# Truss Structures

- A truss is made up of straight two-force members connected at its ends. The triangular arrangement produces stable geometry. Loads on a truss are applied at the joints only.

- Joints are pin-type connections (resist translation, not rotation).

- Forces of action and reaction on a joint must be equal and opposite.

- Members in TENSION are being pulled.

- Members in COMPRESSION are being squeezed.
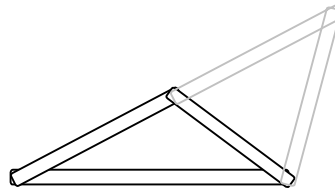
- External forces act on the joints.
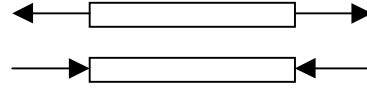
- Truss configuration:

    Three members form a <u>rigid assembly</u> with _____ connections.

    To add members and still have a rigid assembly, _____more must be added with one connection between.

   For rigidity: b = 2n – 3, where *b* is number of members and *n* is number of joints

Method of Joints

- The method takes advantage of the conditions of equilibrium at each joint.

1. Determine support reaction forces.

2. Draw a FBD of each member AND each joint

3. Identify geometry of angled members

4. Identify zero force members and other special (easy to solve) cases

5. Each pin is in equilibrium ($\sum F_x = 0$ and $\sum F_y = 0$ for a concurrent force system)

6. Total equations = 2n = b+3   (one force per member + 3 support reactions)

Advantages: Can find every member force
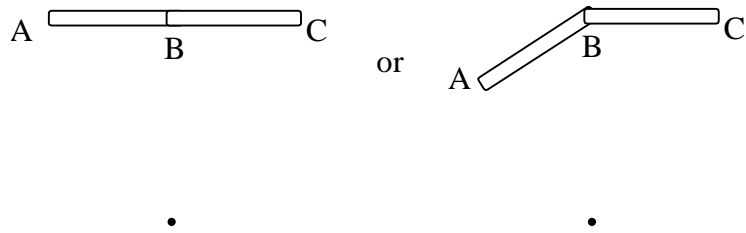Disadvantages: Lots of equations, easy to lose track of forces found.

Tools available: Tip-to-tail method for 3 joint forces must close
                          Analytically, there will be at most 2 unknowns with 2 equilibrium
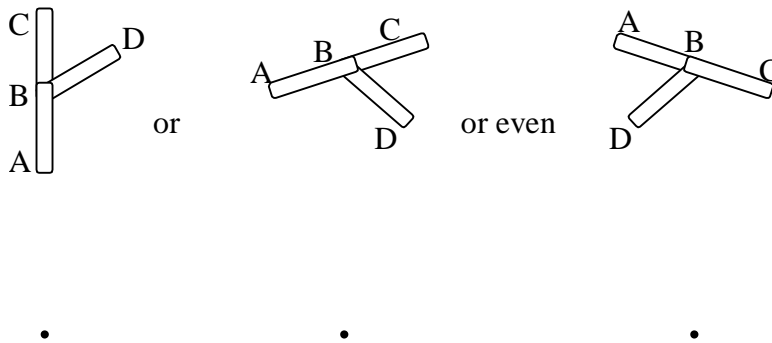   equations.
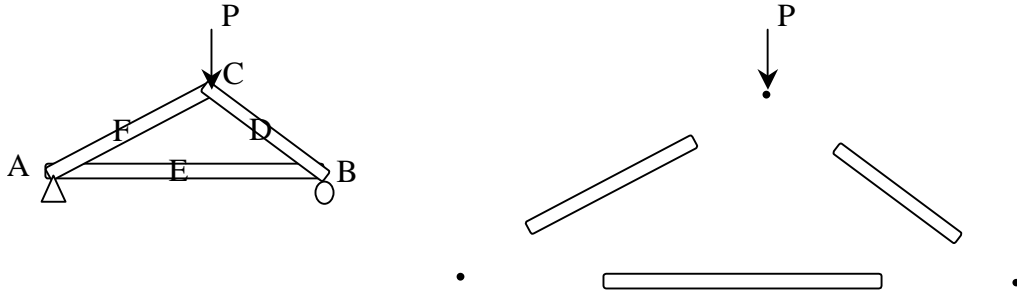
Joint Configurations   (special cases to recognize for faster solutions)

Case 1)   Two Bodies Connected

F_{AB} has to be_____ to F_{BC}

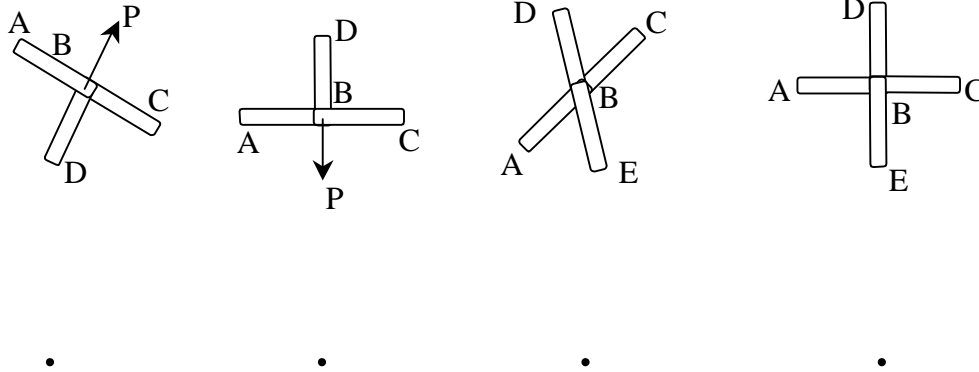Case 2)   Three Bodies Connected with Two Bodies in Line

F_{AB} and F_{BC} have to be equal, and F_{BD} has to be _____

Case 3)   Three Bodies Connected and a Force – 2 Bodies aligned & 1 Body and a Force are
            Aligned

            Four Bodies Connected - 2 Bodies Aligned and the Other 2 Bodies Aligned

F_{AB} has to equal F_{BC}, and [F_{BD} has to equal P] or [F_{BD} has to equal F_{BE}]


Graphical Analysis

The method utilizes what we know about force triangles and plotting force magnitudes *to scale*.

1. Draw an accurate form diagram of the truss at a convenient scale with the loads and support
    reaction forces.

2. Determine the support reaction forces.

3. Working clockwise and from left to right, apply interval notation to the diagram, assigning
    capital letters to the spaces between external forces and numbers to internal spaces.

4. Construct a load line to a convenient scale of length to force by using the interval notation
    and working clockwise around the truss from the upper left plotting the lengths of the vertical
    and horizontal loads.

5. Starting at a left joint where we know there are fewer than three forces, we draw reference
    lines in the direction of the unknown members so that they intersect. Label the intersection
    with the number of the internal space.

6. Go to the next joint (clockwise and left to right) with two unknown forces and repeat for all
    joints. The diagram should close.

7. Measure the line segments and apply interval notation to determine their sense: Proceeding
    clockwise around the joint, follow the notation. The direction toward the joint is
    compressive. The direction away from the joint is tensile.

Example 1 (pg 90)

Example Problem 4.1 (Method of Joints)

An asymmetrical roof truss, shown in Figure 4.4, supports two vertical roof loads. Determine the support reactions at each end, then, using the method of joints, solve for all member forces. Summarize the results of all member forces on a FBD (this diagram is referred to as a *force summation diagram*).

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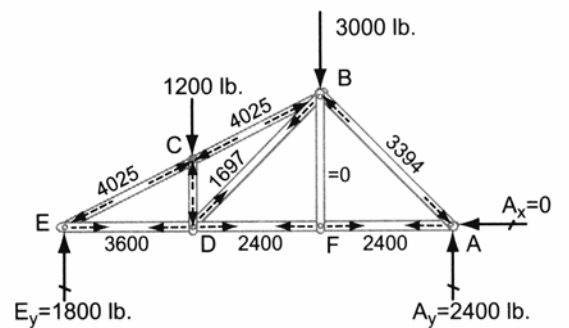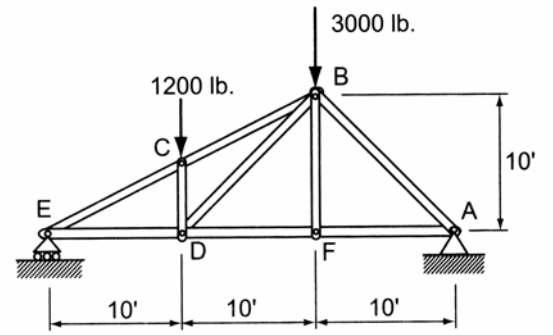
<u>Example 2 (pg 93)</u>

Example Problem 4.2 (Method of Joints)

A simple stadium truss (Figure 4.12) is loaded with two forces as shown. Solve for the support reactions at *A* and *B*, then, using the method of joints, determine all of the member forces.
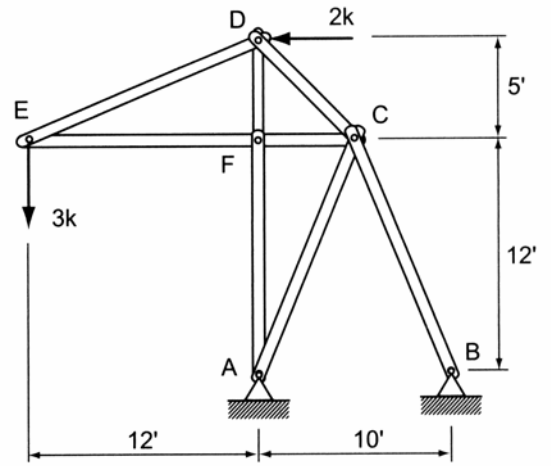
Method of Sections (relies on internal forces being in equilibrium with external forces on a
section)

1. Determine support reaction forces.

2. Cut a section in such a way that force action lines intersect.

3. Solve for equilibrium. Sum moments about an intersection of force lines of action

Advantages: Quick when you only need one or two forces (only 3 equations needed)
Disadvantages: Not always easy to find a place to cut a section or see where force lines intersect
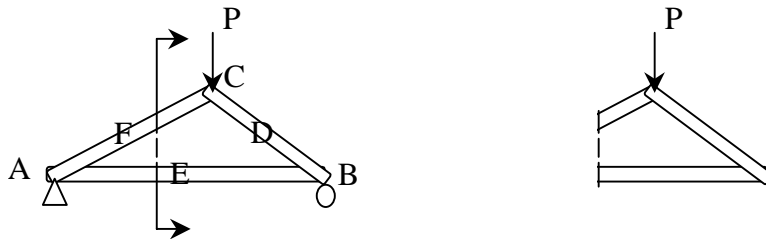
- Compound Truss: A truss assembled of simple trusses and additional links. It has b=2n-3,
  is statically determinate, rigid and completely constrained with a pin and roller. It can be
  identified by triangles with pins in the middle of some sides.

- Statically Indeterminate Trusses:

        Occur if there are more members than equations for all the joints

        OR if there are more reaction supports unknowns than 3

- Diagonal Tension Counters: Crossed bracing of cables or slender members is commonly
  used in bridge trusses, buildings and towers. These trusses look indeterminate, but can be
  solved statically because the bracing cannot hold a compressive force. The members are
  excluded in the analysis.

Method:

1. Determine support reaction forces.

2. Cut a section in such a way that the tension
   counters are exposed.

3. Solve for force equilibrium in *y* with one counter.
   If the value is positive (in tension), this is the
   solution.

4. Solve for force equilibrium in *y* with the other counter.

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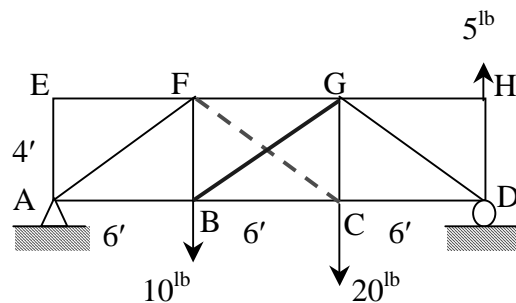
Example 3 (pg 99)

Example Problem 4.3 (Method of Sections)

A 64-foot parallel chord truss (Figure 4.30) supports hori-
zontal and vertical loads as shown. Using the method of
sections, determine the member forces *BC, HG,* and *GD.*