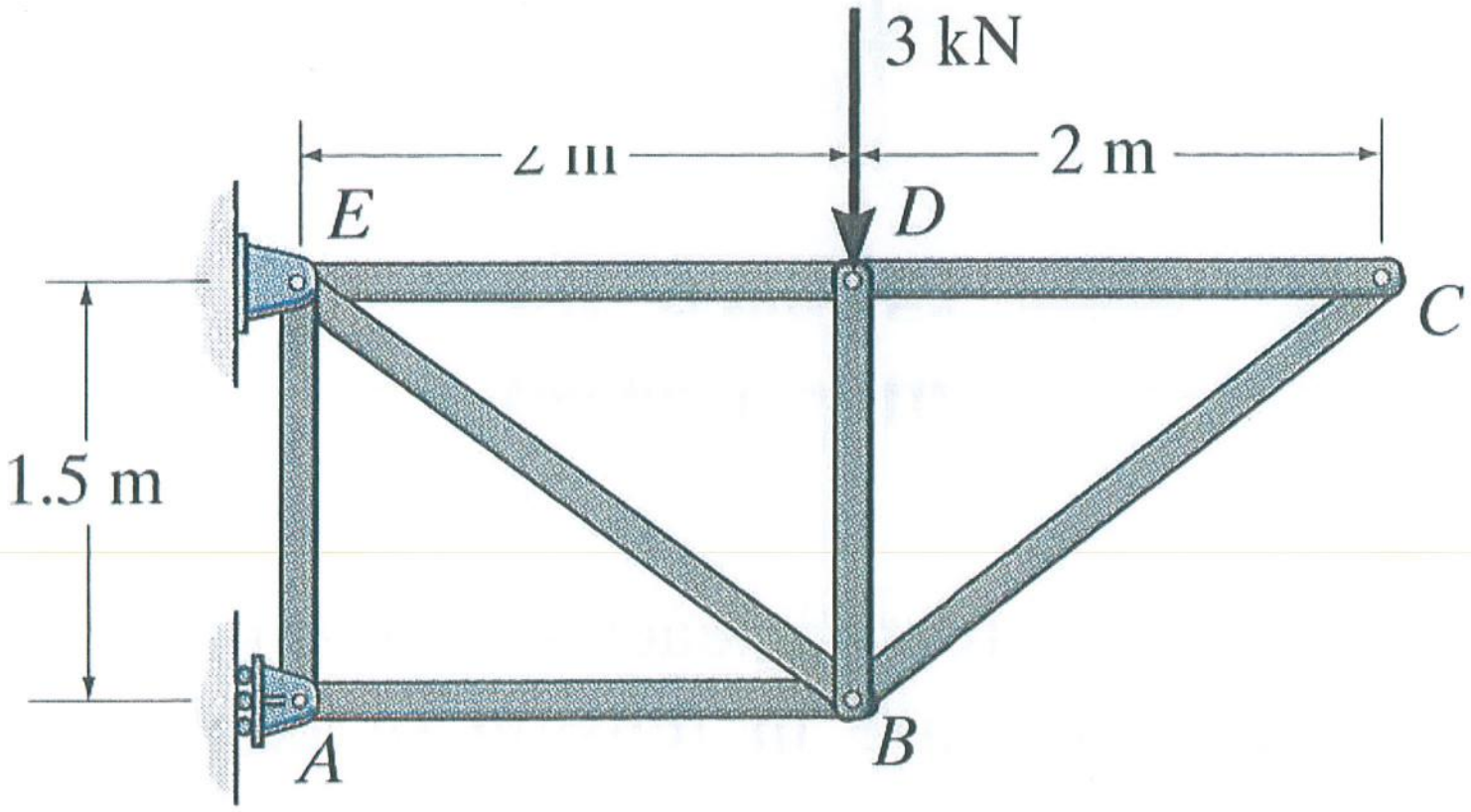


Find:

a) Sketch the overall free body diagram and determine the reactions at the supports.

b) By inspection, identify all zero-force members.

c) Using the method of joints, determine the loads in all members and state whether each is in tension or compression.


3 kN
2 m
E
D
C
1.5 m
A
B

Method of Joints
Group Quiz

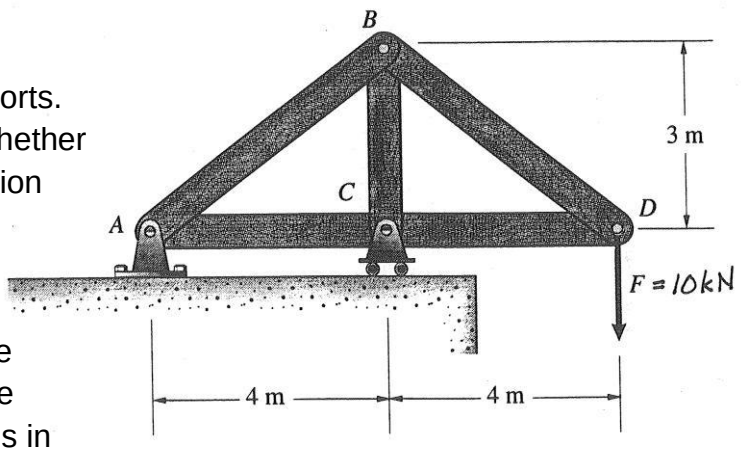
Group #: _____ Group Members: 1) _____
(Present Only)

Date: _____ Period: _____ 2) _____

3) _____

4) _____

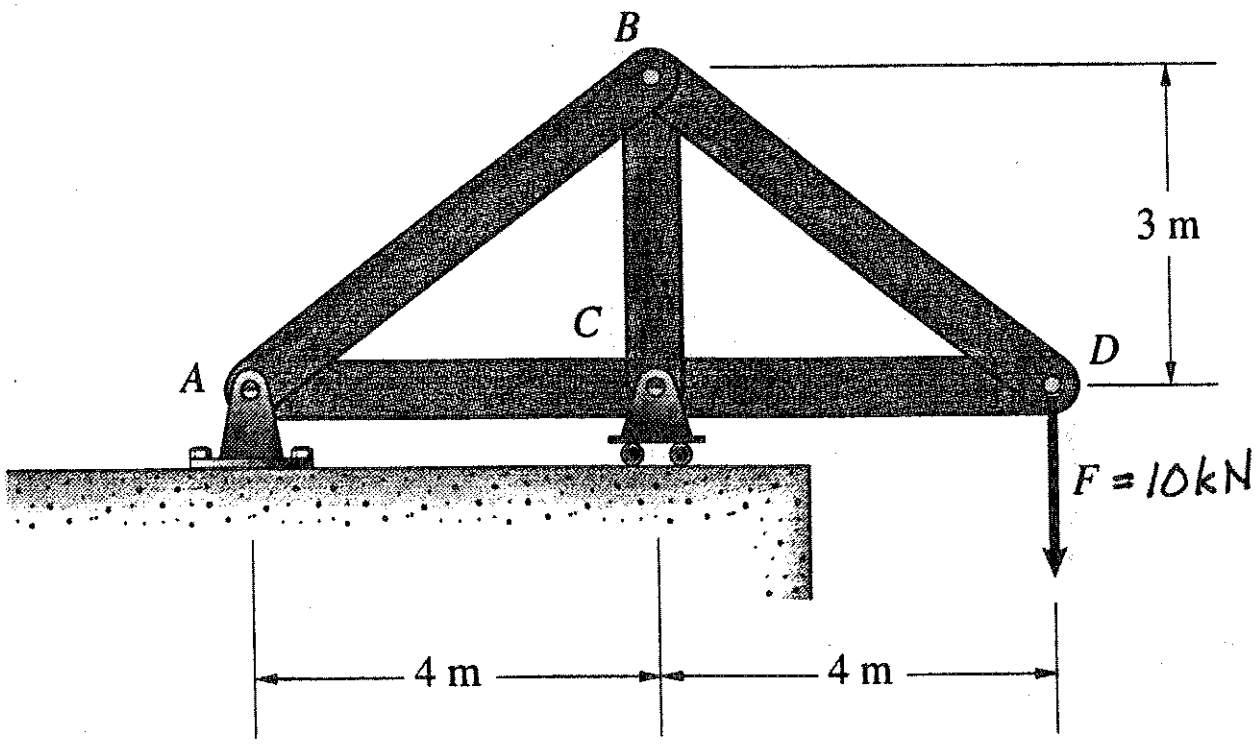
Given: The truss shown is subjected to a load of F = 10 kN.



Find:

a) Determine the reaction forces at the supports.
b) Draw a sketch of the truss and indicate whether you believe each member will be will tension or compression.
c) Using the method of joints, calculate the load carried in each member. Draw a sketch of the truss, indicate the magnitude of the load carried by each member on the sketch along with whether each member is in tension or compression.
d) If each member can safely support a tensile force of 150 kN at a compressive force of 30 kN, what is the largest load F that the truss can safely support?

Solution:


B
3 m
C
A
D
F = 10kN
4 m
4 m