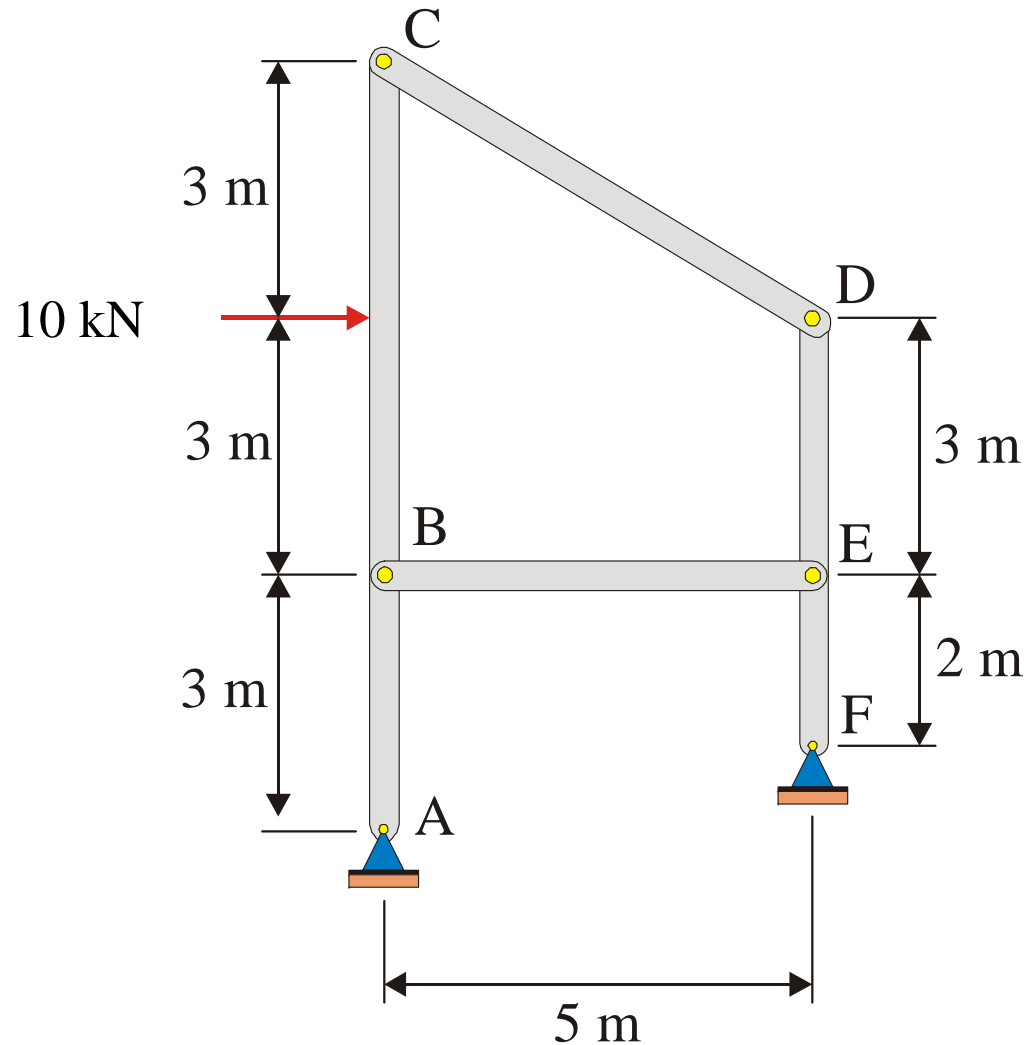
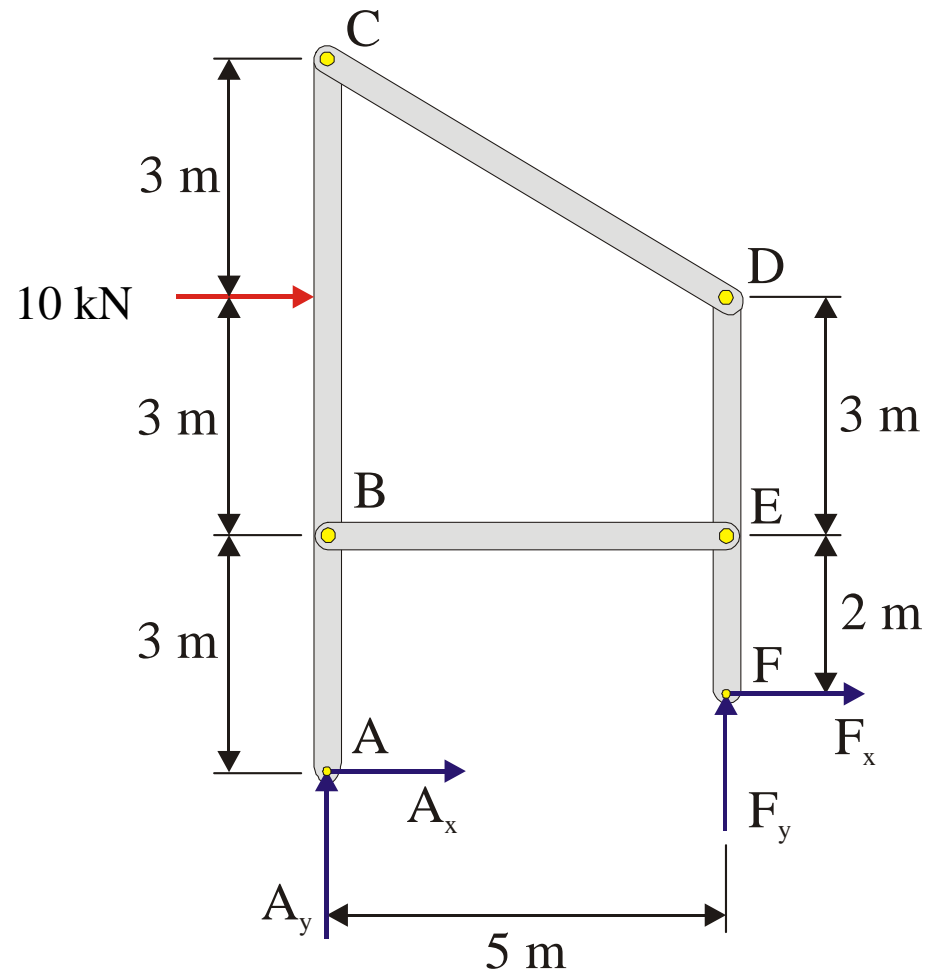


# Example 4.5

### Example 4.5:

Determine the components of the forces acting on each member of the frame shown.





**Free-Body Diagram of Entire Frame**

$$\sum \mathbf{F}_x = 0$$

$$A_x + F_x + 10 = 0 \quad (1)$$

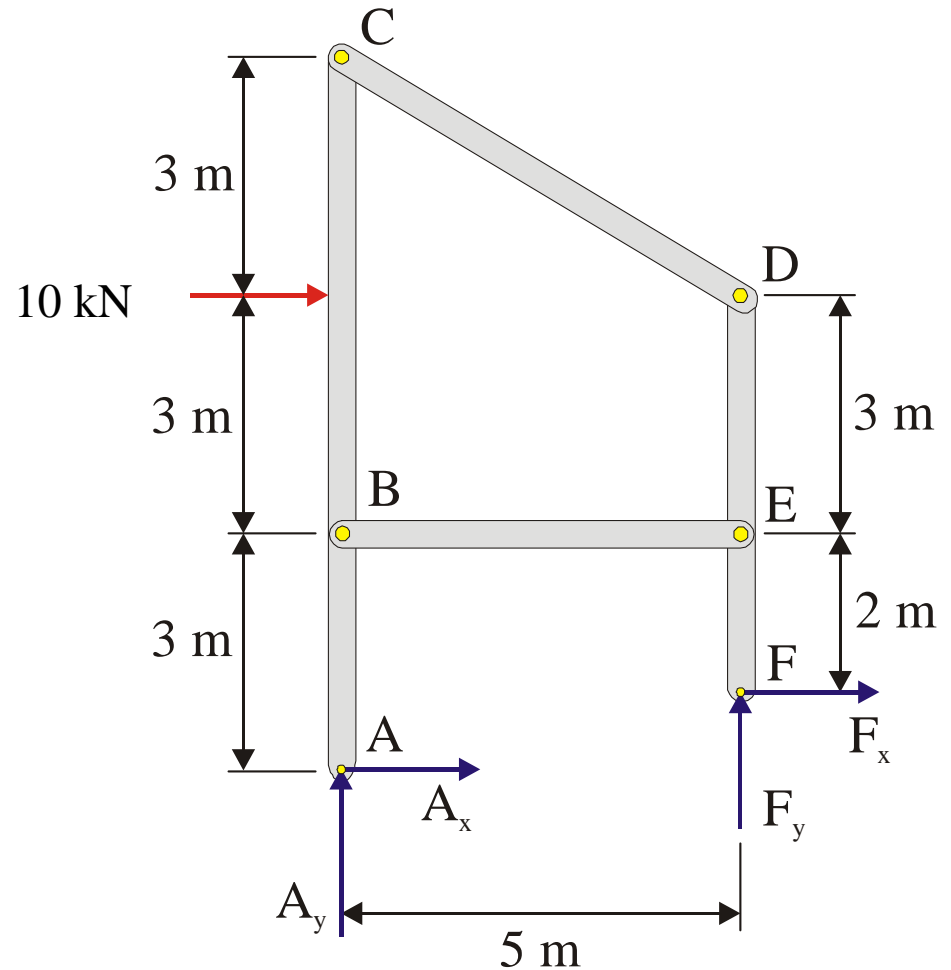
$$\sum \mathbf{F}_y = 0$$

$$A_y + F_y = 0 \quad (2)$$

$$\sum \mathbf{M}_A = 0$$

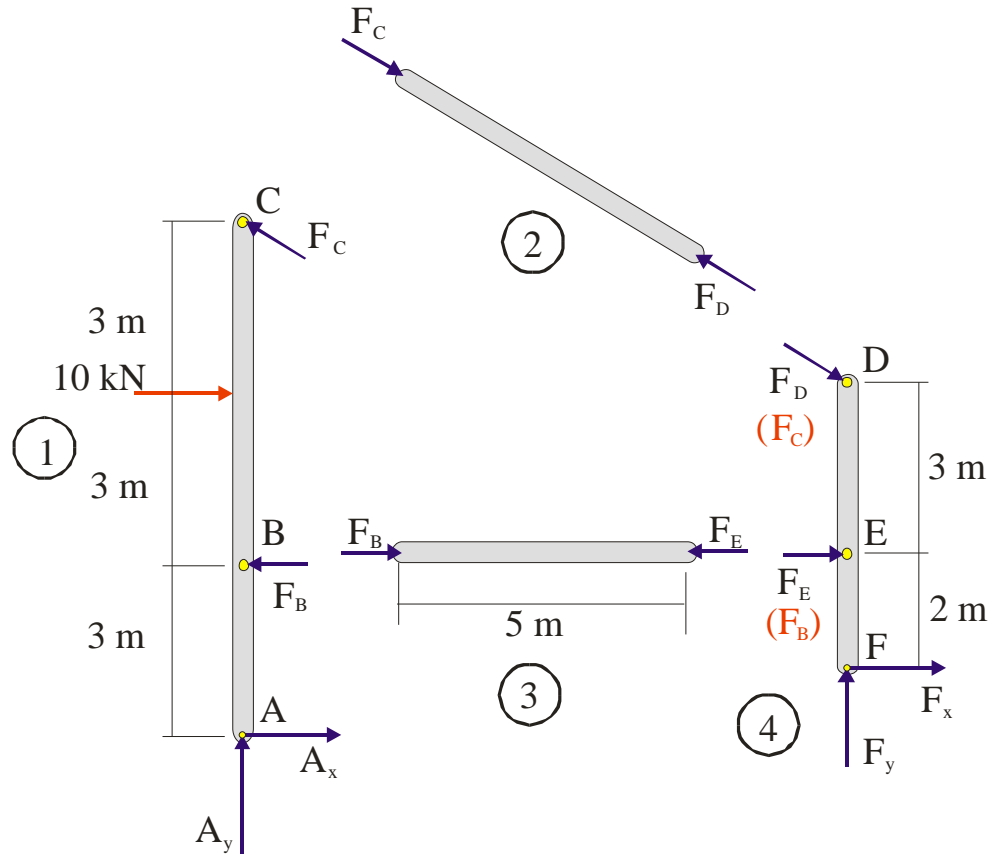
$$-10(6) - F_x(1) + F_y(5) = 0 \quad (3)$$

**3 Equations in 4 Unknowns**



# SUBSTRUCTURE

(Look for 2-Force Members !!!!!)



**Note:** Members CD and BE are 2-Force Members

Therefore:

$$F_C = F_D \text{ and } F_B = F_E$$

## Equilibrium Equations for Individual Members

Free-body Diagrams 1 and 4 both involve **4 unknowns**

However, We can obtain **2 equations in 2 unknowns** by observing that the magnitude of the forces at the ends of the two force members are equal.

We can take moments about Point A in FBD 1 and moments about Point F in FBD 4 to obtain our 2 equations in 2 unknowns.

**From FBD 1 Taking Moments about A:**

$$+\frac{5}{\sqrt{34}}F_C(9) - 10(6) + F_B(3) = 0$$

$$7.72F_C + 3F_B = 60 \quad (1)$$

**From FBD 4 Taking Moments about F:**

$$-\frac{5}{\sqrt{34}}F_C(5) - F_B(2) = 0$$

$$-4.29F_C - 2F_B = 0 \quad (2)$$

Multiplying (1) by 2 and (2) by 3:

$$+15.44F_C + 6F_B = 120$$

$$-12.87F_C - 6F_B = 0$$

Adding :

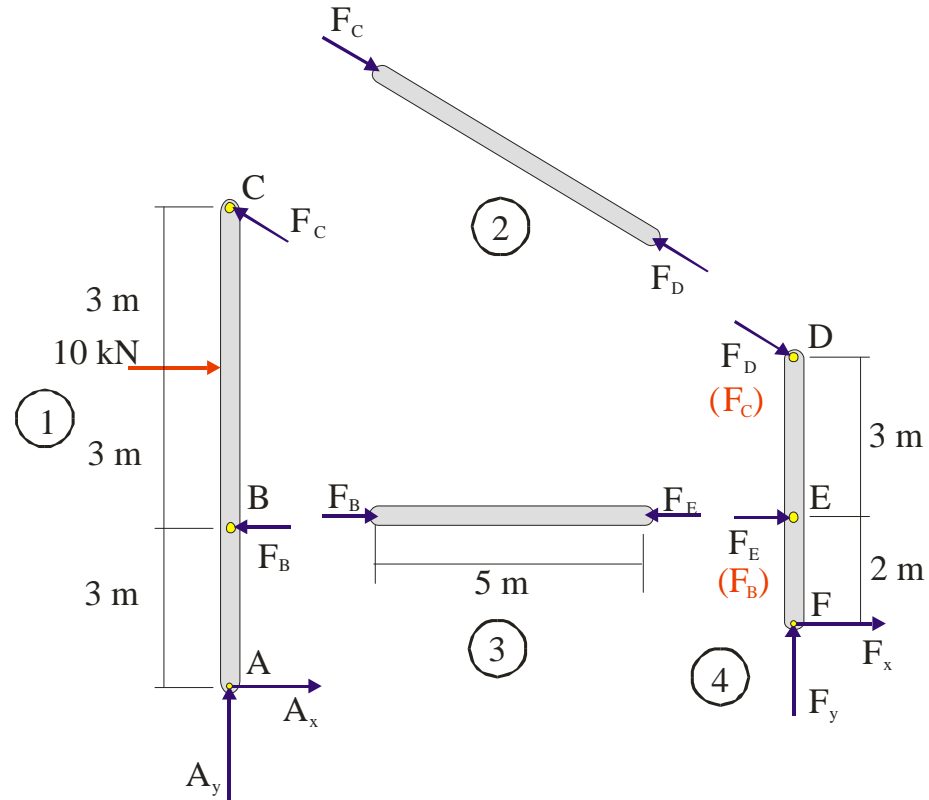
$$+2.57F_C = 120$$

$$F_C = +46.69 \text{ kN (Direction assumed correctly in FBD)}$$

Back - substitution in (1):

$$7.72(+46.69) + 3F_B = 60$$

$$F_B = -99.89 \text{ kN (Direction assumed incorrectly in FBD)}$$

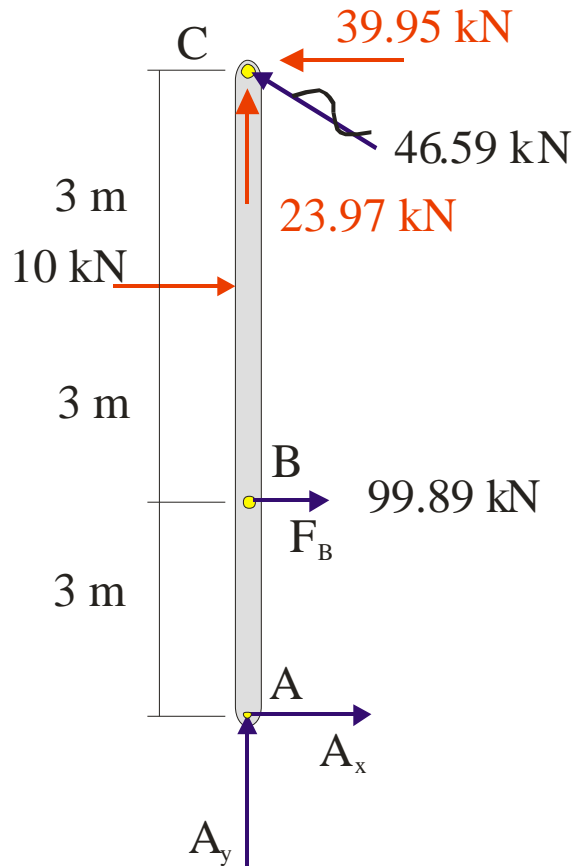


**Note:** Members CD and BE are 2-Force Members

Therefore:

$$F_C = F_D \text{ and } F_B = F_E$$

# We Re-draw FBD of Member ABC and apply the Equilibrium Equations



$$\sum F_x = 0$$

$$-39.95 + 10 + 99.89 + A_x = 0$$

$$A_x = -69.94 \text{ kN} \text{ (Direction of } A_x \text{ in FBD assumed incorrectly.)}$$

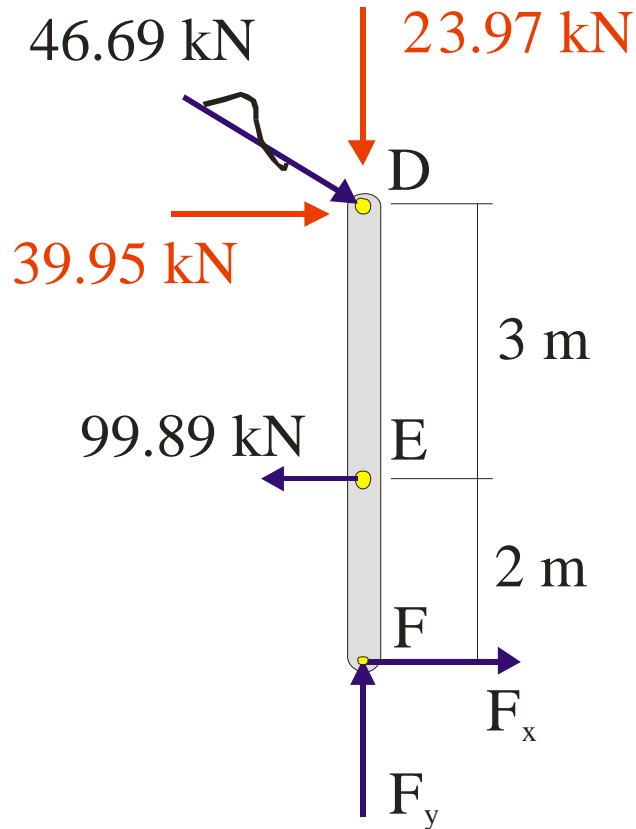
$$\sum F_y = 0$$

$$23.97 + A_y = 0$$

$$A_y = -23.97 \text{ kN} \text{ (Direction of } A_y \text{ in FBD assumed incorrectly.)}$$



# We Re-draw FBD of Member DEF and apply the Equilibrium Equations



$$\sum F_x = 0$$

$$39.95 - 99.89 + F_x = 0$$

$$F_x = +59.94 \text{ kN (Direction of } F_x \text{ in FBD assumed correctly.)}$$

$$\sum F_y = 0$$

$$-23.97 + F_y = 0$$

$$F_y = +23.97 \text{ kN (Direction of } F_y \text{ in FBD assumed correctly.)}$$

# We Re-draw all FBDs and Check our Solution

