

### Method of Joints

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- If a truss is in equilibrium, then each of its joints must be in equilibrium.
- The **method of joints** consists of satisfying the equilibrium equations for forces acting on each joint.

$$\sum F_x = 0 \quad \sum F_y = 0$$

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- Recall, that the line of action of a force acting on a joint is determined by the geometry of the truss member.
- The *line of action* is formed by connecting the two ends of each member with a straight line.
- Since direction of the force is known, the remaining unknown is the magnitude of the force.

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The diagram illustrates two types of forces on a member between joints A and B. In the top part, labeled 'Tension Force', arrows labeled 'T' point away from joints A and B. In the bottom part, labeled 'Compression Force', arrows labeled 'C' point towards joints A and B.

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A truss structure is shown with labels for its components: 'Upper chord members' at the top, 'Lower chord members' at the bottom, 'Verticals' connecting them, and 'Diagonals' crossing the interior.

### Method of Joints

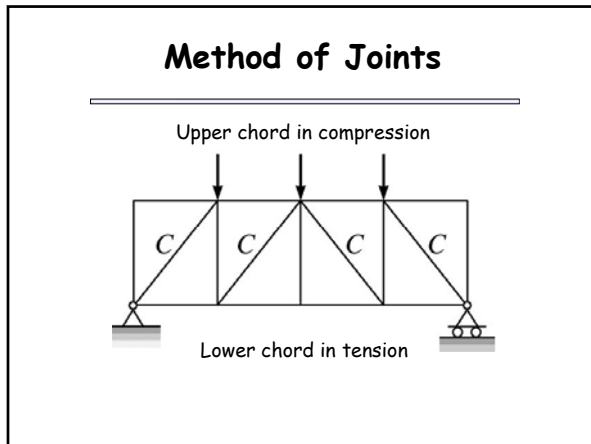
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On the left, a 3D diagram shows a 'gusset plate' being joined to a member by a 'weld'. On the right, a 2D diagram shows an 'Idealized joint - members connected by a frictionless pin', with a dashed line representing the line of action.

### Method of Joints

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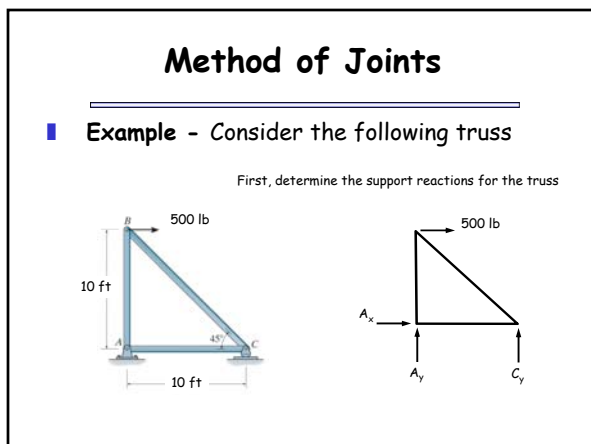
A truss under a downward load is shown. The top members are labeled 'Upper chord in compression' and the bottom members are labeled 'Lower chord in tension'. Diagonal members are labeled with 'T' for tension.



- ### Method of Joints
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- **Procedure for analysis** - the following is a procedure for analyzing a truss using the method of joints:
    1. If possible, determine the support reactions
    2. Draw the free body diagram for each joint. In general, assume all the force member reactions are **tension** (this is not a rule, however, it is helpful in keeping track of tension and compression members).

- ### Method of Joints
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- **Procedure for analysis** - the following is a procedure for analyzing a truss using the method of joints:
    3. Write the equations of equilibrium for each joint,
 
$$\sum F_x = 0 \quad \sum F_y = 0$$

- ### Method of Joints
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- **Procedure for analysis** - the following is a procedure for analyzing a truss using the method of joints:
    4. If possible, begin solving the equilibrium equations at a joint where only two unknown reactions exist. Work your way from joint to joint, selecting the new joint using the criterion of two unknown reactions.
    5. Solve the joint equations of equilibrium simultaneously, typically using a computer or an advanced calculator.



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- **Example** - Consider the following truss
 

First, determine the support reactions for the truss

$$\sum M_A = 0 = -500 \text{ lb}(10 \text{ ft}) + C_y(10 \text{ ft})$$

$$C_y = 500 \text{ lb}$$

$$\sum F_y = 0 = A_y + C_y$$

$$A_y = -500 \text{ lb}$$

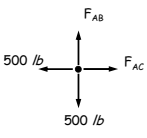
$$\sum F_x = 0 = A_x + 500 \text{ lb}$$

$$A_x = -500 \text{ lb}$$

### Method of Joints

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The equations of equilibrium for Joint A



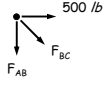
$$\sum F_x = 0 = F_{AC} - 500 \text{ lb} \quad \boxed{F_{AC} = 500 \text{ lb}}$$

$$\sum F_y = 0 = F_{AB} - 500 \text{ lb} \quad \boxed{F_{AB} = 500 \text{ lb}}$$

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The equations of equilibrium for Joint B



$$\sum F_x = 0 = F_{BC} \cos 45^\circ + 500 \text{ lb} \quad \boxed{F_{BC} = -707.2 \text{ lb}}$$

The forces in the truss can be summarized as:

$F_{AB} = 500 \text{ lb (T)}$

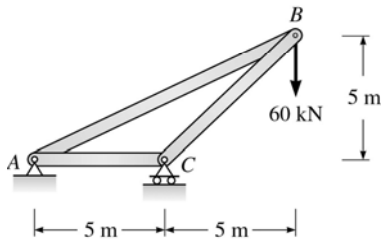
$F_{BC} = 707.2 \text{ lb (C)}$

$F_{AC} = 500 \text{ lb (T)}$

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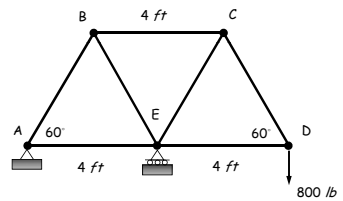
- **Problem** - Determine the force in each member of the truss shown below



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- **Problem** - Determine the force in each member of the truss shown below

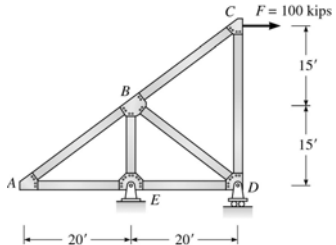


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### Method of Joints

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- **Problem** - Determine the force in each member of the truss shown below



### Zero Force Members

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- Truss analysis may be simplified by determining members with no loading or zero-force.
- These members may provide stability or be useful if the loading changes.
- Zero-force members may be determined by inspection of the joints

### Zero Force Members

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- Case 1: If two members are connected at a joint and there is no external force applied to the joint

$$\sum F_y = 0 = F_1 \sin \theta \quad \boxed{F_1 = 0}$$

$$\sum F_x = 0 = F_1 \cos \theta + F_2 \quad \boxed{F_2 = 0}$$

### Zero Force Members

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- Case 2: If three members are connected at a joint and there is no external force applied to the joint and two of the members are colinear

$$\sum F_y = 0 = F_1 \sin \theta \quad \boxed{F_1 = 0}$$

### Zero Force Members

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- Determine the force in each member of the truss shown below:

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Using Case 2  $F_{BG}$  and  $F_{DF}$  are zero-force members

### Zero Force Members

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- Determine the force in each member of the truss shown below:

Using Case 1  $F_{AG}$  and  $F_{CE}$  are zero-force members

Using Case 1  $F_{EG}$  and  $F_{CF}$  are zero-force members

### Zero Force Members

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- Determine the force in each member of the truss shown below:

The remaining non-zero forces can be found using the method of joints

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The equations of equilibrium for Joint C

$$\sum F_x = 0 = -\frac{4}{5}F_{BC} + \frac{4}{5}F_{CD} \quad \boxed{F_{BC} = F_{CD}}$$

$$\sum F_y = 0 = -\frac{3}{5}F_{BC} - \frac{3}{5}F_{CD} - 800 \text{ lb}$$

$$\boxed{F_{BC} = -666.7 \text{ lb}}$$

$$\boxed{F_{BC} = 666.7 \text{ lb (C)}}$$

## End of Trusses - Part 2

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Any questions?

