Engineering Mechanics : Statics

Chapter 6: Structural analysis

Chapter outline

- Simple Trusses
- **The Method of Joints**
- Zero-Force Members
- The Method of Sections
- Space Trusses
- Frames and Machines

6. 2 The Method of joints

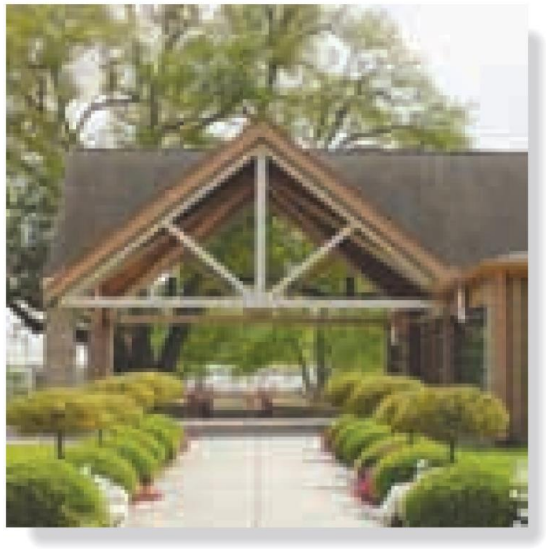
- For design analysis of a truss, we need to obtain the force in each of the members
- Considering the FBD, the forces in the members are internal forces and could not be obtained from an equilibrium analysis
- Considering the equilibrium of a joint of the truss, a member force becomes an external force on the joint's FBD and equations of equilibrium can be applied
- This forms the basis for the method of joints
- Truss members are all straight two force members lying in the same plane
- The force system acting at each joint is coplanar and concurrent
- Rotational or moment equilibrium is automatically satisfied at the pin
- $\sum F_x = 0$ and $\sum F_y = 0$ must be satisfied for equilibrium

6. 2 The Method of joints

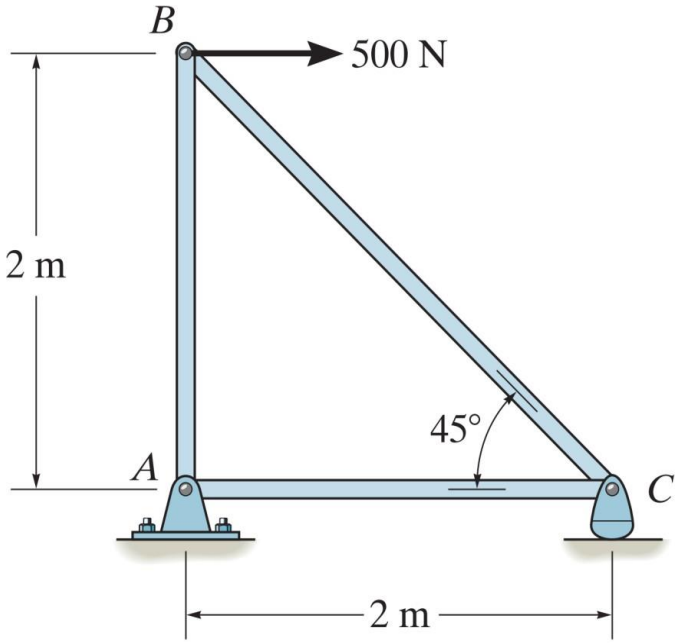
Example

-Consider pin at joint B

-Three forces: 500N force and forces exerted by members BA and BC



The forces in the members of this simple roof truss can be determined using the method of joints. (© Russell C. Hibbeler)



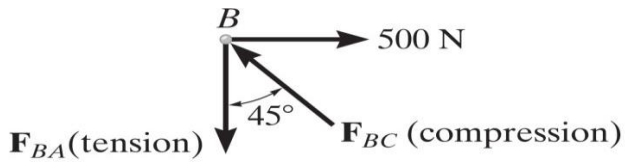
(a)

6. 2 The Method of joints

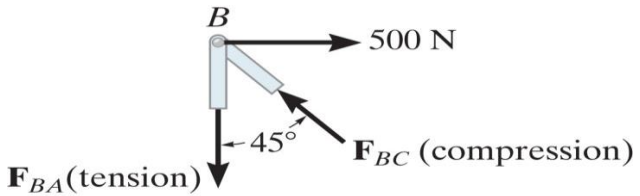
-$\mathbf{F}_{BA}$ is “pulling” on the pin, meaning the member BA is in tension
-$\mathbf{F}_{BC}$ is “pushing” on the pin, meaning the member BC is in compression
-The pushing and pulling indicates the effect of the member being either in tension or compression

Sense of Direction

By inspection Or by assuming all forces as tension and let the math decide.



(b)



(c)

6. 2 The Method of joints

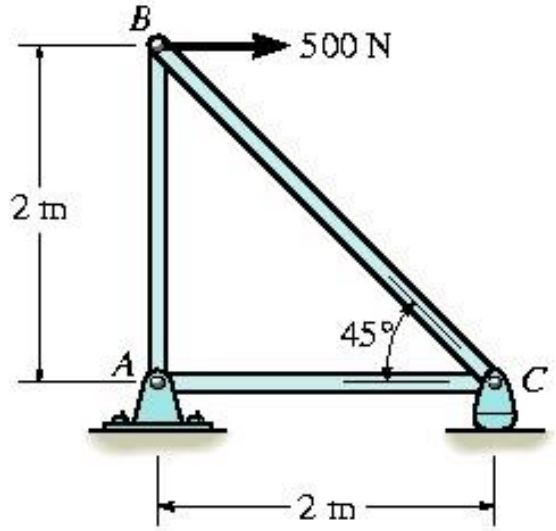
Choosing the correct sense of direction of an unknown member force:

1. The correct sense of direction of an unknown member force can, in many cases be determined by inspection. However, in more complicated cases, the sense of an unknown member force can be assumed; then after applying the equilibrium equations, the assumed sense can be verified from the numerical results.
2. A positive answer indicates that the sense is correct, whereas a negative answer indicates that the sense shown on the FBD must be reversed.
3. Always assume the unknown member forces acting on the joint's FBD to be in tension; i.e. the forces pull on the pin. If this is done, then numerical solution of the equilibrium equations will yield *positive scalars for members in tension and negative scalars for members in compression*. Once an unknown member force is found, use its *correct* magnitude and sense (T or C) on subsequent joint free-body diagrams.

6. 2 The Method of joints

Example 6.1

Determine the force in each member of the truss and indicate whether the members are in tension or compression.



(a)

Solution

- Two unknown member forces at joint B
- One unknown reaction force at joint C
- Two unknown member forces and two unknown reaction forces at point A

6. 2 The Method of joints

Solution

Joint B

$$+\rightarrow \sum F_x = 0;$$

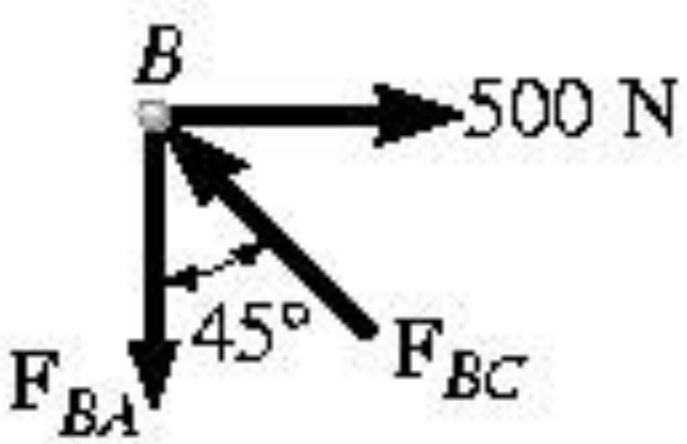
$$500N - F_{BC}\sin 45^\circ N = 0$$

$$F_{BC} = 707.1N(C)$$

$$+\uparrow \sum F_y = 0;$$

$$F_{BC}\cos 45^\circ N - F_{BA} = 0$$

$$F_{BA} = 500N(T)$$



(b)

6. 2 The Method of joints

Solution

Joint C

$$+\rightarrow \sum F_x = 0;$$

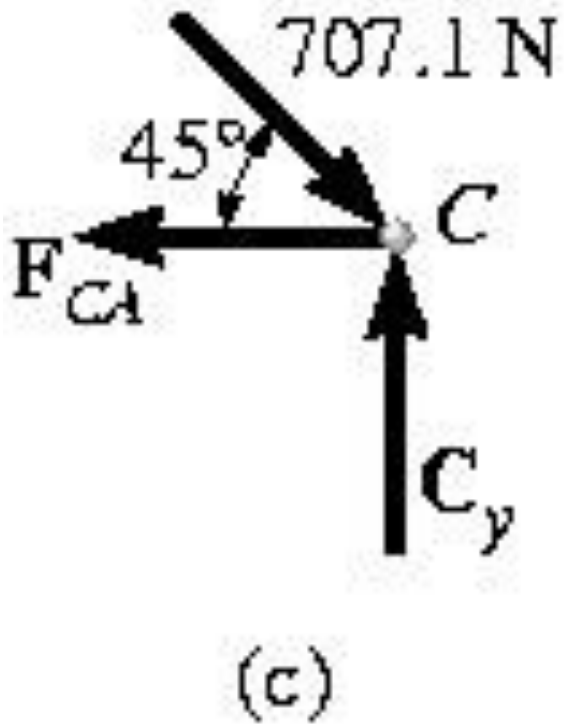
$$-F_{CA} + 707.1\cos 45^\circ N = 0$$

$$F_{CA} = 500N(T)$$

$$+\uparrow \sum F_y = 0;$$

$$C_y - 707.1\sin 45^\circ N = 0$$

$$C_y = 500N$$



(c)

6. 2 The Method of joints

Solution

Joint A

$$+\rightarrow \sum F_x = 0;$$

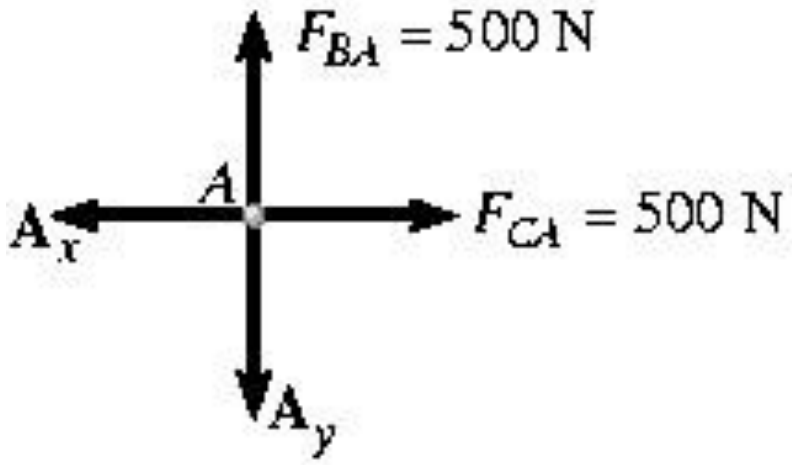
$$500N - A_x = 0$$

$$A_x = 500N$$

$$+\uparrow \sum F_y = 0;$$

$$500N - A_y = 0$$

$$A_y = 500N$$

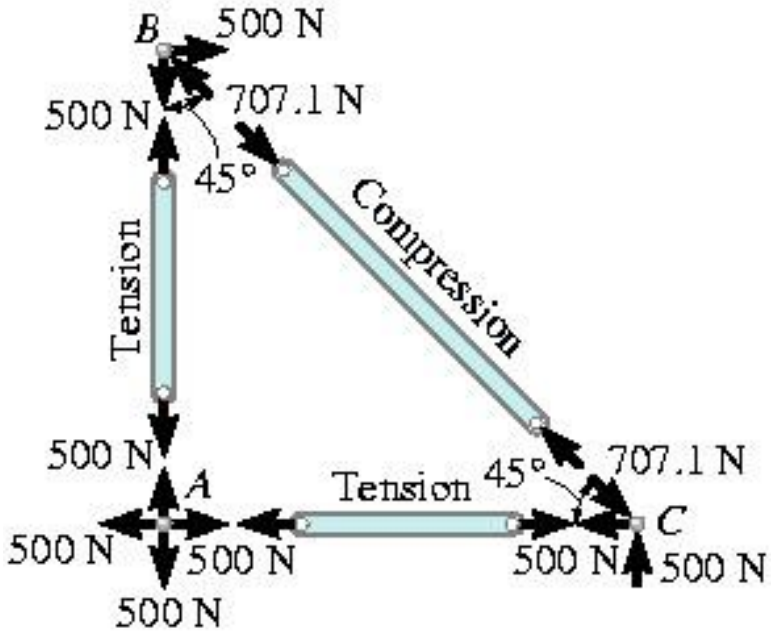


(d)

6. 2 The Method of joints

Solution

- FBD of each pin shows the effect of all the connected members and external forces applied to the pin
- FBD of each member shows only the effect of the end pins on the member

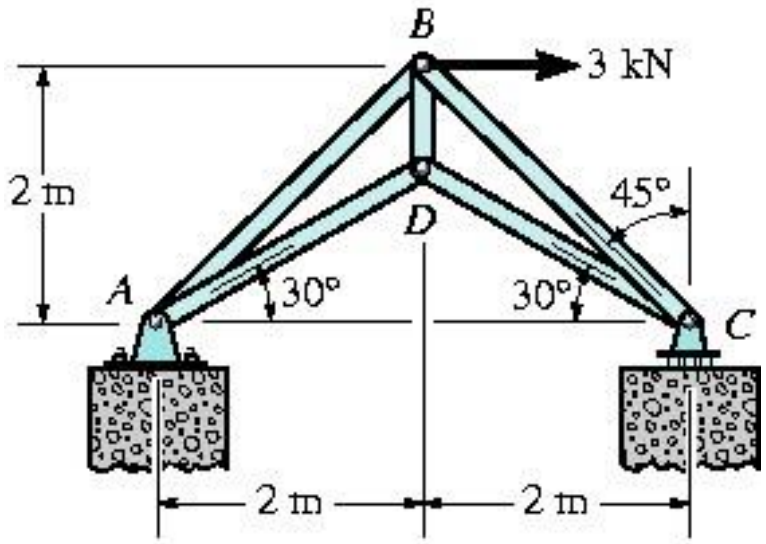


(e)

6. 2 The Method of joints

Example 6.2

Determine the forces acting in all the members of the truss.

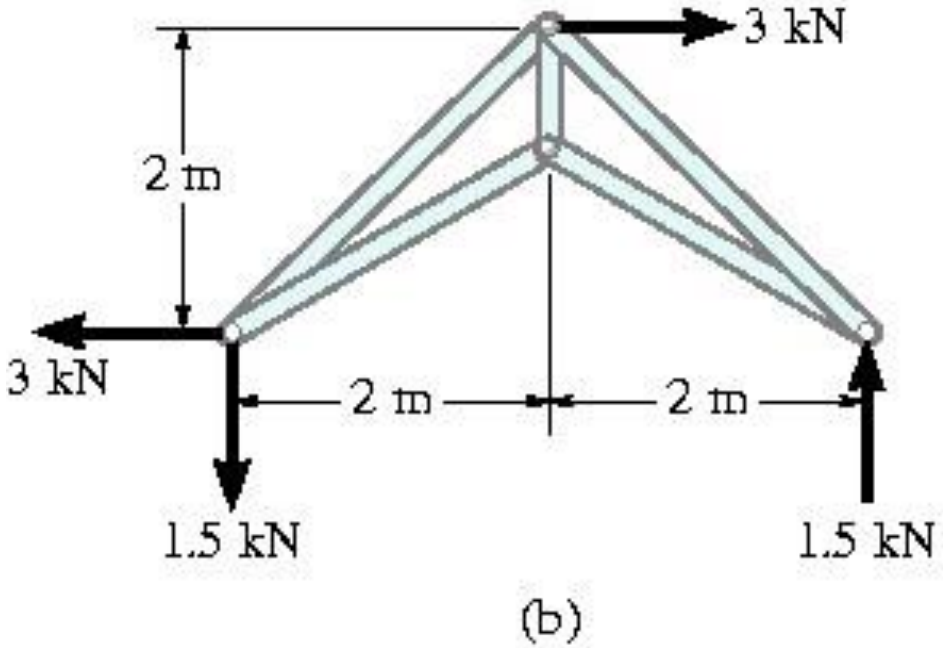


(a)

6. 2 The Method of joints

Solution

- Two unknowns at each joint
- Support reactions on the truss must be determined



(b)

6. 2 The Method of joints

Solution

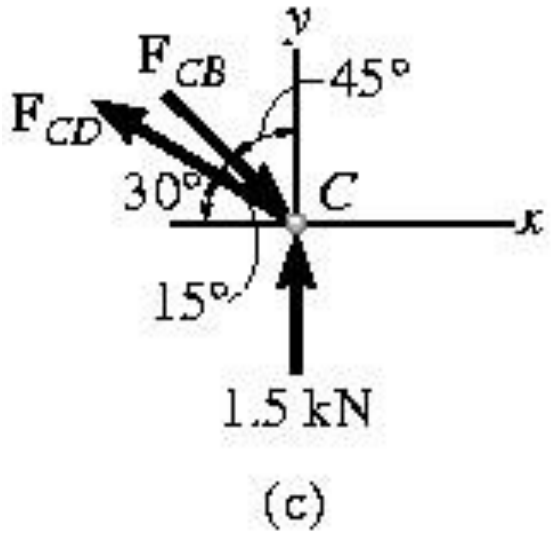
Joint C

$$+\rightarrow \sum F_x = 0;$$

$$-F_{CD}\cos 30^\circ kN + F_{CB}\sin 45^\circ kN = 0$$

$$+\uparrow \sum F_y = 0;$$

$$1.5kN + F_{CD}\sin 30^\circ kN - F_{CB}\cos 45^\circ kN = 0$$



(c)

6. 2 The Method of joints

Solution

Joint D

$$+\rightarrow \sum F_x = 0;$$

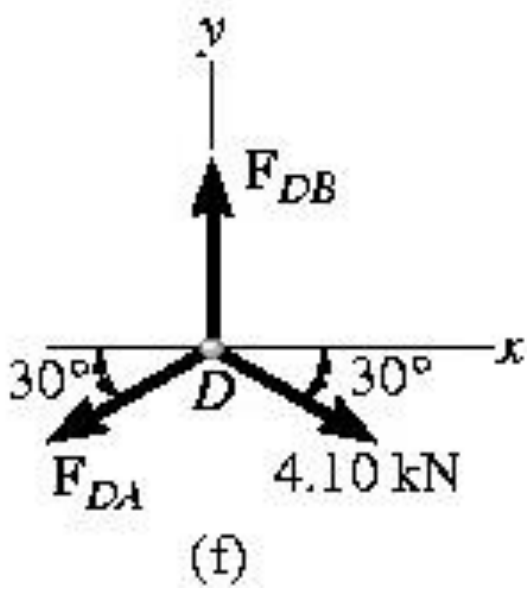
$$-F_{DA}\cos 30^\circ kN + 4.10\cos 30^\circ kN = 0$$

$$F_{DA} = 4.10kN(T)$$

$$+\uparrow \sum F_y = 0;$$

$$F_{DB} - 2(4.10\sin 30^\circ kN) = 0$$

$$F_{DB} = 4.10kN(T)$$



(f)

HOME ASSIGNMENT

- Example 6.3.