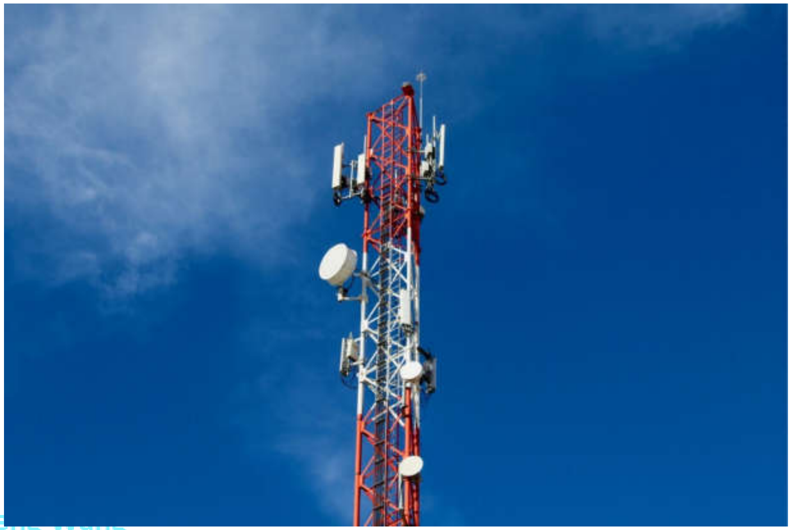
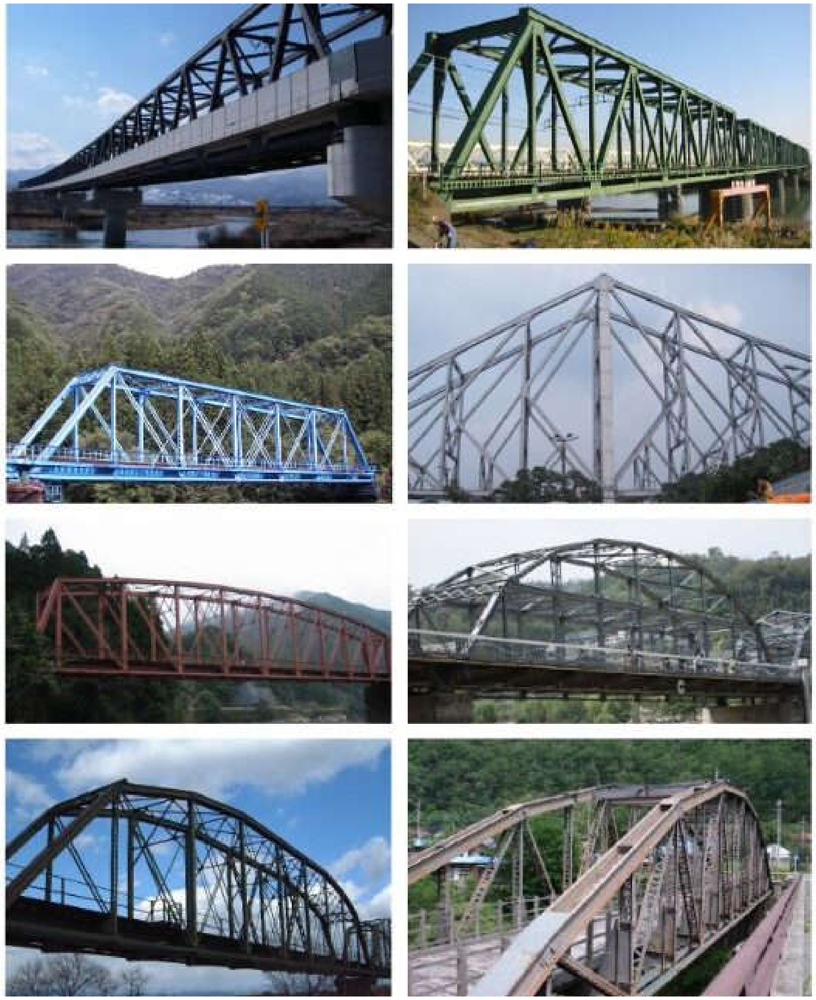
# Truss structures

# Engineering Mechanics: Statics

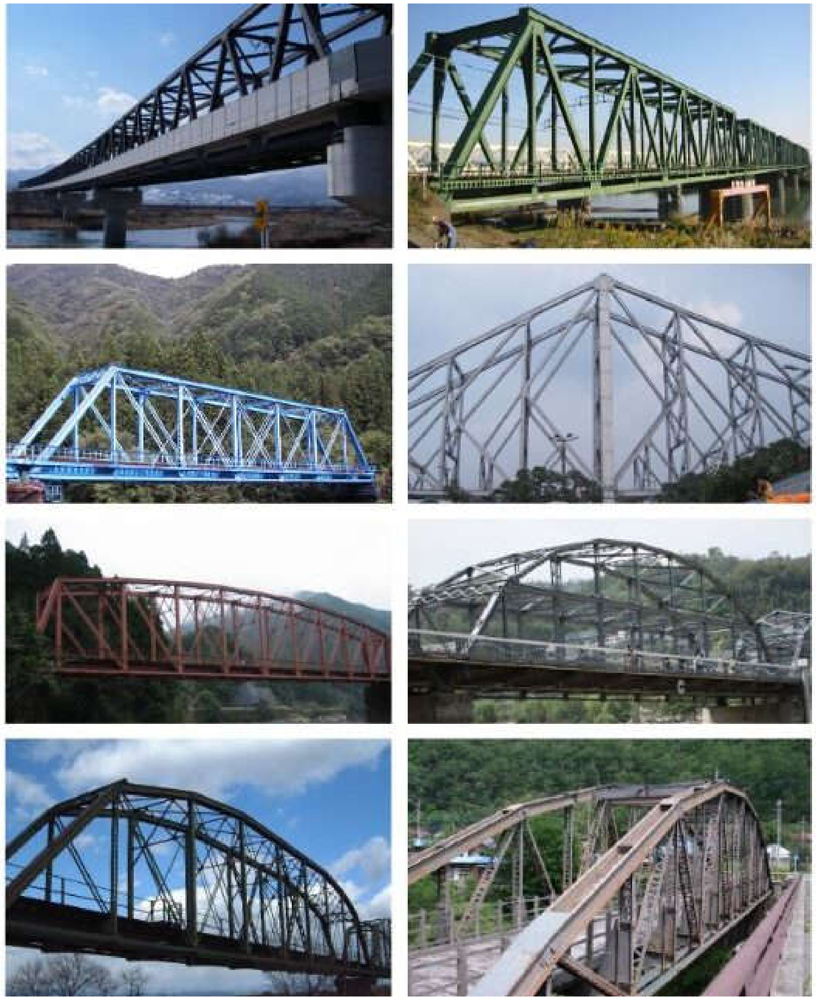




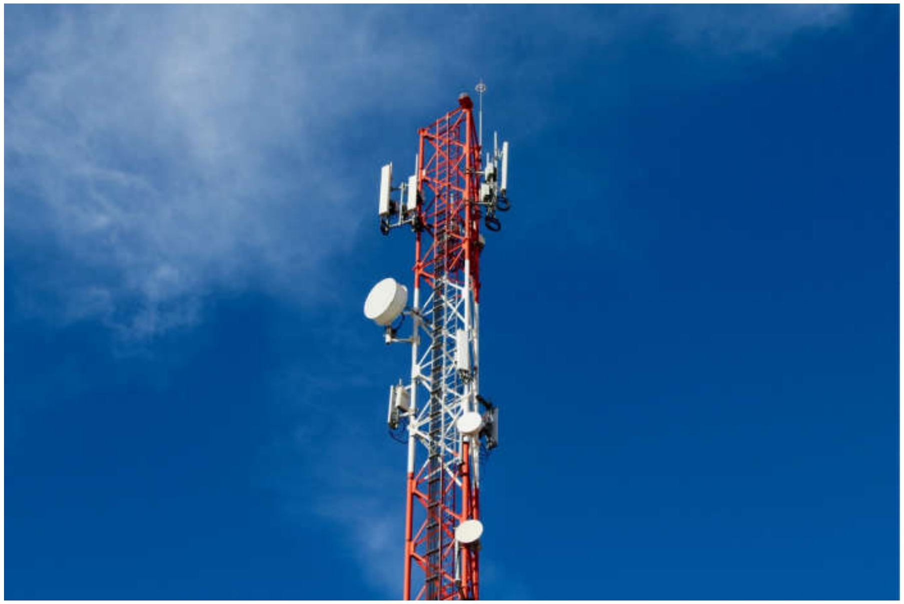
## Truss structures:

### Introduction:

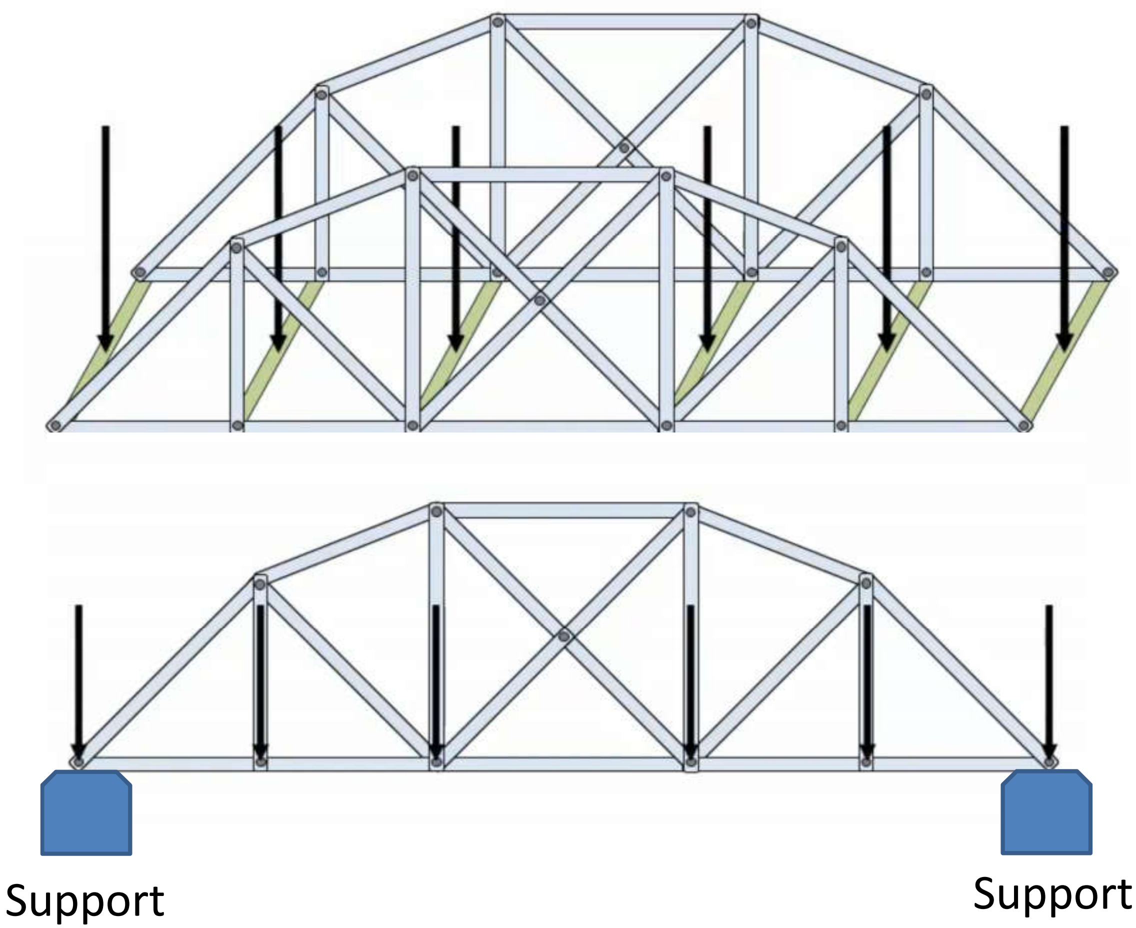
**Truss structures is widely used in construction, especially in bridges, roofs, and communication towers**

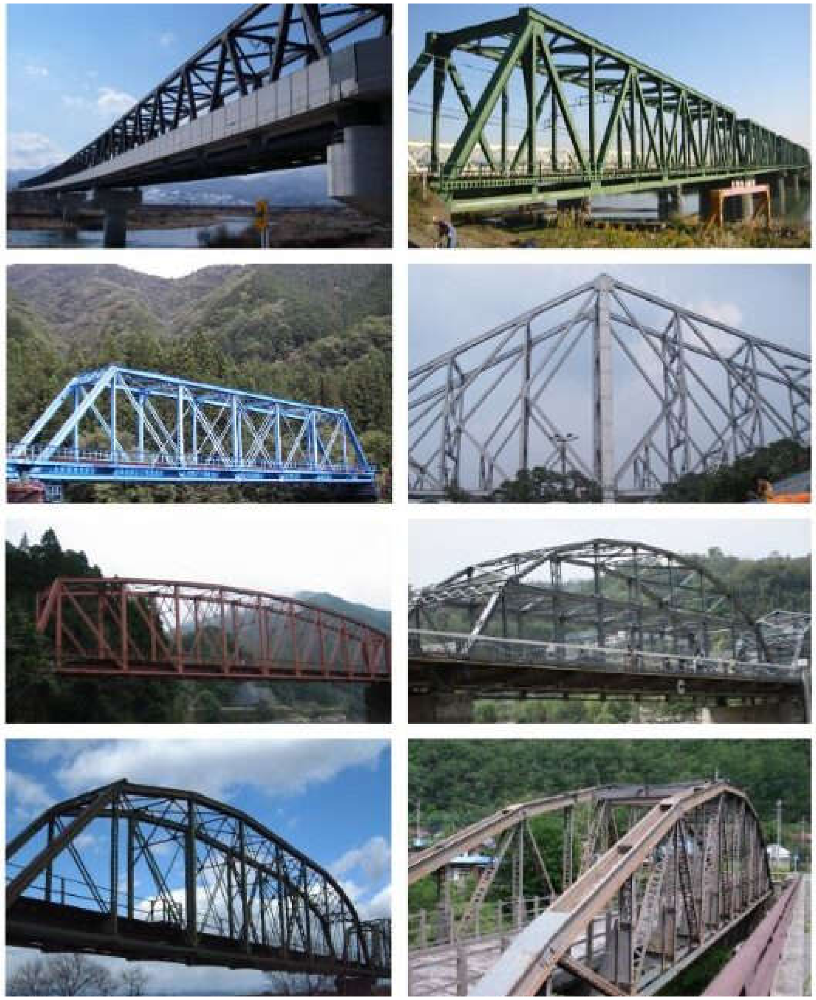


Warehouse/ or other usage



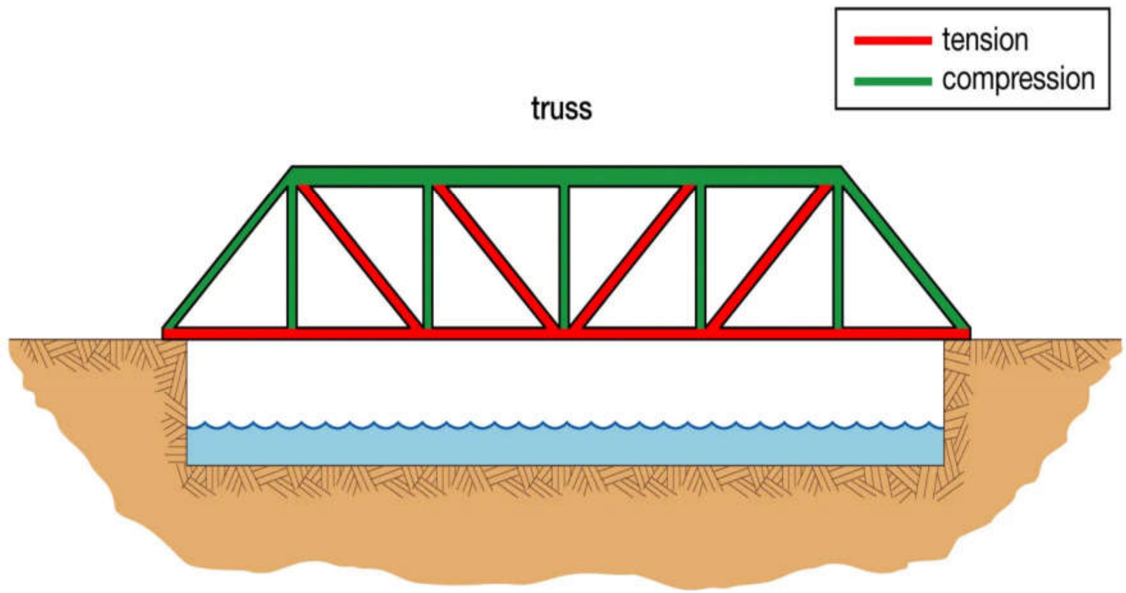
Communication tower


Support
Support



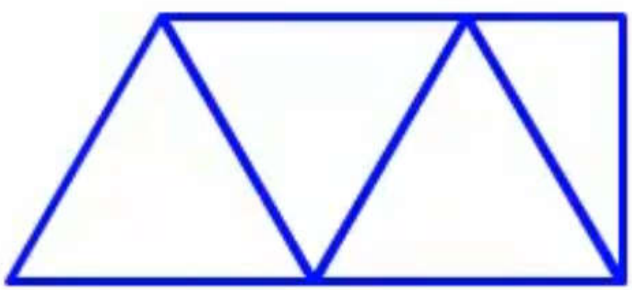
## Objective:

**The objective of this section is to determine the forces in the truss elements**

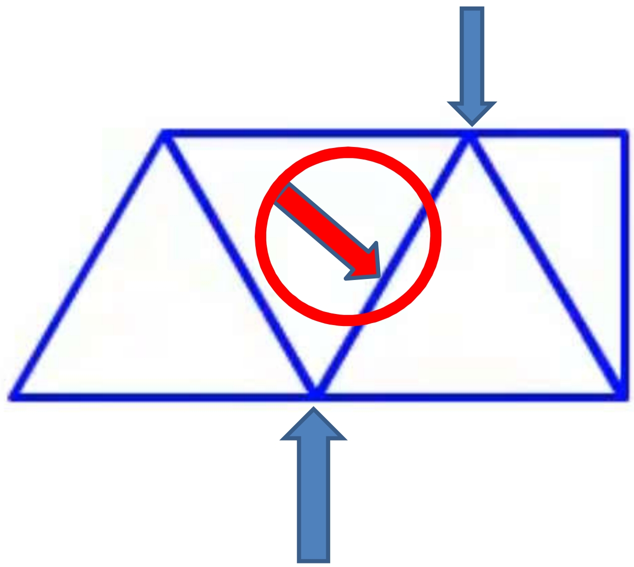


## Assumptions:

1- Simple truss are constructed expending triangles

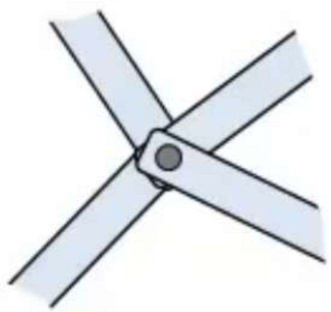


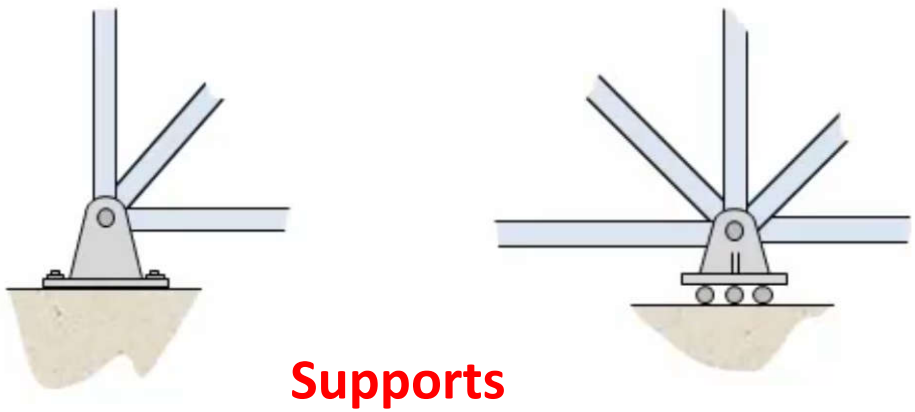
2- All the forces are applied to the joint



## Assumptions:

**3- All the members are joined together with pins**

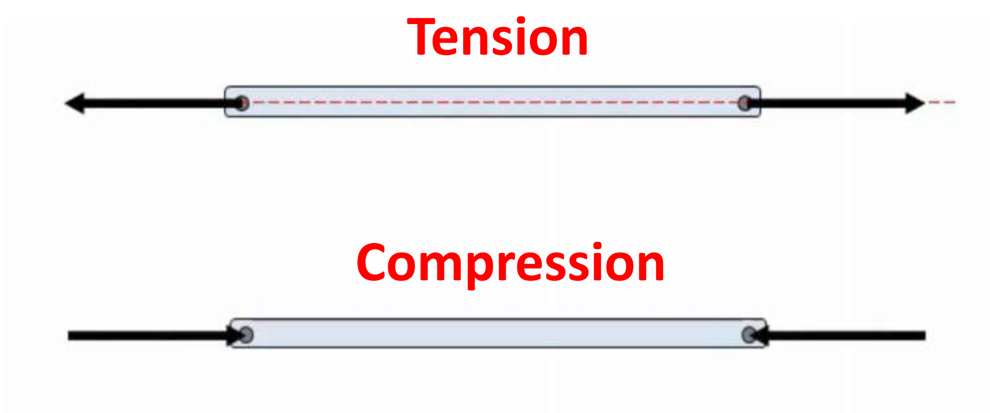


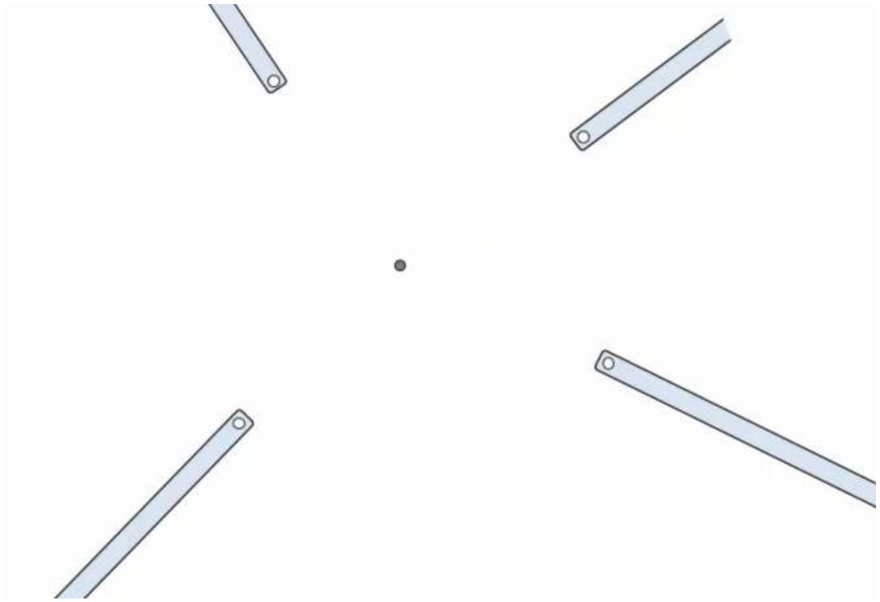


Supports

- **We are going to work in 2D**

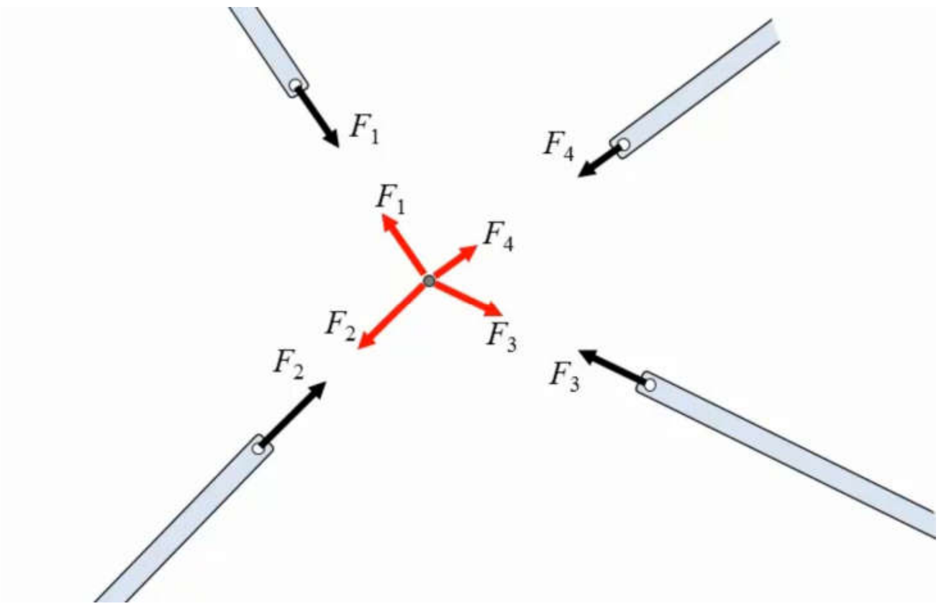
# Forces in the elements:

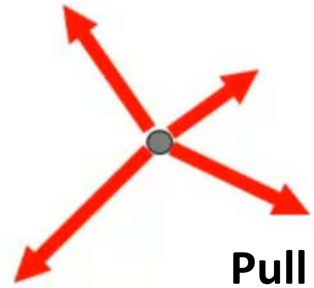


Joint

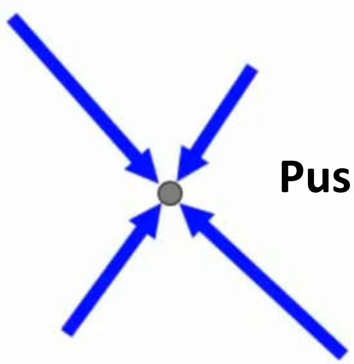
# Forces in joint and in the elements:



**Tension**

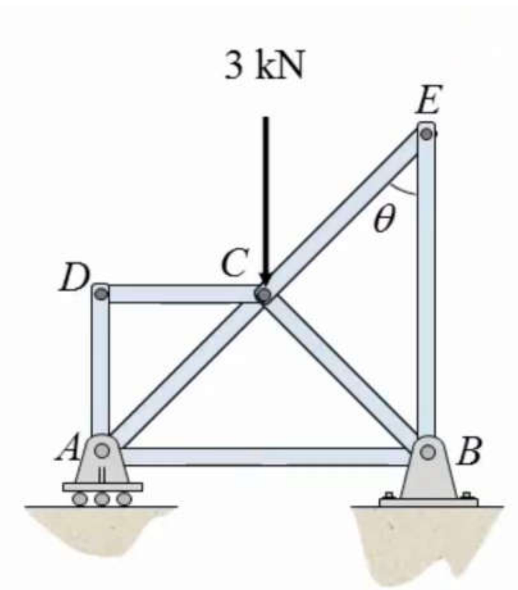
**Pull away from the joint**

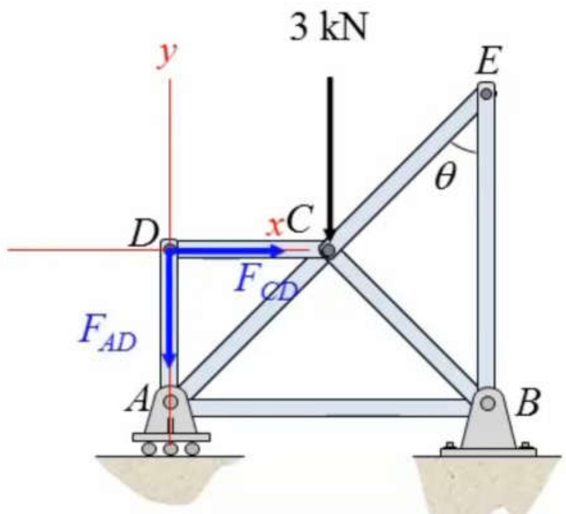


**Compression**

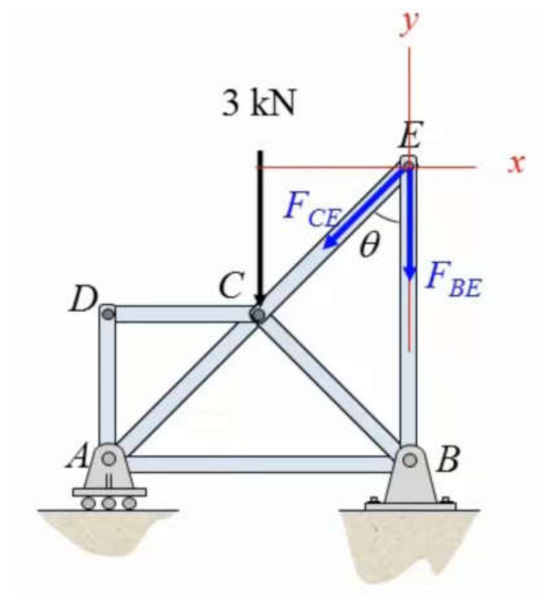
**Push towards the joint**

# Zero-force member:



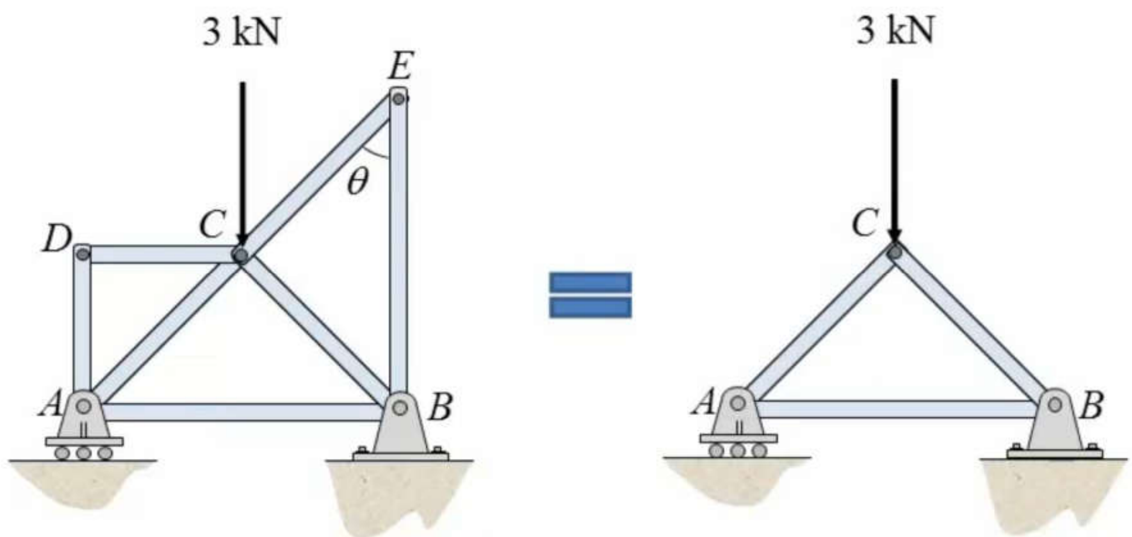




$$\begin{cases} \sum F_x = F_{CD} = 0 \\ \sum F_y = -F_{AD} = 0 \end{cases}$$




$$\begin{cases} \sum F_x = -F_{CE} \sin\theta = 0 \\ \sum F_y = -F_{BE} - F_{CE} \cos\theta = 0 \end{cases}$$

# Zero-force member:




You can no longer simplify this structure

# Zero-force member:

**You can find the zero-force element by inspection following these rules:**

## Case 1:

**Truss joints with 2 members:**

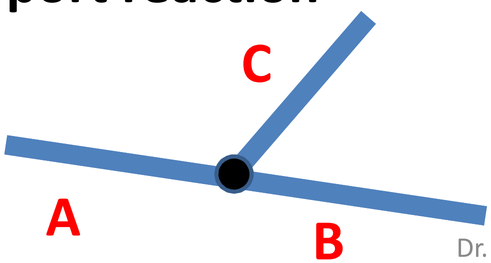
- No external load on joint
- Not support reaction

Previous example

## Case 2:

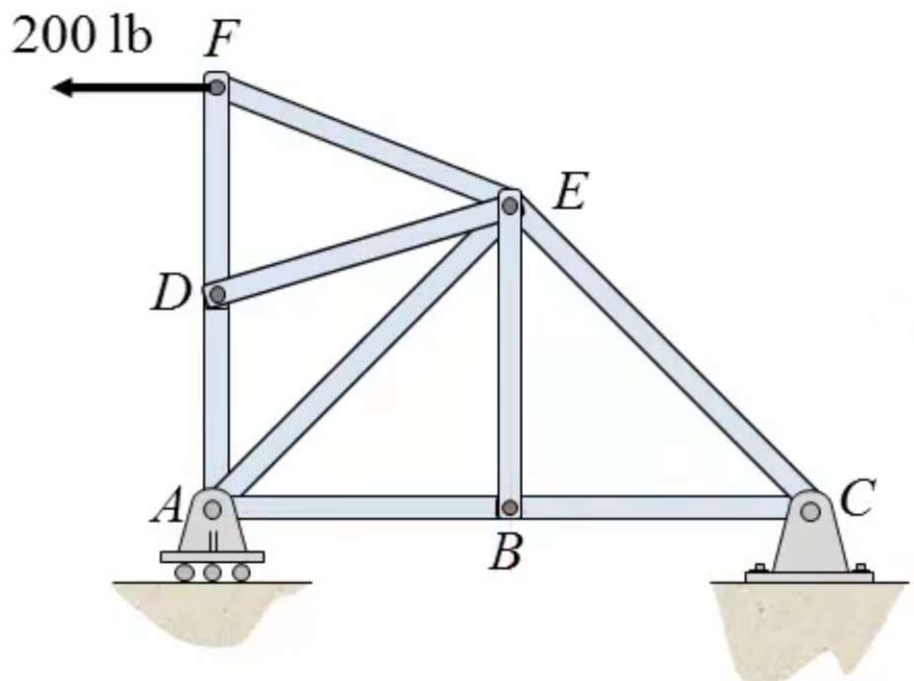
**Truss joints with 3 members and 2 members are collinear:**

- No external load on joint
- Not support reaction



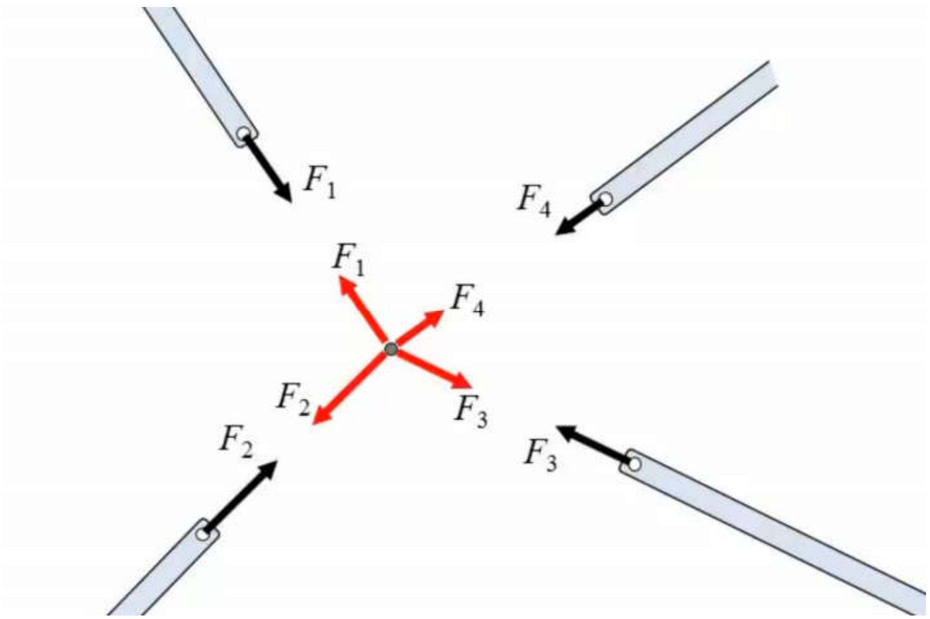
# Zero-force member:

**What are the zero-force elements in this example?**




- **To provide more stability**
- **Prevent buckling**
- **To carry unexpected loadings**

# Method of joints:



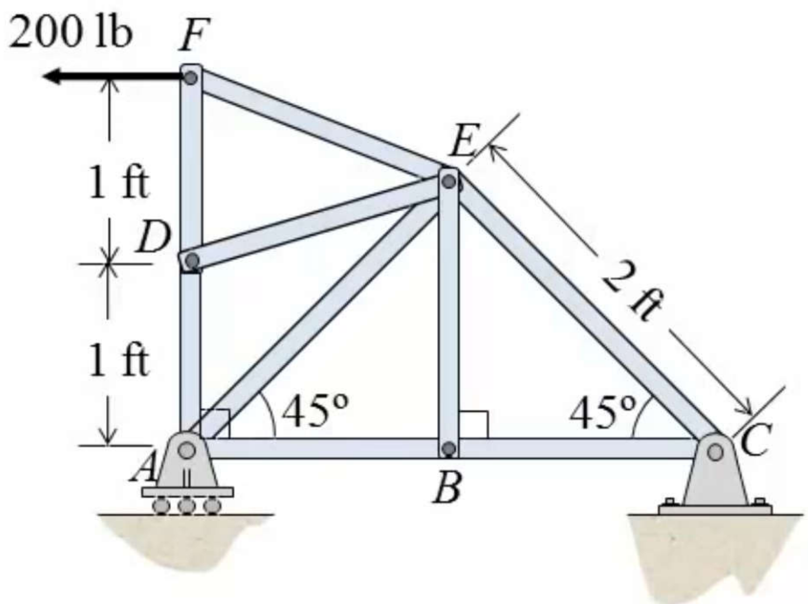

**Particle equilibrium**

$$\begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \end{cases}$$

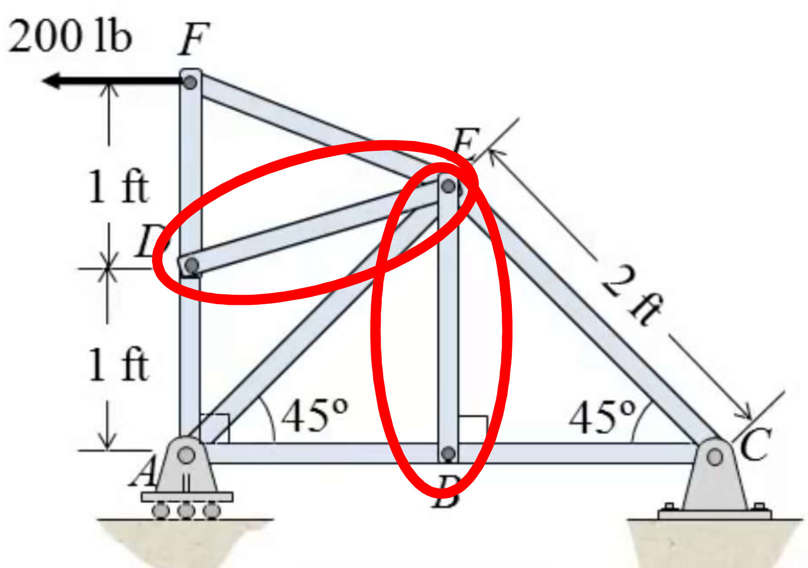
**Reminder: 2-D particle equilibrium enables us to solve for two unknowns at a time**

# Method of joints:

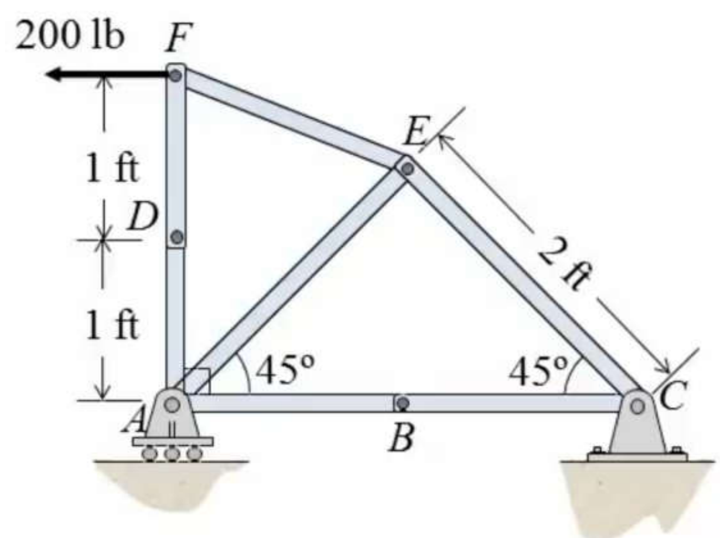
**Determine the force in each member of the truss and indicate if the member is in tension or compression using the method of Joint**



## Step 1: remove the zero-force element by inspection:

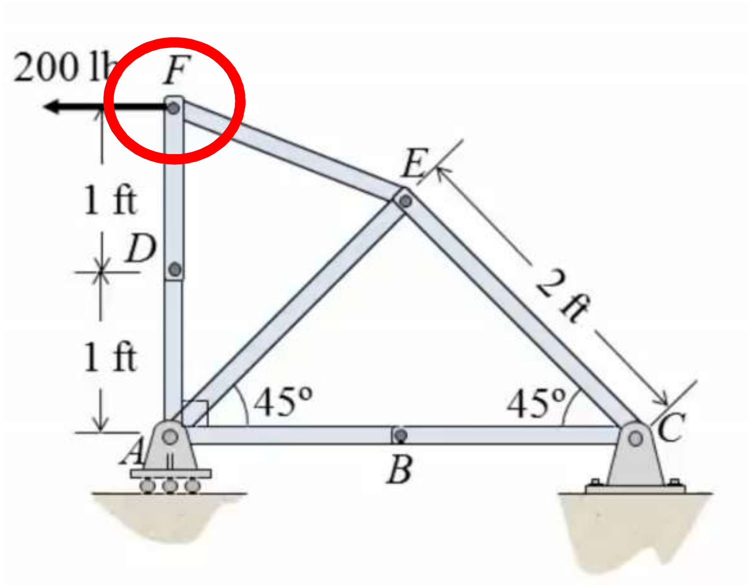


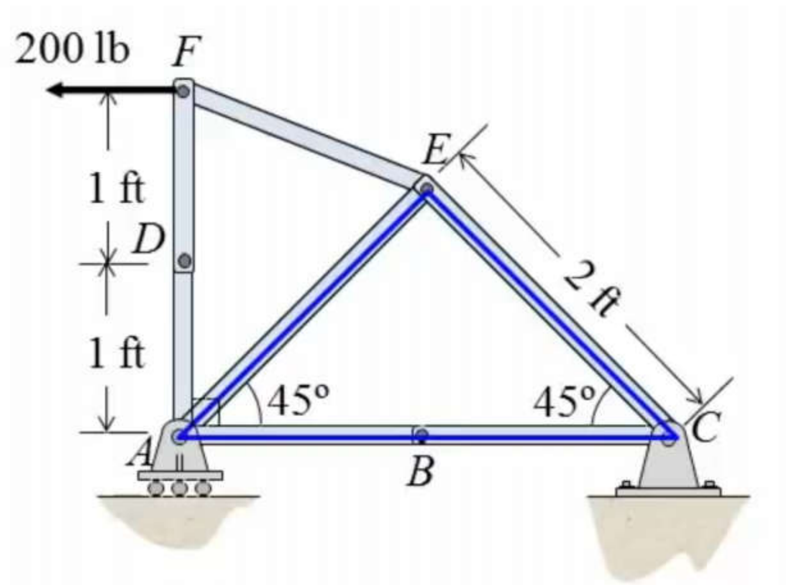

$$\begin{cases} F_{DE} = 0 \\ F_{BE} = 0 \end{cases}$$



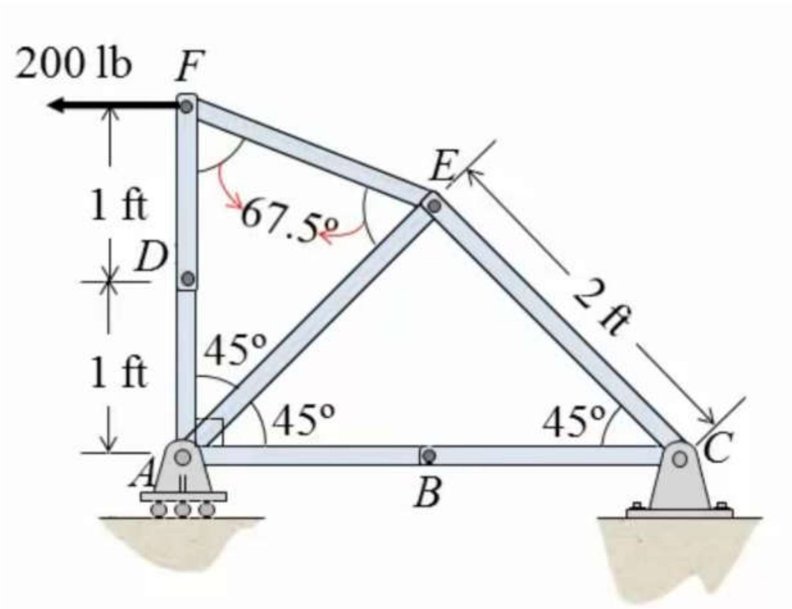
**Step 2**: Decide if you support reactions need to be determined , and which joint to start with

**Step 3**: solve each joint from easy to hard

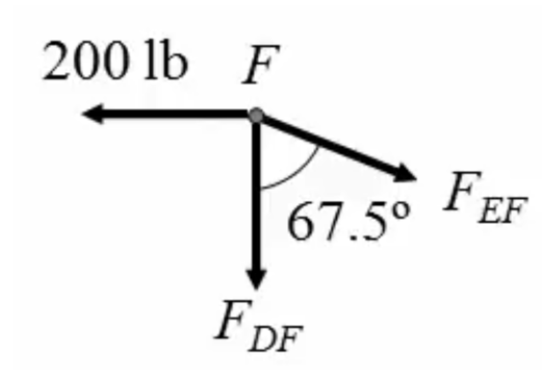


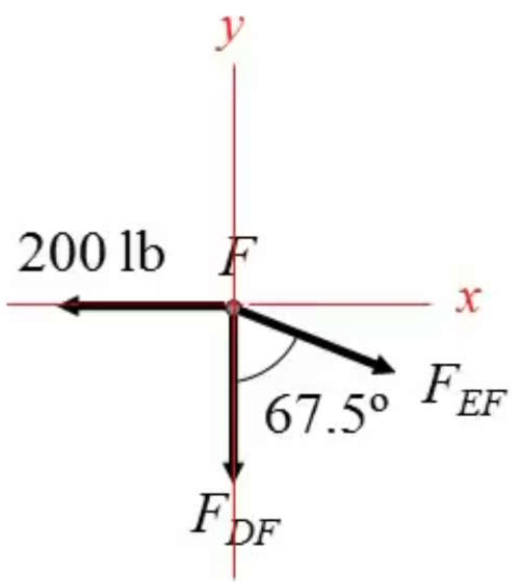
## Some geometry:




**Joint F**

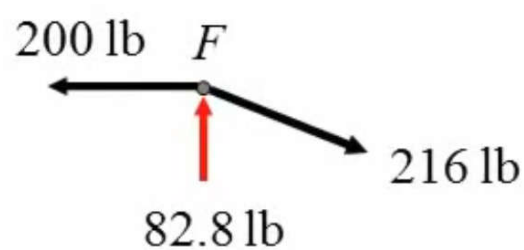


## Joint F

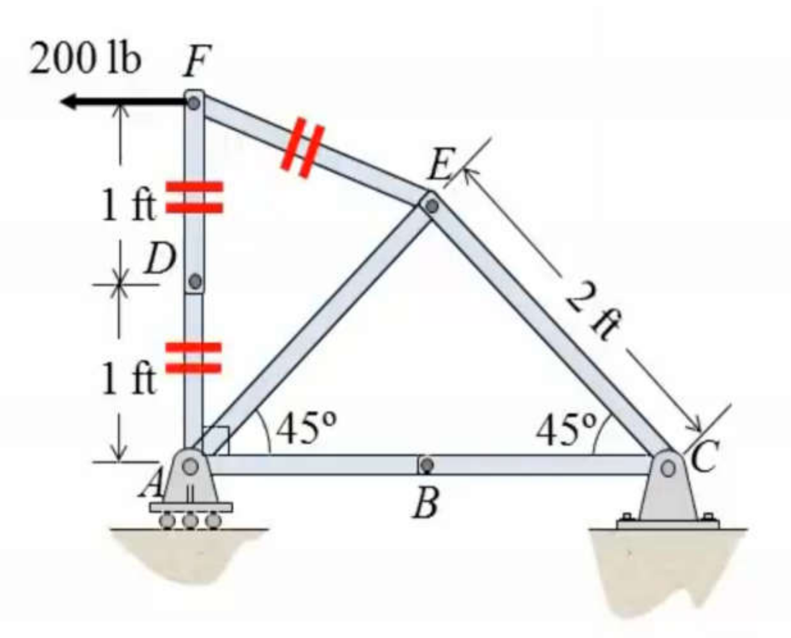


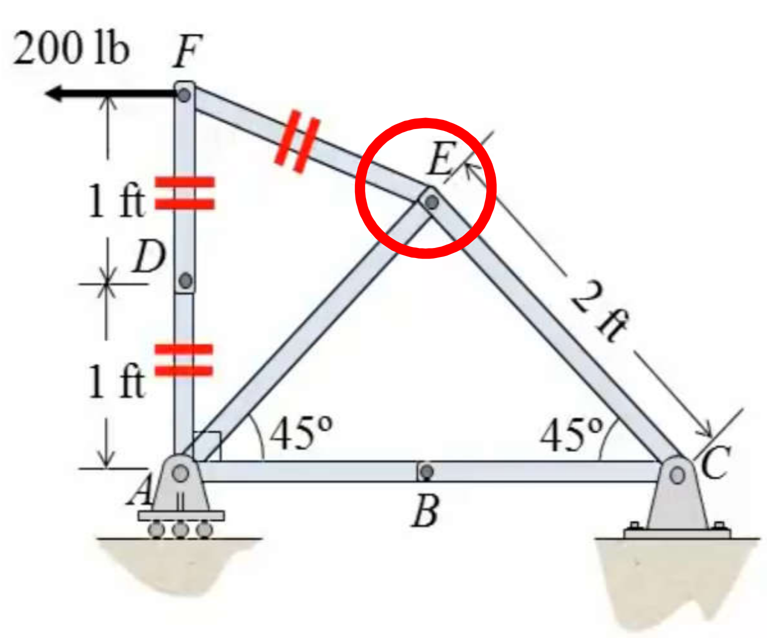

$$\begin{cases} \sum F_x = F_{EF} \sin 67.5^\circ - 200 \text{ lb} = 0 \\ \sum F_y = -F_{EF} \cos 67.5^\circ - F_{DF} = 0 \end{cases}$$

$$\begin{cases} F_{DF} = -82.8 \text{ lb} \quad (C) \\ F_{EF} = 216 \text{ lb} \quad (T) \end{cases}$$

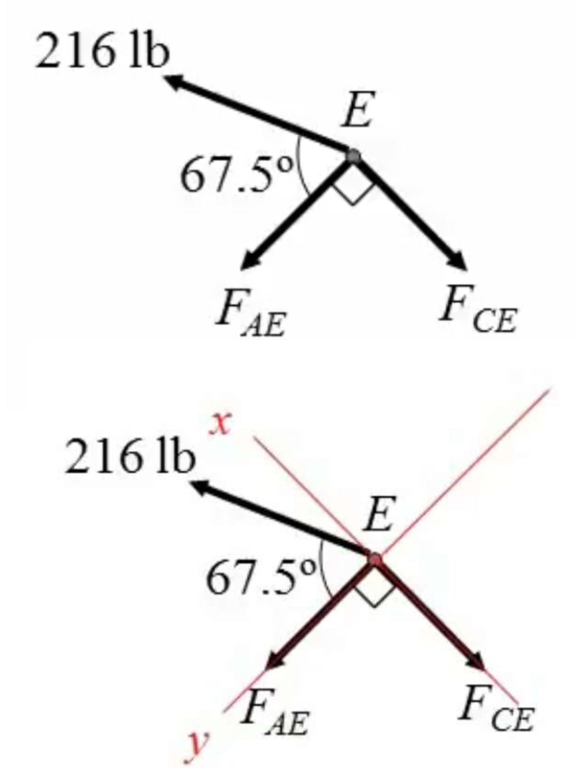



**Draw the unknown forces in the joint as tension**


200 lb
F
1 ft
D
1 ft
E
2 ft
45°
45°
A
B
C


200 lb
F
1 ft
D
1 ft
E
2 ft
45°
45°
A
B
C

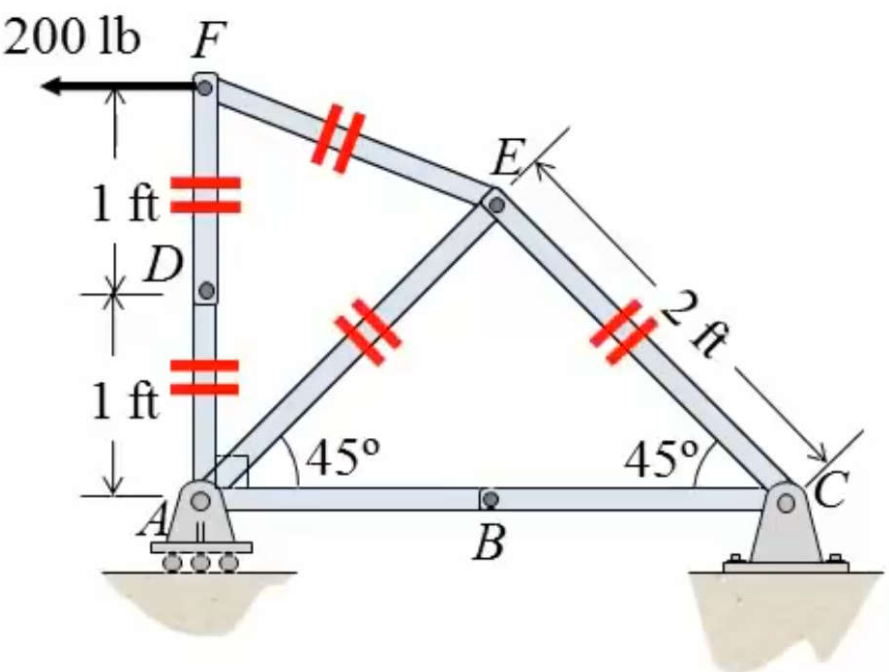
# Joint E

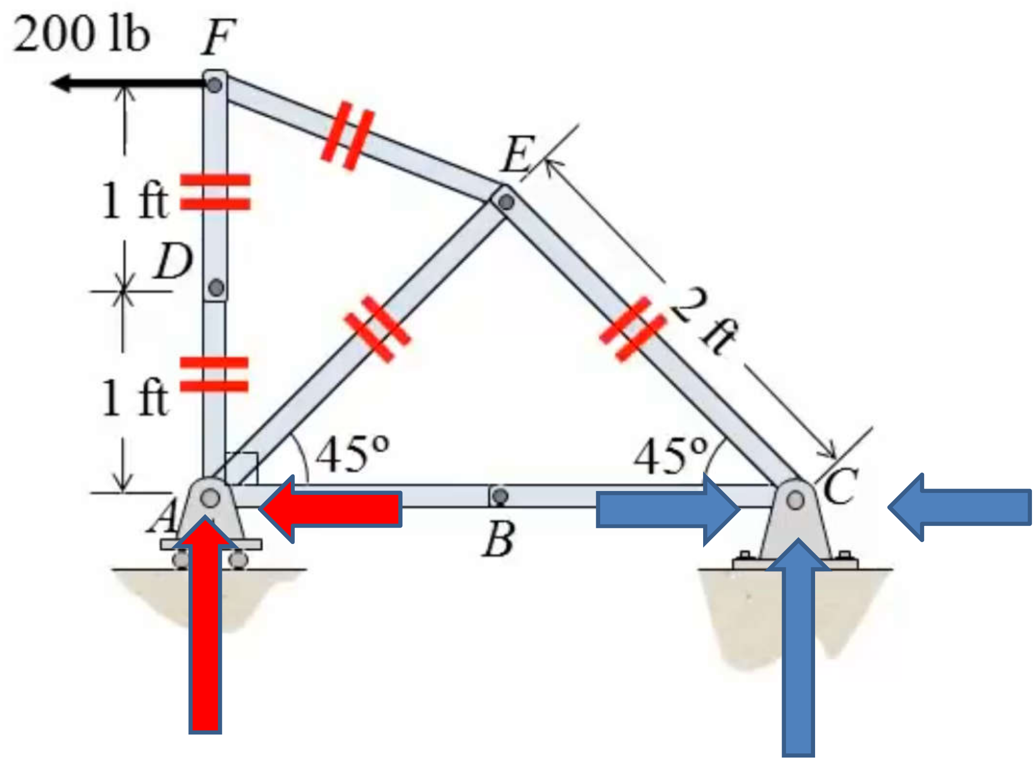



$$\begin{cases} \sum F_x = 216\text{ lb}\cdot\sin 67.5^\circ - F_{CE} = 0 \\ \sum F_y = 216\text{ lb}\cdot\cos 67.5^\circ + F_{AE} = 0 \end{cases}$$

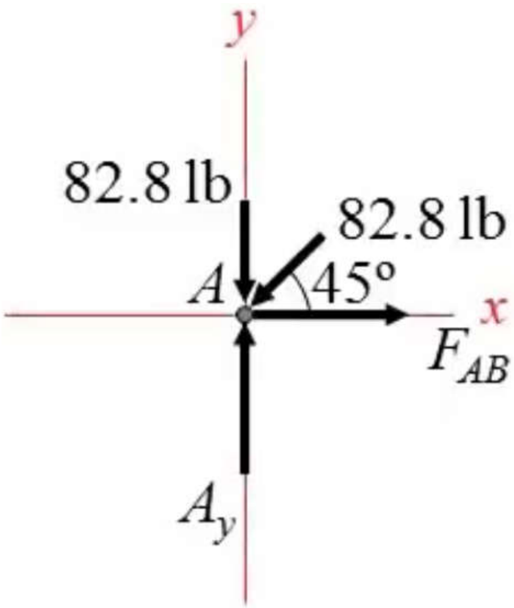
$$\begin{cases} F_{CE} = 200\text{ lb} \quad (\text{T}) \\ F_{AE} = -82.8\text{ lb} \quad (\text{C}) \end{cases}$$

**What comes next:**



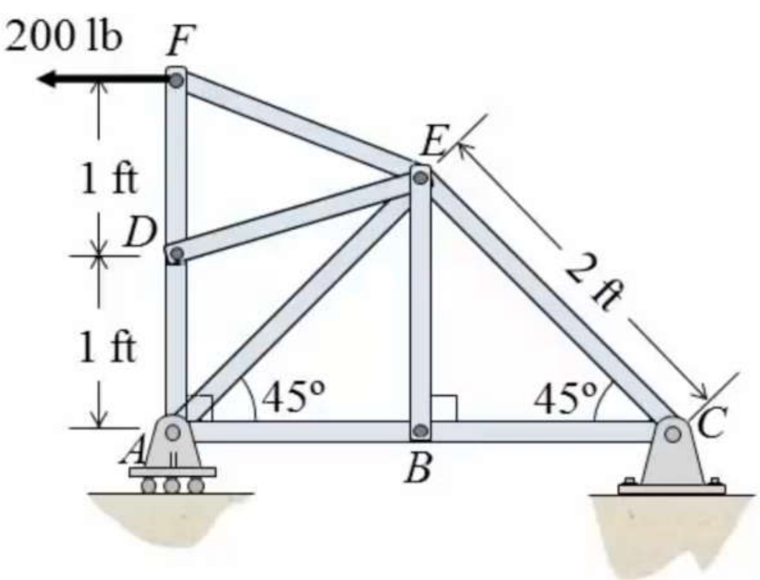
## Joint A




$$\begin{cases} \sum F_x = F_{AB} - 82.8\text{ lb} \cdot \cos 45^\circ = 0 \\ \sum F_y = -82.8\text{ lb} - 82.8\text{ lb} \cdot \sin 45^\circ + A_y = 0 \end{cases}$$

$$\begin{cases} F_{AB} = 58.3\text{ lb} \quad (\text{T}) \\ A_y = 141\text{ lb} \end{cases}$$

## Finally:




$$
\begin{cases}
F_{DE} = 0 \\
F_{BE} = 0 \\
F_{EF} = 216 \text{ lb} \quad (T) \\
F_{DF} = F_{AD} = -82.8 \text{ lb} \quad (C) \\
F_{CE} = 200 \text{ lb} \quad (T) \\
F_{AE} = -82.8 \text{ lb} \quad (C) \\
F_{AB} = F_{BC} = 58.3 \text{ lb} \quad (T)
\end{cases}
$$

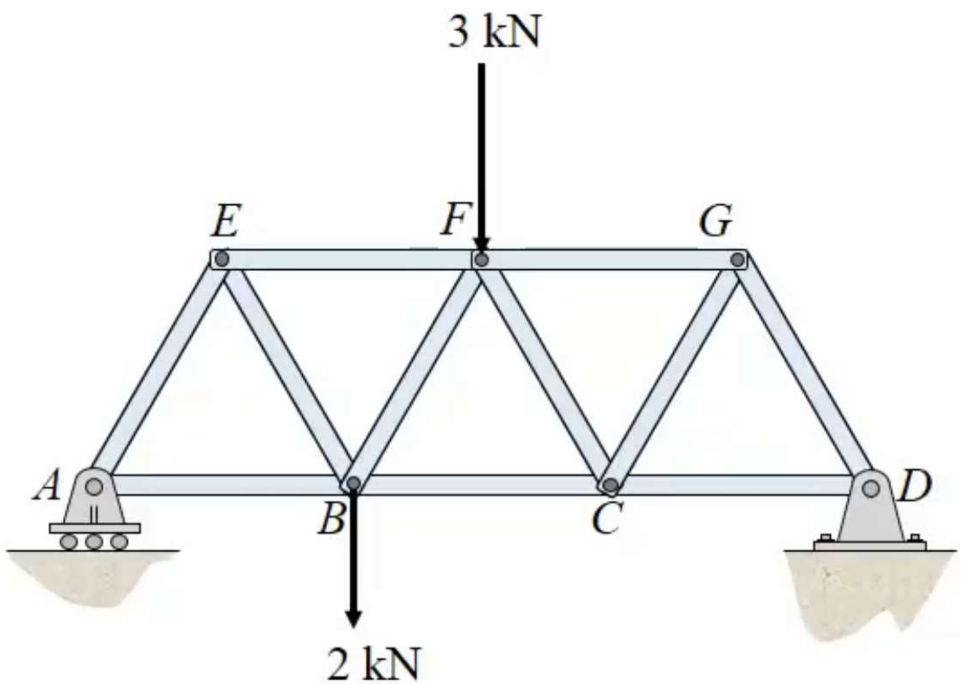
# Method of Sections:

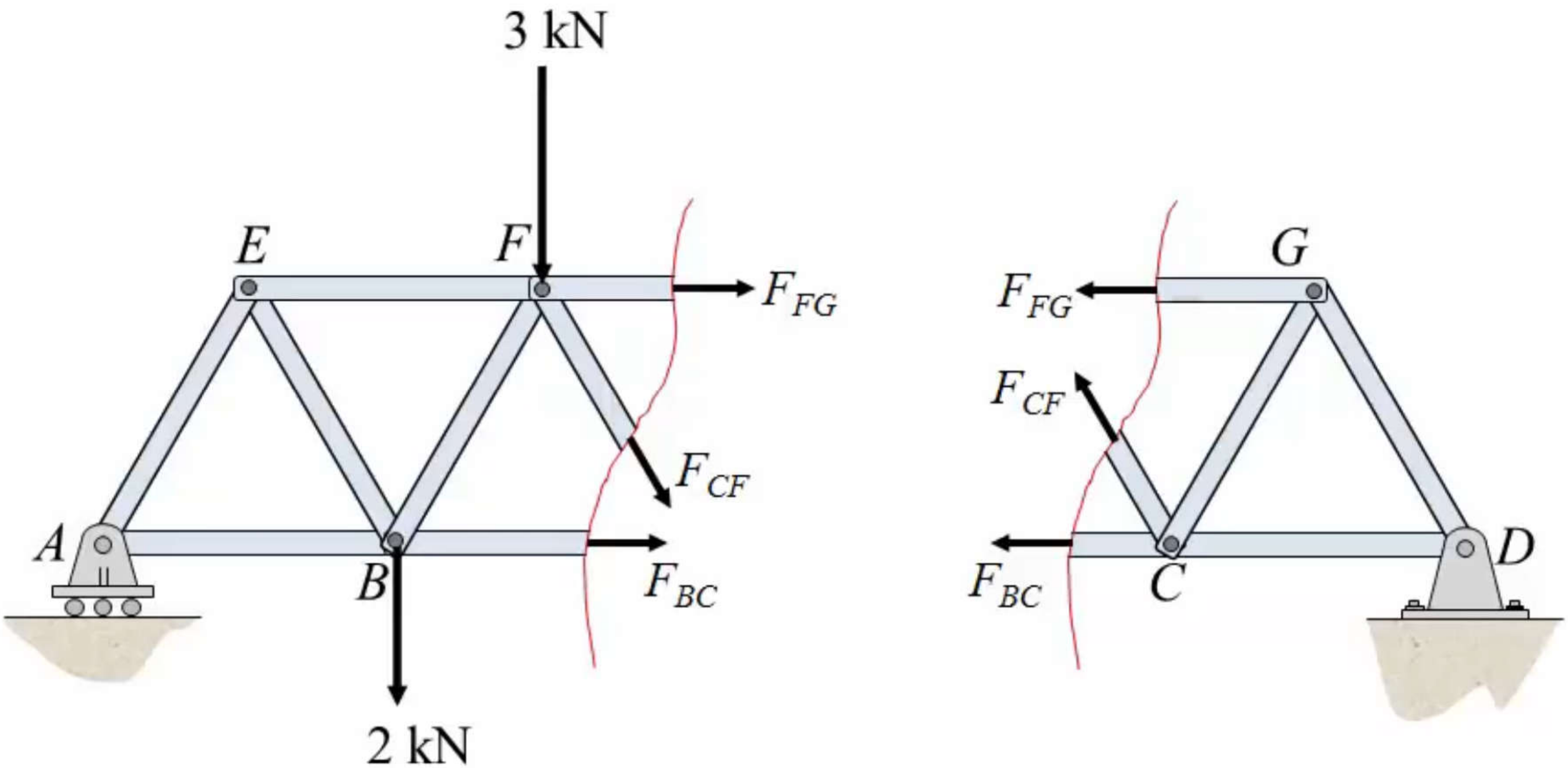
## Objective:

**Analyze the truss of structure and to determine the forces in each member**

# Method of Sections:

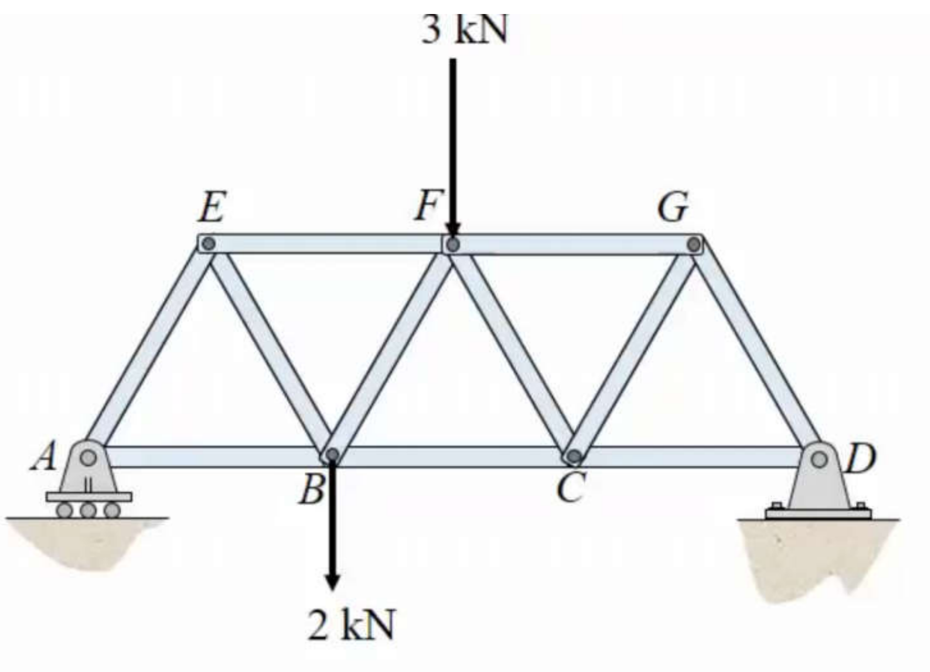
**Determine the force in members BC, CF and CG and indicate if the member is in tension or compression. Each member in the truss is 0.6 m long using the method of Sections**

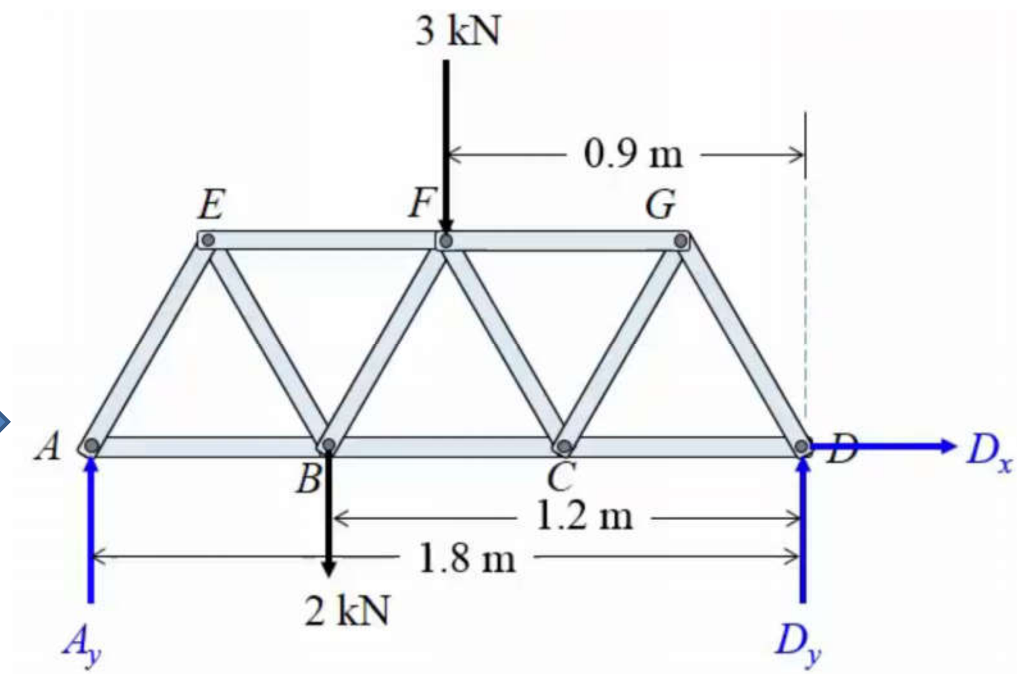





**Note: for each segment, you can solve for maximum 3 reactions**

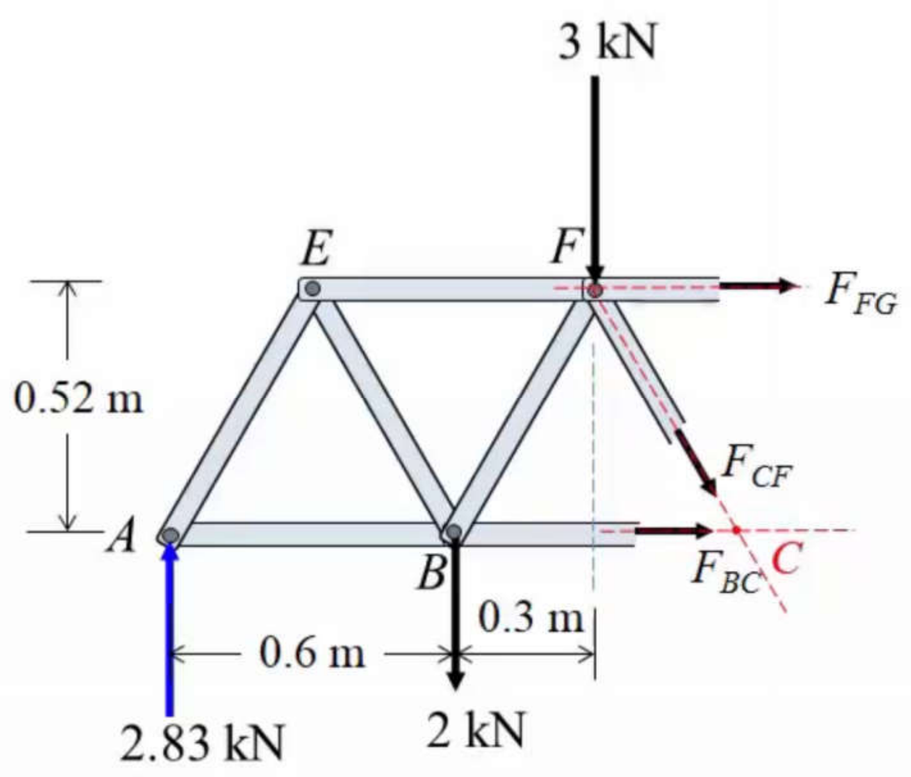
## Step 01: if necessary, determine the support reactions




$$A_y = 2.83 \text{ kN}$$

**Step 02: cut the structure and choose the segment , step 03: solve for the unknowns**




$$\sum M_F = F_{BC} \cdot 0.52\text{ m}$$
$$-2.83\text{ kN} \cdot 0.9\text{ m} + 2\text{ kN} \cdot 0.3\text{ m} = 0$$
$$\therefore \quad F_{BC} = 3.74\text{ kN} \quad (\text{T})$$

$$\sum M_C = -F_{FG} \cdot 0.52\text{ m} + 3\text{ kN} \cdot 0.3\text{ m}$$
$$-2.83\text{ kN} \cdot 1.2\text{ m} + 2\text{ kN} \cdot 0.6\text{ m} = 0$$
$$\therefore \quad F_{FG} = -2.49\text{ kN} \quad (\text{C})$$

$$\xrightarrow{+} \sum F_x = F_{BC} + F_{FG} + F_{CF} \cos 60^\circ = 0$$
$$\therefore \quad F_{CF} = -2.50\text{ kN} \quad (\text{C})$$