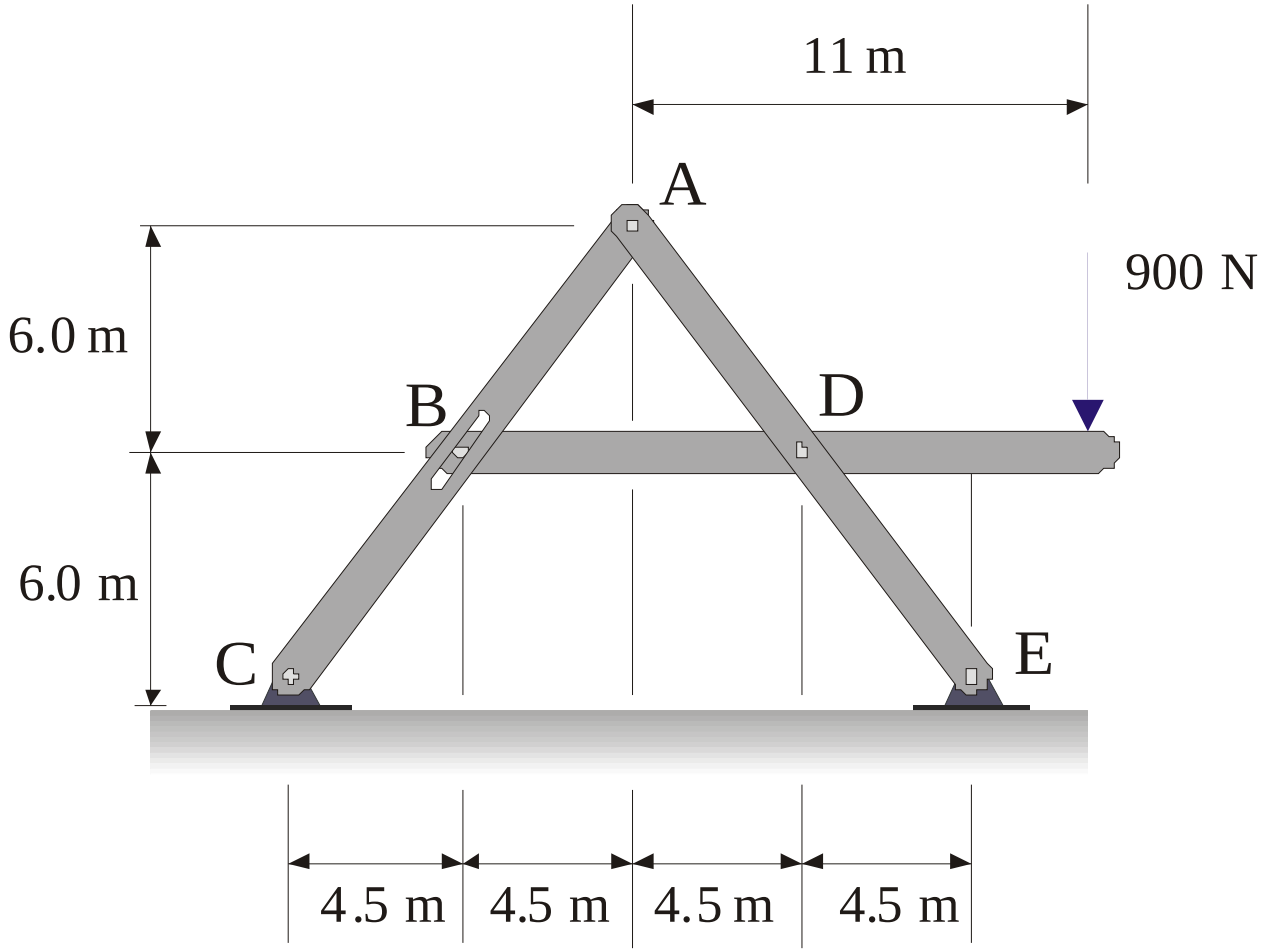
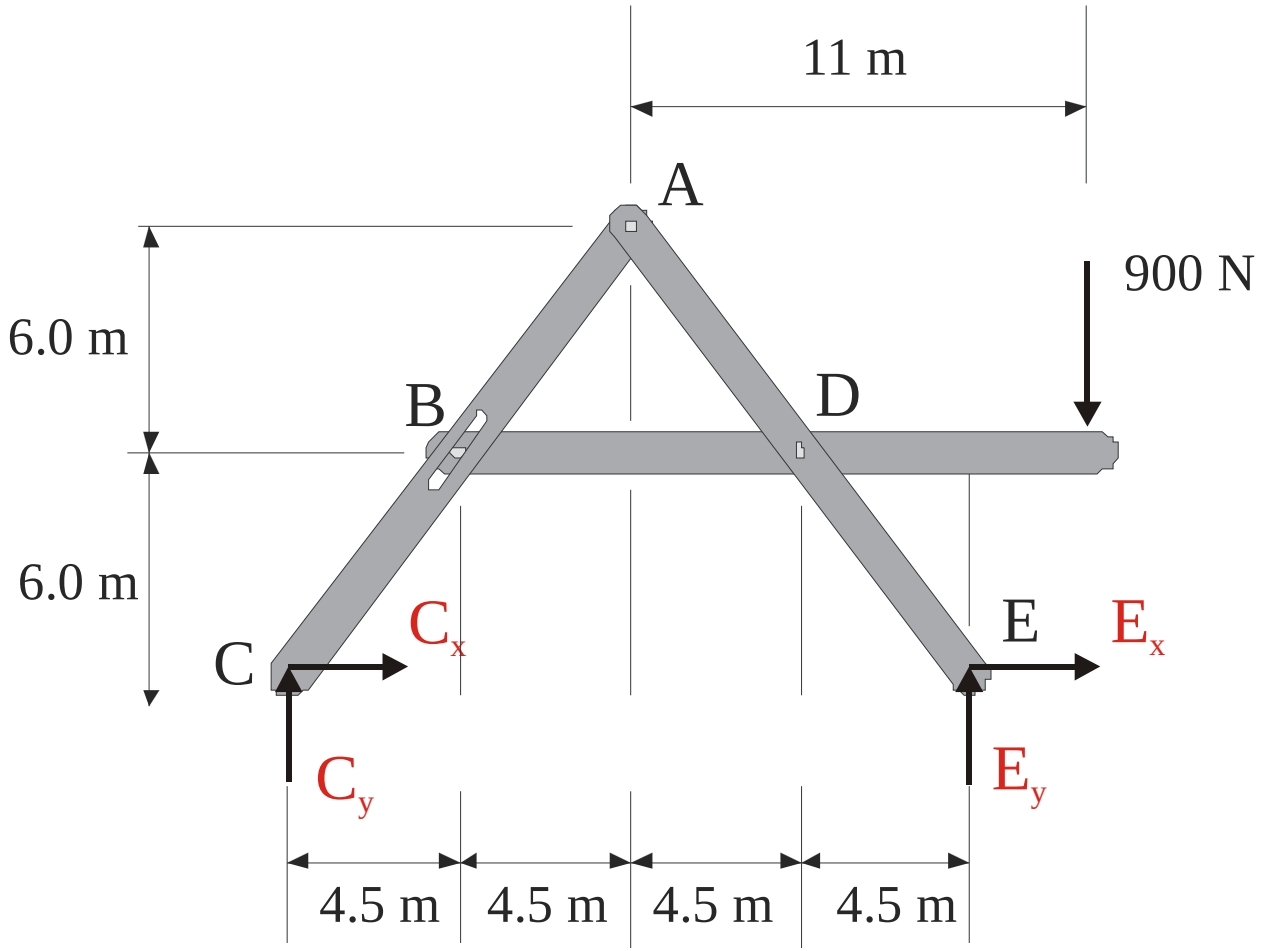
Example 4.4

J. Frye

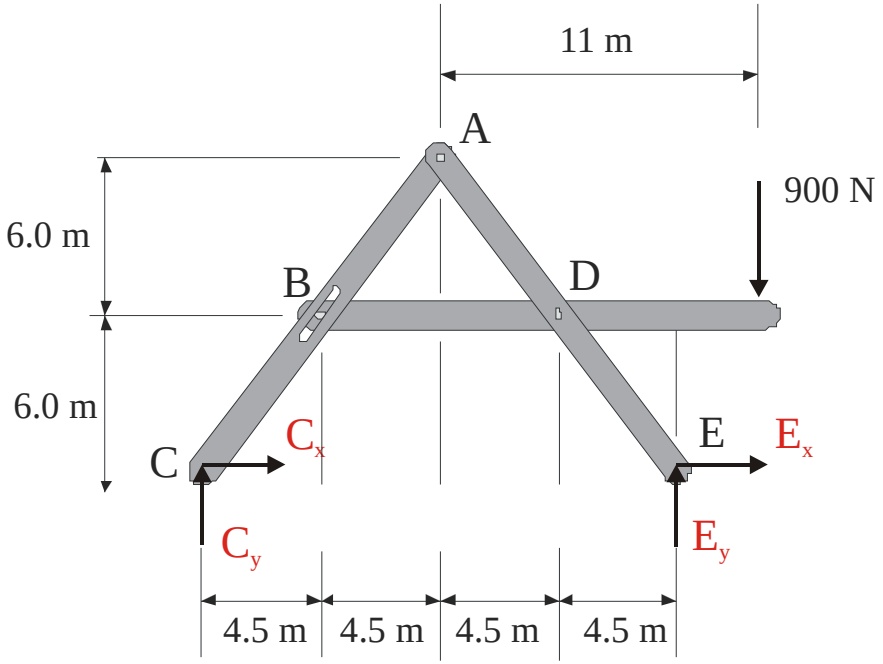
Example 4.4:
Determine the components of the forces acting on each member of the frame shown.



Step 1: Draw the FBD for the entire frame. Apply the equilibrium equations and solve for as many unknown reaction forces as you can.



Because supports C and E are on the same level, we are able to solve for 2 of the unknown reaction forces.



$$\sum F_x = 0 \rightarrow$$

$$C_x + E_x = 0 \quad (1)$$

$$\sum F_y = 0 \uparrow$$

$$C_y - 900 + E_y = 0 \quad (2)$$

$$\sum M_C = 0$$

$$-900(20) + E_y(18) = 0 \quad (3)$$

$$E_y = +1000\text{N}$$

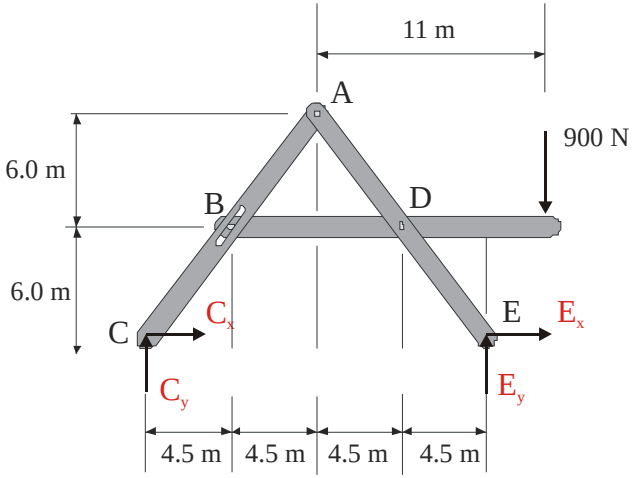
$$\therefore \mathbf{E_y} = 1000\text{N} \uparrow$$

Substitute into (2):

$$C_y - 900 + 1000 = 0$$

$$C_y = -100\text{N}$$

$$\therefore \mathbf{C_y} = 100\text{N} \downarrow$$



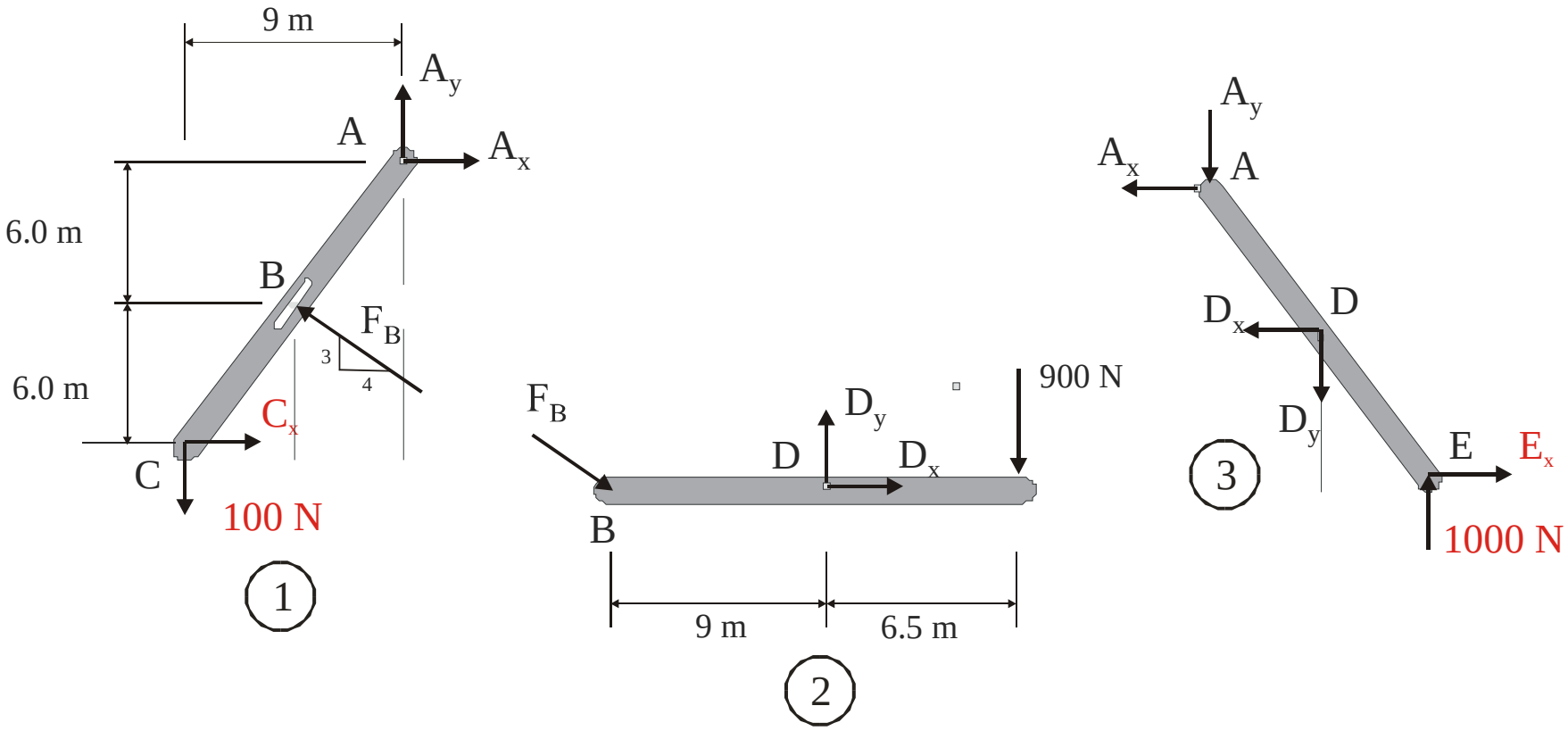
IMPORTANT: Before sub-structuring, identify any 2-Force members.

Identifying 2-Force members before sub-structuring will greatly simplify the problem.

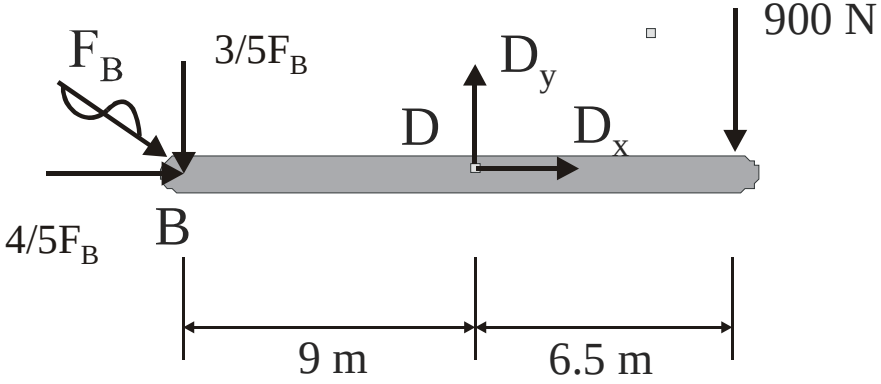
There are NO 2-Force members in this frame.

Sub-structures:

Important: Never write results on these FBDs



We work with FBD of Member 2 first since there are only 3 unknown forces and we have 3 equilibrium equations. We can therefore solve for all of the unknown forces.



$$\sum M_B = 0$$

$$D_y(9) - 900(15.5) = 0$$

$$D_y = +1550\text{N}$$

$$\therefore \mathbf{D_y} = 1550\text{N} \uparrow \text{ on member BD}$$

$$\sum F_y = 0$$

$$-\frac{3}{5}F_B + 1550 - 900 = 0$$

$$F_B = +1083.33\text{N}$$

$$\therefore \mathbf{F_B} = 1083.33\text{N} \text{ (3-4 slope)} \text{ on member BD}$$

$$\sum F_x = 0 \rightarrow$$

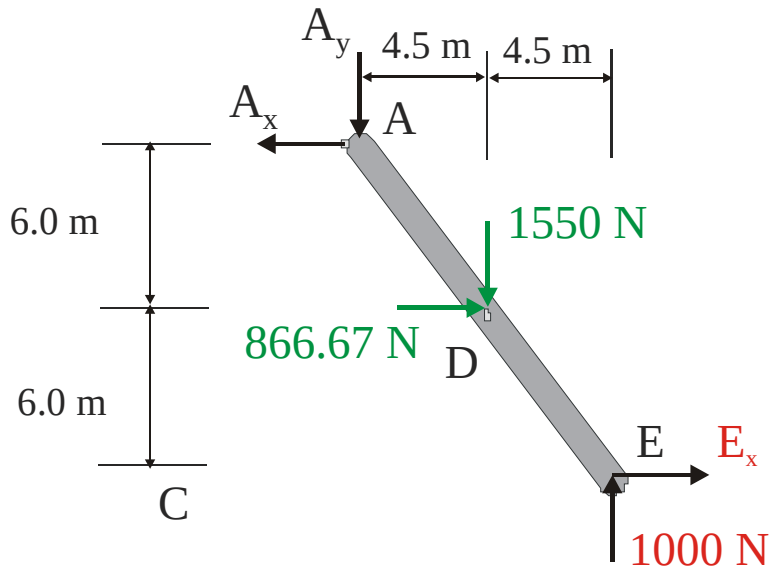
$$\frac{4}{5}F_B + D_x = 0$$

$$\frac{4}{5}(1083.33) + D_x = 0$$

$$D_x = -866.67\text{N}$$

$$\therefore \mathbf{D_x} = 866.67\text{N} \leftarrow \text{ on member BD}$$

We re-draw FBD 3 indicating the internal forces at D in the correct directions. We apply the equilibrium equations to this FBD.



$$\sum F_y = 0 \uparrow$$

$$-A_y - 1550 + 1000 = 0 \quad (1)$$

$$A_y = -550\text{N}$$

$$\therefore \mathbf{A_y} = 550\text{N} \uparrow \text{ on member ADE}$$

$$\sum F_x = 0 \rightarrow$$

$$-A_x + 866.67 + E_x = 0 \quad (2)$$

$$\sum M_A = 0$$

$$866.67(6) - 1550(4.5) + 1000(9) + E_x(12) = 0 \quad (3)$$

$$E_x = -602.09\text{N}$$

$$\therefore \mathbf{E_x} = 602.09\text{N} \leftarrow$$

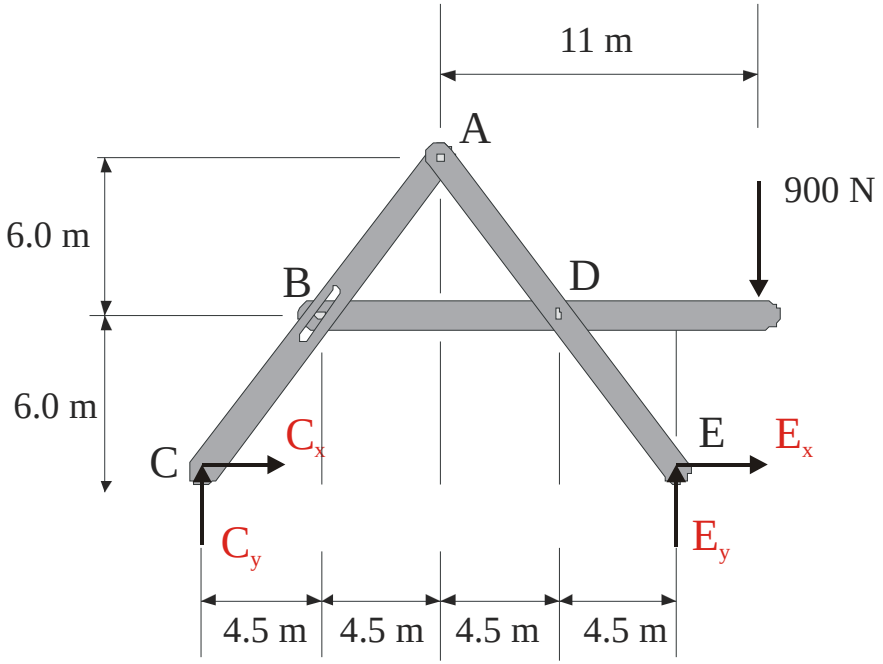
Substitute in (2):

$$-A_x + 866.67 + (-602.09) = 0$$

$$A_x = +264.58\text{N}$$

$$\therefore \mathbf{A_x} = 264.68\text{N} \leftarrow \text{ on member ADE}$$

We can return to our original FBD of the entire frame to determine C_x.



$$\sum F_x = 0 \rightarrow$$

$$C_x + E_x = 0 \quad (1)$$

$$C_x + (-602.09) = 0$$

$$C_x = +602.09\text{N}$$

$$\therefore \mathbf{C_x} = 602.09\text{N} \rightarrow$$

Re-draw all FBDs with results and Check Equilibrium