Lecture 17
GEN_ENG 205-2: Engineering Analysis 2
Winter Quarter 2018
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Chapter 6: §6.2 The Method of Joints[1]

Acknowledgements

Portions of these lecture notes are taken from those of Prof. Jeff Thomas.

Method of Joints

The method of joints is one of two approaches that we will use to compute the forces in a truss.

Analysis steps:

1. If necessary, draw the free-body diagram for the whole structure to determine reactions.
2. Select a joint for which there are either 1 or 2 unknown forces, as well as 1 known force.
3. Draw the free-body diagram for the joint, drawing the forces exerted by the members on the joint and paying attention to the direction of the forces (compression or tension). Typically, we assume tension for unknown forces.
4. Solve for the unknown forces using $\sum F_x = 0$ and $\sum F_y = 0$.
5. Repeat Steps (2)-(4) for the remaining joints.

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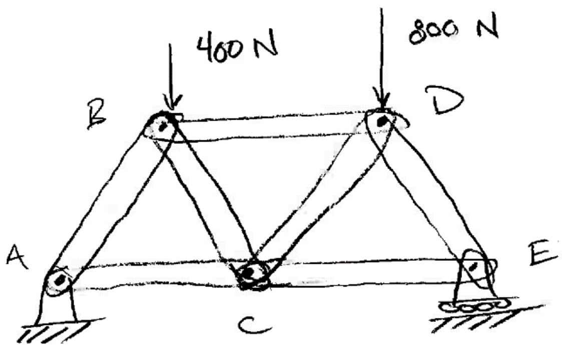
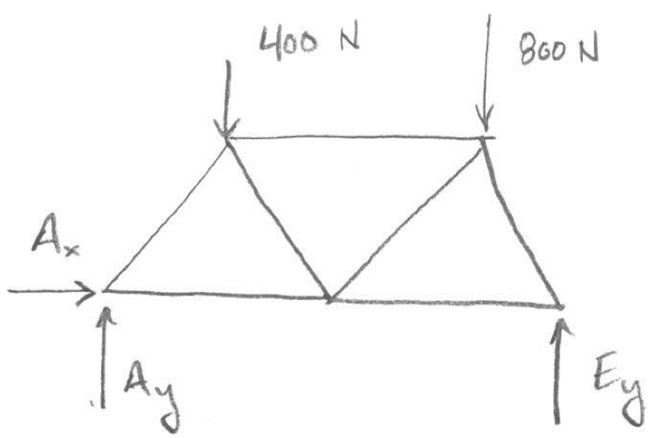
[1] Bedford, A., & Fowler, W. (2008). *Engineering Mechanics: Statics and Dynamics* (5th ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

Example[2]



All members have length L = 2 m.

Step 1: Free-body diagram for whole truss



$$\sum F_x = 0:\ A_x = 0$$

$$\sum F_y = 0:\ A_y + E_y - (400\,\mathrm{N}) - (800\,\mathrm{N}) = 0$$

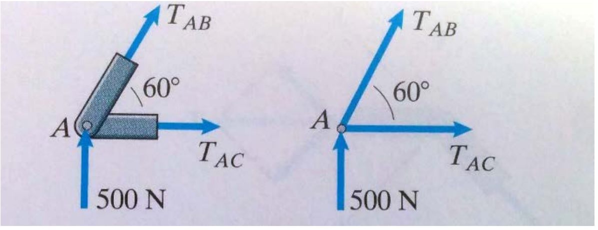
$$\sum M_A = 0:\ -(400\,\mathrm{N})(1\mathrm{m}) - (800\,\mathrm{N})(3\mathrm{m}) + E_y(4\mathrm{m}) = 0$$

Solve to find E_y = 700 N and A_y = 500 N.

[2] From Section 6.2.

Now, select joint *A*, for example (Step 2), and draw the free-body diagram (Step 3):

We can draw either the joint with short sections of the members (left figure below) or the forces on the joint, using Newton's third law[3] (right figure below).



Unknown forces are drawn here in tension.

Solve for the unknown forces considering equilibrium (Step 4):

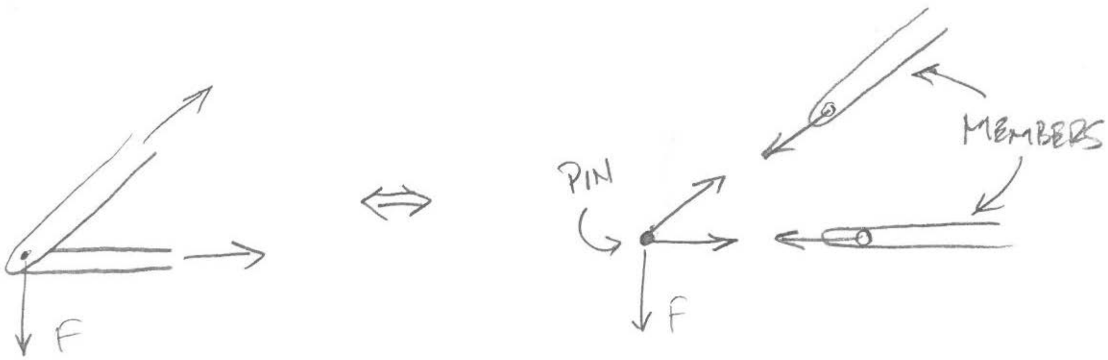
$$\sum F_x = 0: T_{AC} + T_{AB}\cos 60^\circ = 0$$
$$\sum F_y = 0: (500\,\text{N}) + T_{AB}\sin 60^\circ = 0$$

Solve to find $T_{AB} = -577\,\text{N}$ (compression) and $T_{AC} = 289\,\text{N}$ (tension).

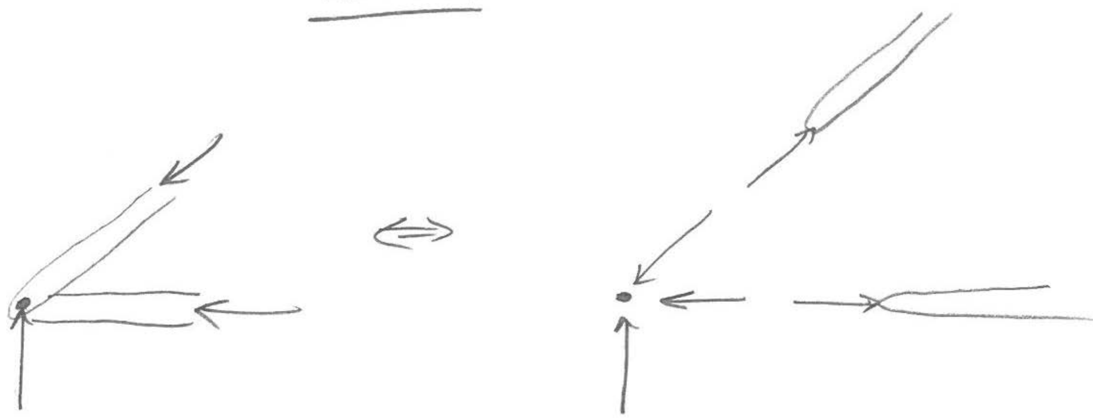
Next, we would proceed to joints *B*, *C*, *D*, and *E* in any sequence such that the forces for a particular joint can be determined. For example, we can consider joint *E* at any time, and use that information to move from right to left across the truss. However, we cannot directly consider joint *C*.

[3] Sketch separate free-body diagrams for the member and joint to show this clearly.

Note the change in direction for tension and compression:

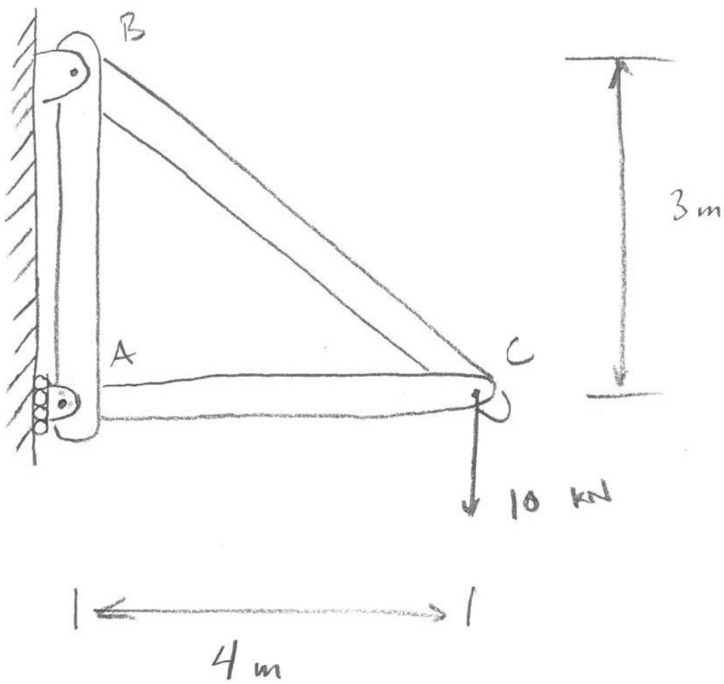


TENSION



COMPRESSION

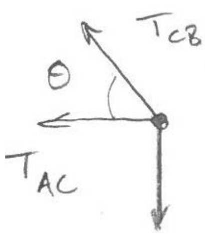
Example:



Determine the internal forces in all three members of the truss.

Strategy: Looking at the truss, we can see that we can solve Joint C, then Joint A, and then finally Joint B. There is no need to consider the free-body diagram for the whole truss.

Joint C:



10 kN

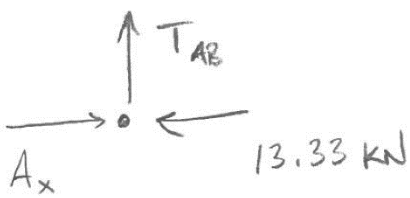
Assume tension in both members, as drawn above.

$$\tan\theta = \frac{3\text{ m}}{4\text{ m}} \;\Rightarrow\; \theta = 36.87^\circ$$

$$\sum F_x = 0: -T_{CB}\cos 36.87^\circ - T_{AC} = 0$$
$$\sum F_y = 0:\; T_{CB}\sin 36.87^\circ - 10 = 0 \;\text{(kN)}$$

Solve to find $\boxed{T_{CB} = 16.67\text{ kN (T)}}$ and $\boxed{T_{AC} = -13.33\text{ kN (C)}}$.

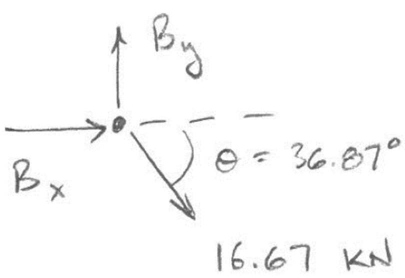
Joint A[4]:



$$\sum F_x = 0:\; A_x = 13.33\text{ kN}$$
$$\sum F_y = 0:\; T_{AB} = 0$$

Now we have the forces in all three beams. But if we want to keep going…

Joint B:



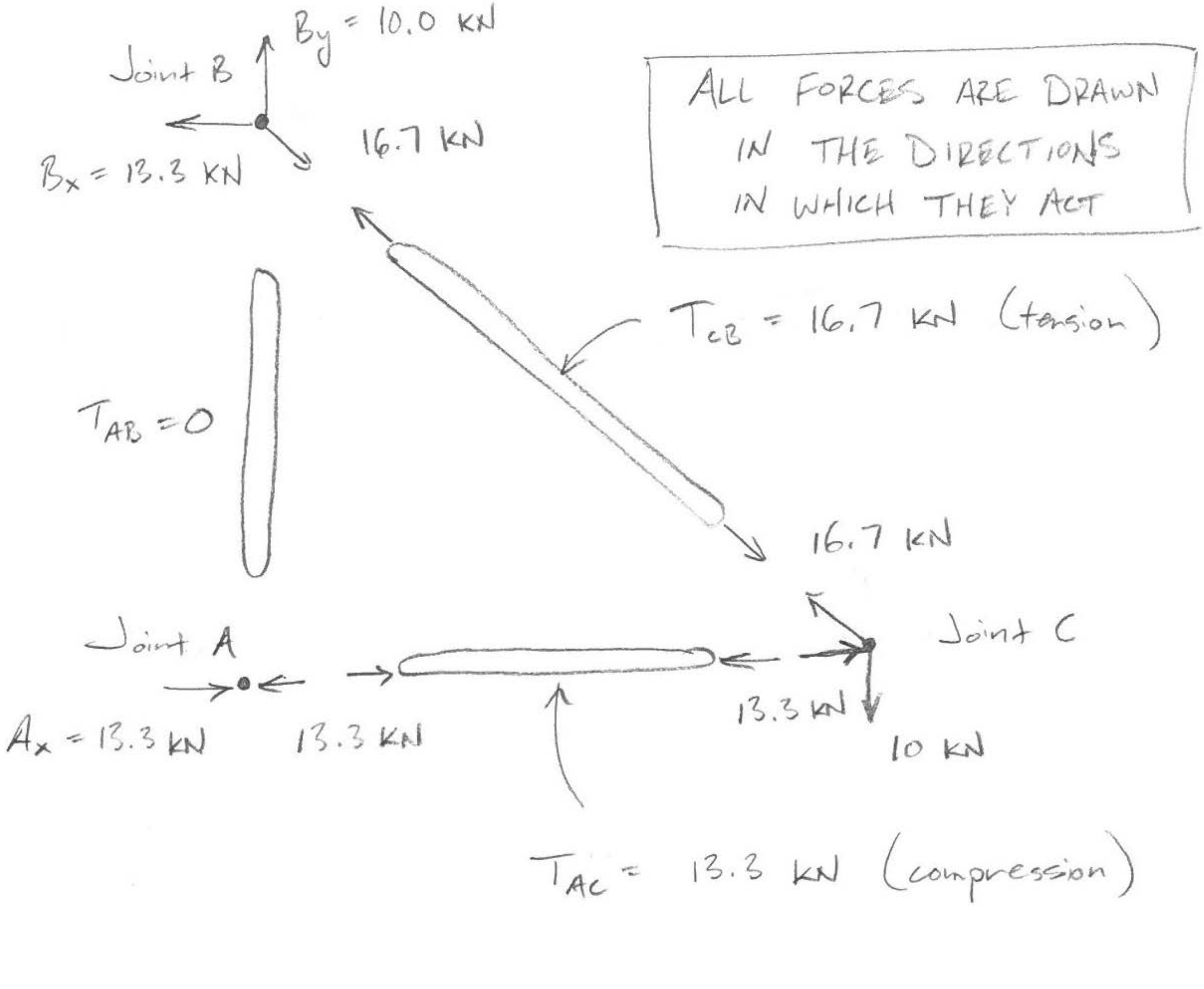
[4] Explain that force T_{AC} is drawn as a compressive force, given the computed result.

$$\sum F_x = 0:\ B_x + 16.67\cos 36.87^\circ = 0\ \text{(kN)}$$
$$\sum F_y = 0:\ B_y - 16.67\sin 36.87^\circ = 0\ \text{(kN)}$$

Solve to find $\boxed{B_x = -13.3\ \text{kN}}$ and $\boxed{B_y = 10.0\ \text{kN}}$.

We only needed to do this last step if we wanted the reactions at the supports.

Solution summary:



Note that we could have drawn all forces in tension as assumed, and then carried the negative sign through the calculations. I find this confusing, and would not recommend it.

Go through examples 6.1 and 6.2 in the textbook on your own.