Structural Analysis

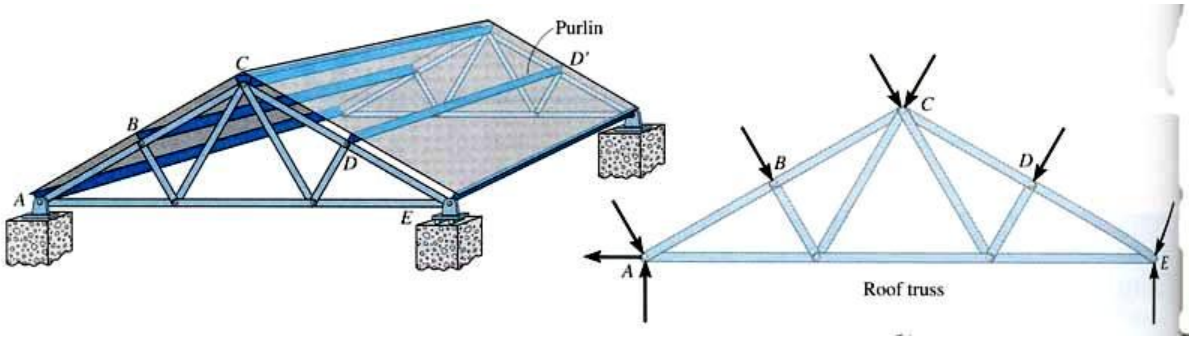
Chapter 6

Overview

- Trusses
- Analysis of Trusses
  - Method of Joints
  - Zero Force Members
  - Method of Sections
- 3-D Trusses or Space Trusses
- Frames and Machines

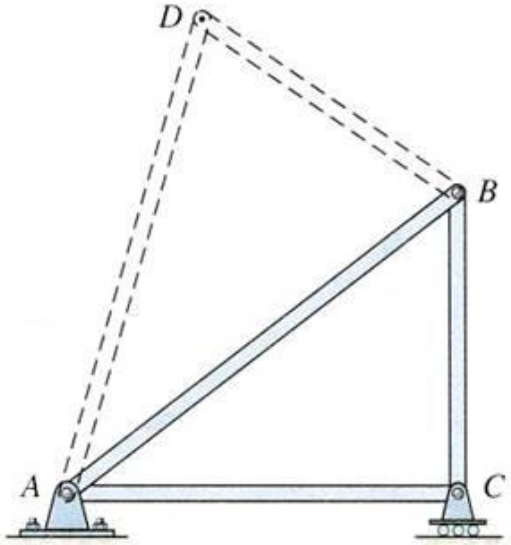
Simple Truss

- A *truss* is a structure composed of slender members joined together at their end points.
- If a truss, along with the imposed load, lies in a single plane then it is called a *planar truss*.



Simple Truss

- A *simple truss* is a planar truss which begins with a triangular element and can be expanded by adding two members and a joint.
- The number of members (M) and the number of joints (J) are related by the equation
  $M = 2J - 3$.



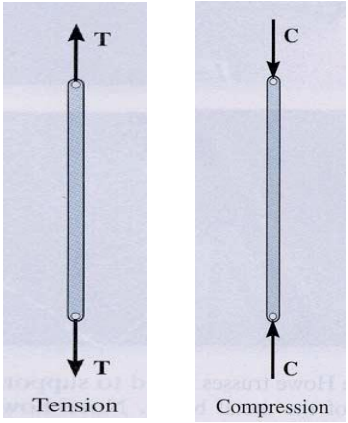
Analysis of Trusses

- It is necessary to determine the forces in each truss member. This is called the *force analysis* of a truss.

Assumptions:

- All loads are applied at the joints.
- The weight of the truss members is neglected
- The members are joined together by smooth pins (in practice by bolts)

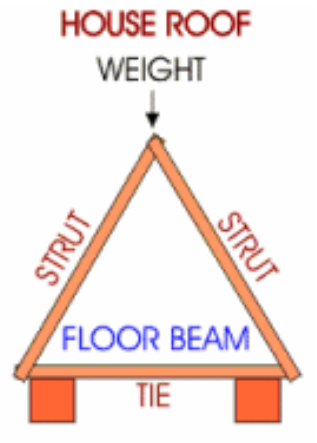
Analysis of Trusses

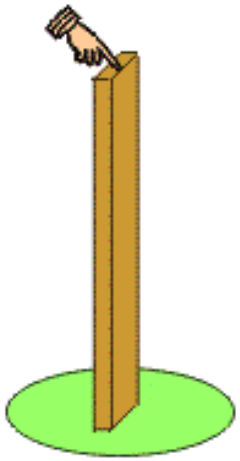


As a result of the above:

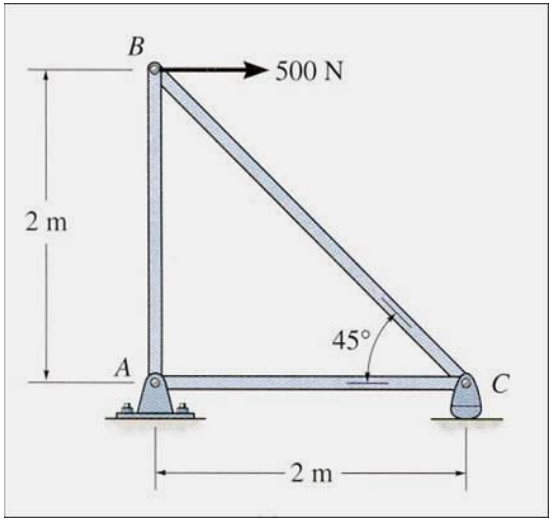
- Members act as two-force members
- Members are either in *tension* or *compression*.

In practice compression members are made thicker to prevent *buckling*





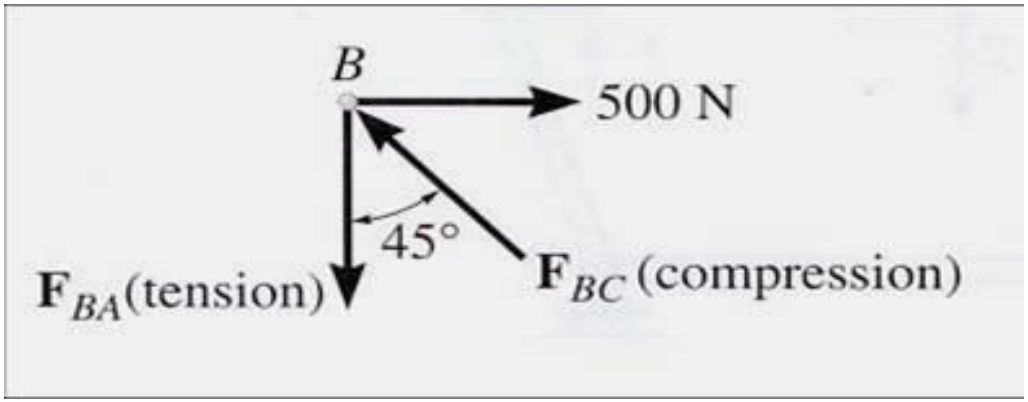
The Method of Joints



- Consider the simple frame
- We can draw the free-body diagram for the joint B
- We can apply the Equations of Equilibrium at B to solve for the unknowns

$$\sum F_X = 0$$

$$\sum F_Y = 0$$



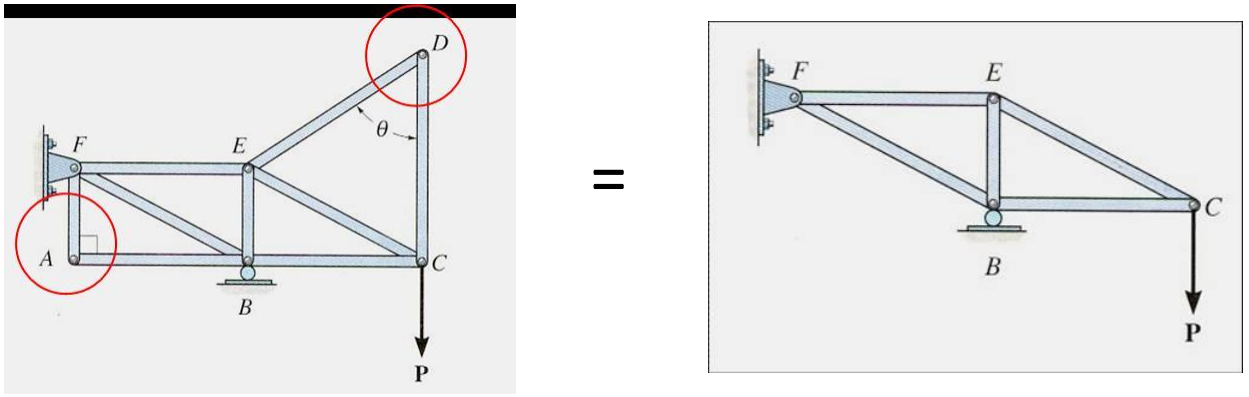
- We can repeat the process for all the other members

Method of Joints: Step-by-step

1. draw a FBD of the whole truss and determine the support reactions (using scalar equations of equilibrium
2. Draw the FBD diagram of a joint with one or two unknowns.
3. Apply the scalar equations of equilibrium,
   $\sum F_X = 0$ and $\sum F_Y = 0$,
   to determine the unknown(s).
4. Repeat steps 2 and 3 at each joint in succession until all forces are determined

Zero-Force Members

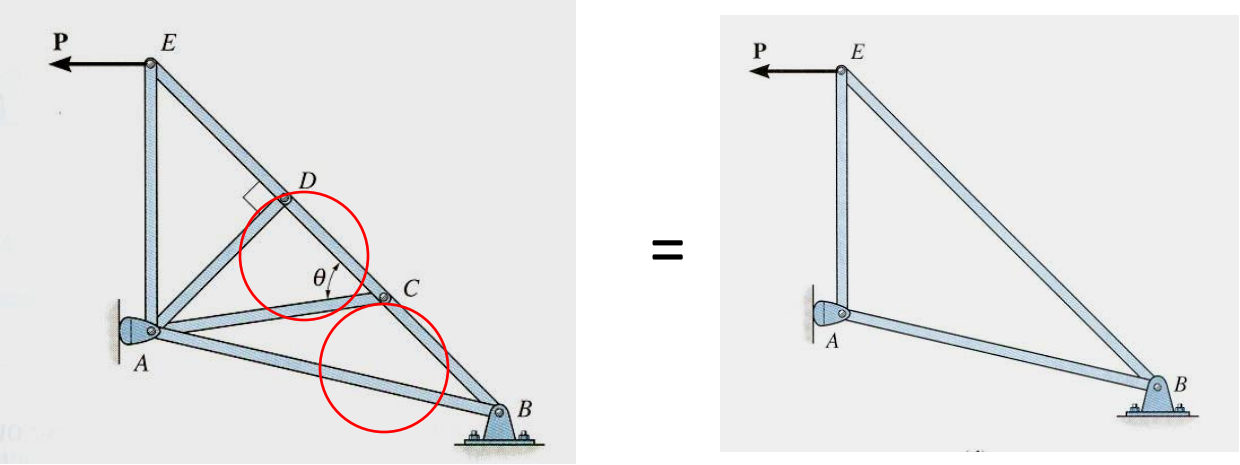
- If a joint has only two non-collinear members and there is no external load or support reaction at that joint, then those two members are *zero-force members.*



- Students: Prove on your own using Method of Joints

Zero-Force Members

- If three members form a truss joint for which two of the members are collinear and there is no external load or reaction at that joint, then the third non-collinear member is a zero force member.



- Students: Again, prove on your own using Method of Joints

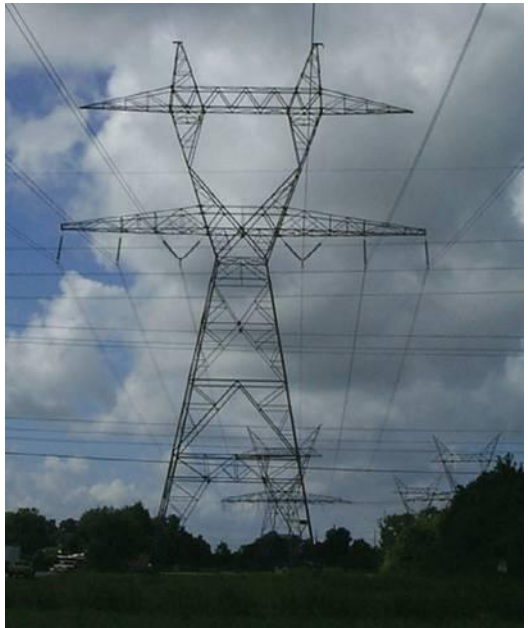
Zero-Force Members

- If they are not needed why do we see them in structures?
- They are used to increase stability and rigidity of the truss, and to provide support for various different loading conditions.

Questions & Comments

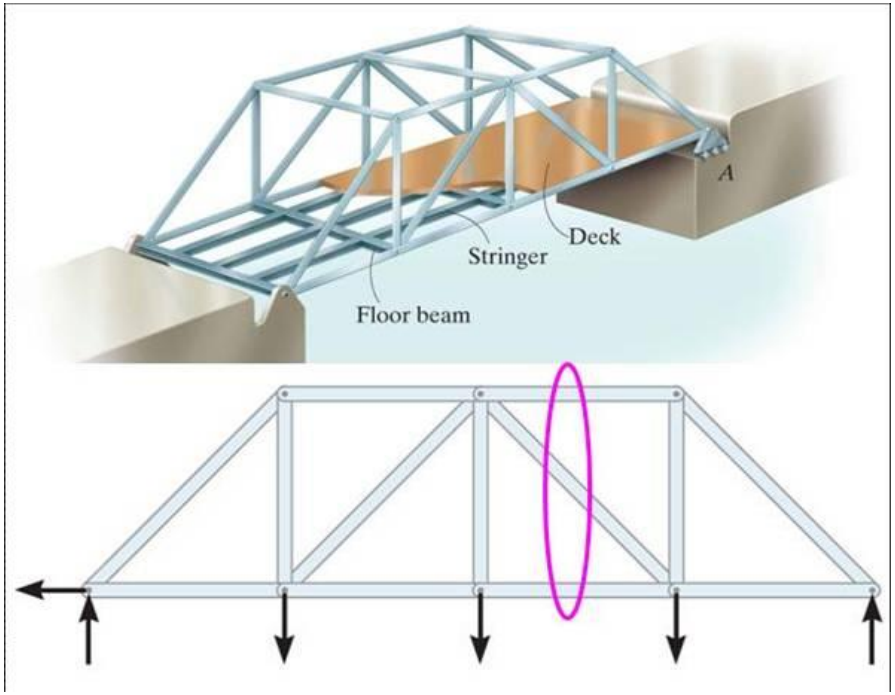
The Method Of Sections

- The method of joints requires many joints be analyzed successively before we can determine the forces all over the truss
- For large and complex trusses this can be a tedious and intensive undertaking even with modern computers



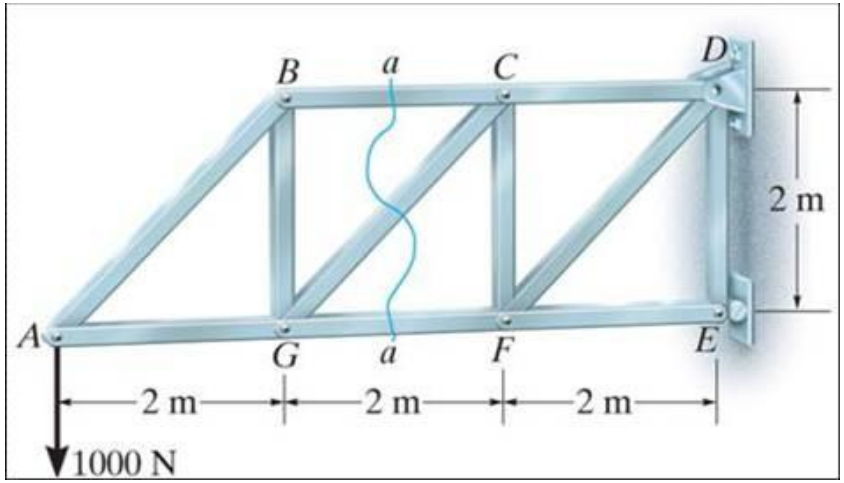
The Method Of Sections

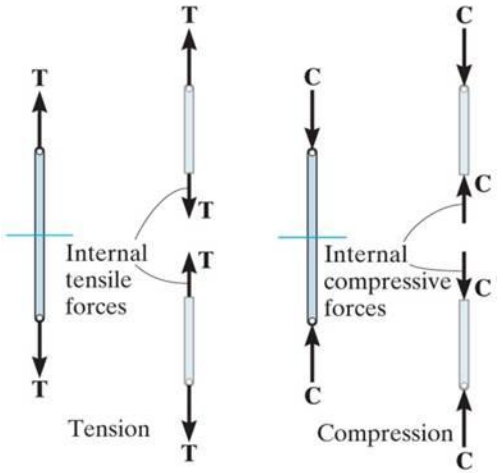
- The method of sections enables us to zoom in and analyze a member of interest without analyzing several joints to get to it.



The Method Of Sections

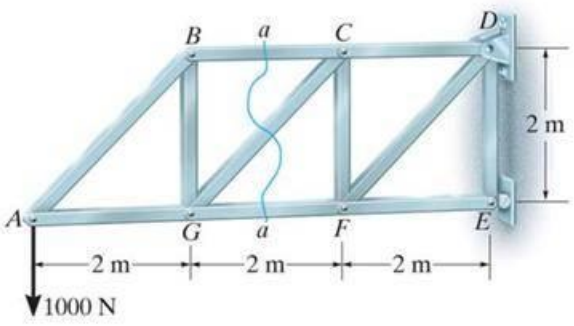
- Make an imaginary “cut” through the truss, cutting through a member of interest.
- Since truss members are subjected to only tensile or compressive forces along their length, the *internal forces* at the cut members will also be either tensile or compressive with the same magnitude

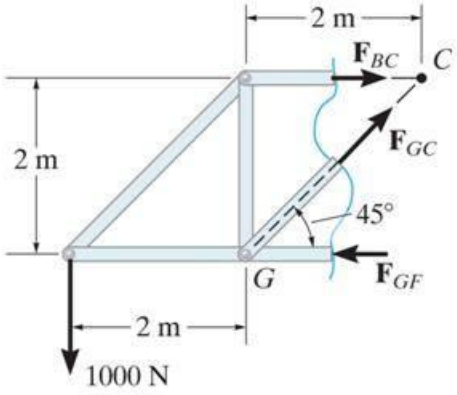


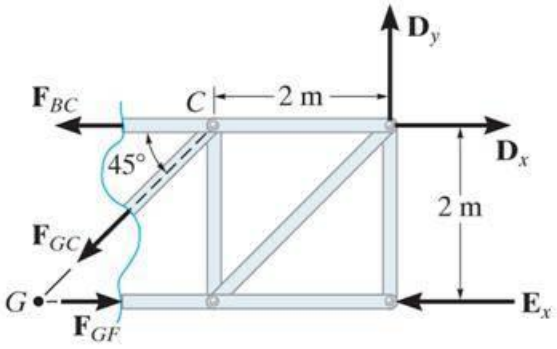


The Method Of Sections - Steps

1. Where to make the cut?
   a) where you need to determine forces, and, b) where the total number of unknowns does not exceed three
2. Decide which side of the cut truss will be easier to work with (minimize the number unknowns).

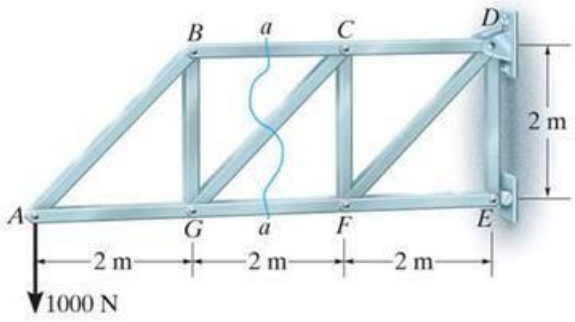


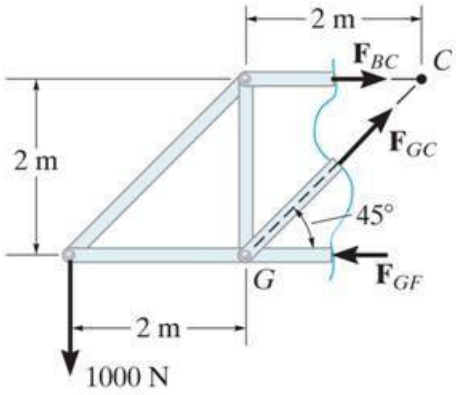


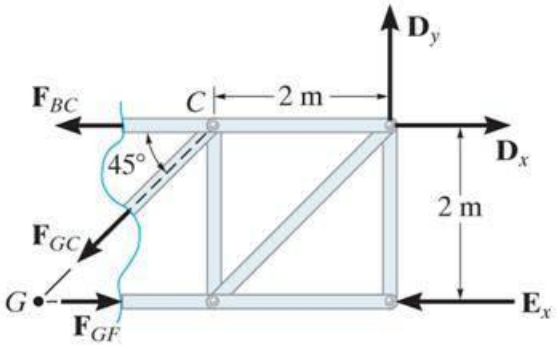


The Method Of Sections - Steps

3. determine any necessary support reactions by drawing the FBD of the entire truss
4. Draw the FBD of the selected part of the cut truss. We need to indicate the unknown forces at the cut members.



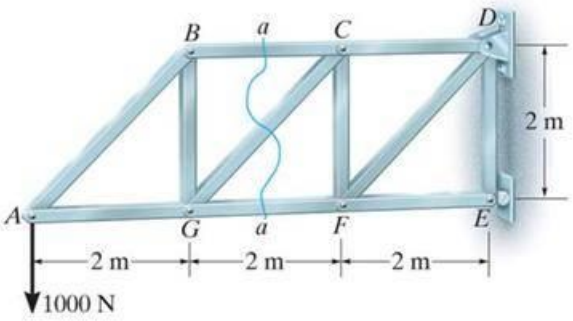


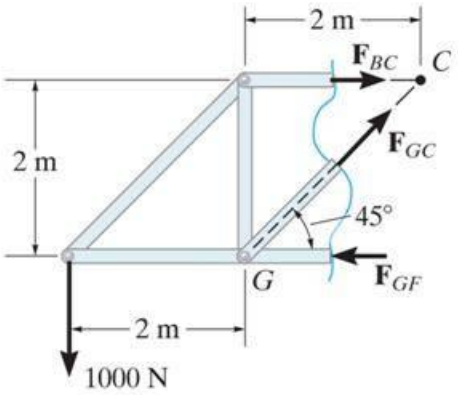


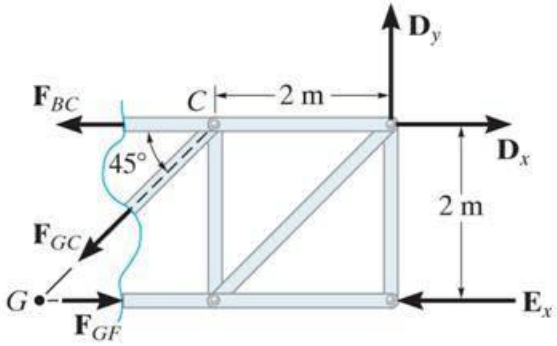
The Method Of Sections - Steps

5. Apply the *equations of equilibrium* to the selected cut section to solve for the unknown member forces.

- Note that in most cases it is possible to write one equation to solve for one unknown directly.



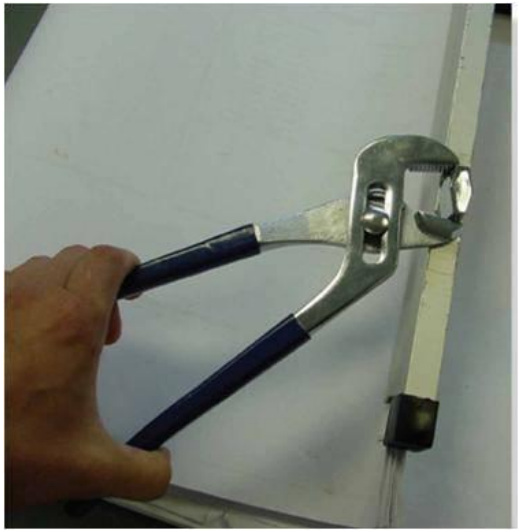




Questions & Comments ??

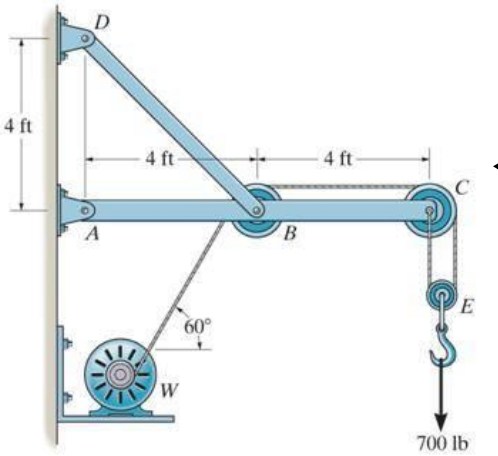
- Examples

Frames & Machines



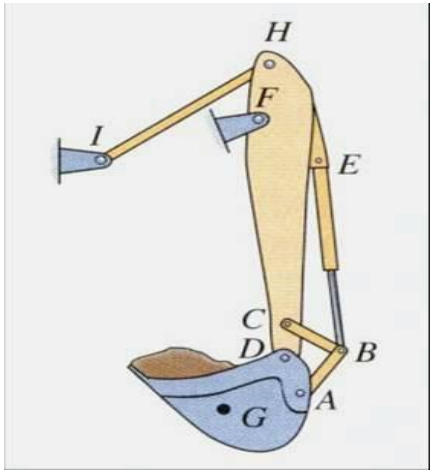
Frames and Machines: Definitions

- *Frames* are generally *stationary* and support external loads
- *Machines* contain *moving parts* and are designed to alter the effect of forces.
- Frames and machines have at least one *multi-force member*. (Recall that trusses have two-force members)



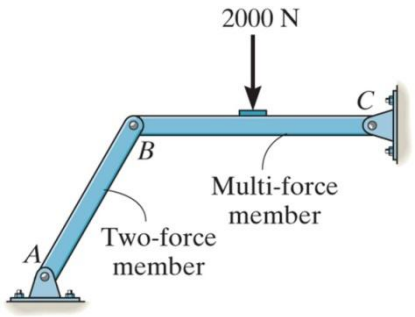
← Frame

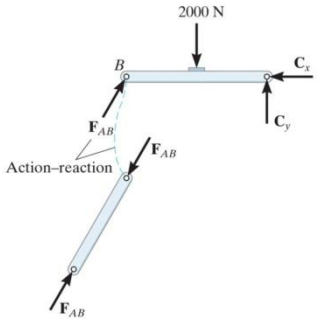
Machine →



Analysis of Frames & Machines

1. Draw the FBD of the frame or machine and its members





2. Develop a strategy to apply the equations of equilibrium to solve for the unknowns.

Analysis of Frames & Machines: Hints

- Identify any two-force members
- forces on contacting surfaces (usually between a pin and a member) are equal and opposite
- for a joint with more than two members or an external force, it is advisable to draw a FBD of the pin.
- Develop a strategy to apply the equations of equilibrium to solve for the unknowns.
- Problems are quite challenging since there are usually several unknowns.
- Practice and develop good strategies.

Questions & Comments ??

- Examples