PEARSON NEW INTERNATIONAL EDITION

Applied Mechanics for Engineering Technology

Keith M. Walker

Eighth Edition

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member is found by taking consecutive free-body diagrams of joints throughout the complete truss.

An alternative to the method of joints is the method of sections. A brief introductory comparison of the two methods can be seen in Figure 5–1 and Figure 5–2. More details on each method are covered in future examples.

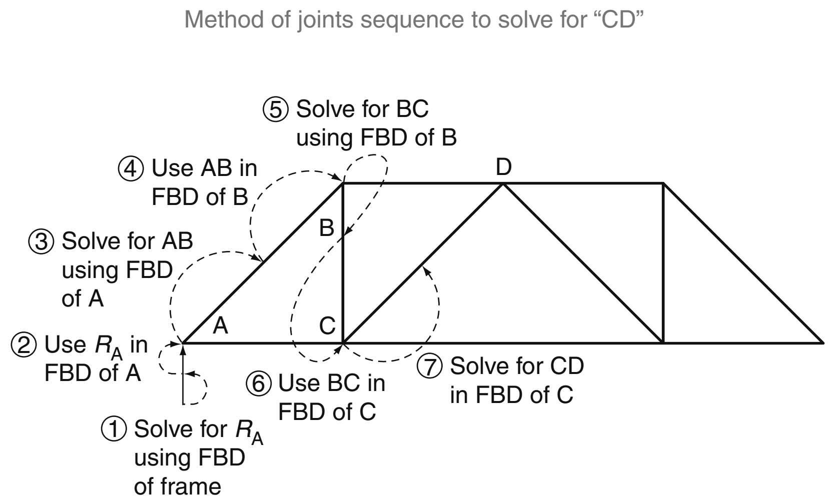

FIGURE 5–1

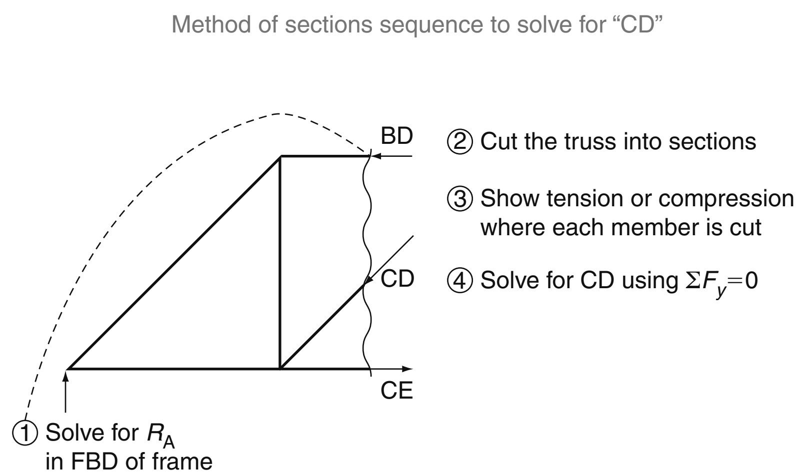

FIGURE 5–2

EXAMPLE 5–1

Determine the load in each member of the truss shown in Figure 5–3.

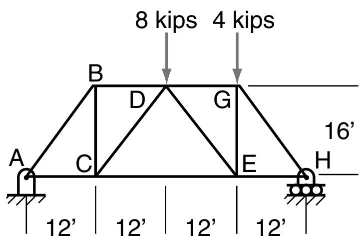

FIGURE 5–3

Free-Body Diagram of Truss

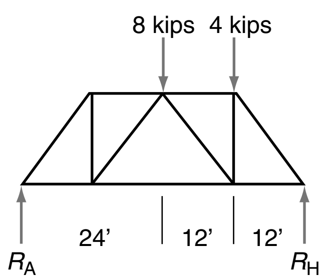

FIGURE 5–4

Step 1. Solve for the external reactions R_A and R_H.

The first step of the solution is one with which you are already familiar: Solve for the external reactions at points A and H (Figure 5–4). Taking moments about point H and solving for R_A, we obtain:

$$\Sigma M_H = 0$$

$$(8 \text{ kips})(24 \text{ ft}) + (4 \text{ kips})(12 \text{ ft}) - R_A(48 \text{ ft}) = 0$$

$$48R_A = 192 + 48$$

$$R_A = \frac{240}{48}$$

$$\underline{R_A = 5 \text{ kips}\uparrow}$$

$$\Sigma F_y = 0$$

$$5 \text{ kips} + R_H - 8 \text{ kips} - 4 \text{ kips} = 0$$

$$\underline{R_H = 7 \text{ kips}\uparrow}$$

Step 2. Choose a pin or joint for the first free-body diagram.

In choosing the first joint of which you will draw a free-body diagram, notice that only four joints—A, D, G, and H—have known forces. Joint D has four unknowns, G has three unknowns, and joints A and H each have two unknowns. Thus, the first free-body diagram could be of joint A or H. Let us arbitrarily choose joint A.

Step 3. Draw a free-body diagram of A.

Considering member AB with its dimensions of 16 ft and 12 ft, we find the slope to be 4 to 3 (Figure 5–5).

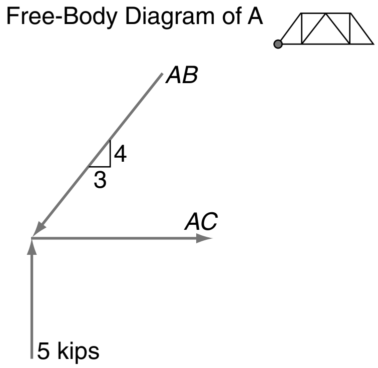

FIGURE 5–5

Assume member AB to be in compression and member AC to be in tension. (Experience will make you more confident of these assumptions later.) The vectors are drawn so that member AB is pushing on the joint (compression) and member AC is pulling on it (tension).

In considering vertical forces first, we find that the equation contains only one unknown, *AB*. The vertical component of *AB* is equal to 5 kips since there are no other vertical forces.

Step 4. Solve for *AB,* using

$$\Sigma F_y = 0$$

$$5 \text{ kips} - \frac{4}{5}AB = 0$$

$$\underline{AB = 6.25 \text{ kips } C}$$

Step 5. Solve for *AC,* using

$$\Sigma F_x = 0$$

$$AC - \frac{3}{5}AB = 0$$

$$AC = \frac{3}{5}(6.25 \text{ kips})$$

$$\underline{AC = 3.75 \text{ kips } T}$$

The compression or tension of a member should be indicated following the value with *C* or *T,* respectively.

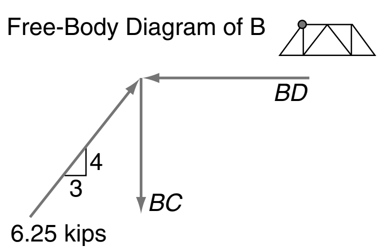

FIGURE 5–6

Step 6. Follow the value of a new known load, AB = 6.25, from pin A to an adjacent pin, B.

We draw a free-body diagram of joint B next, since it has only two unknowns (Figure 5–6). AB was found to have a compression of 6.25 kips; therefore, 6.25 kips must be pushing on joint B even though vector direction is opposite to that in the free-body diagram of A.

Step 7. Solve for *BD,* using

$$\Sigma F_x = 0$$

$$\frac{3}{5}(6.25 \text{ kips}) - BD = 0$$

$$\underline{BD = 3.75 \text{ kips } C}$$

Step 8. Solve for *BC,* using

$\Sigma F_y = 0$

$$\frac{4}{5}(6.25 \text{ kips}) - BC = 0$$

$$\underline{BC = 5 \text{ kips } T}$$

Step 9. Knowing the value of BC = 5, move from pin B to pin C and draw a free-body diagram (Figure 5–7).

Free-Body Diagram of C

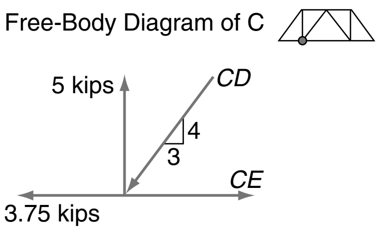

FIGURE 5–7

Step 10. Solve for *CD,* using

$\Sigma F_y = 0$

$$5 \text{ kips} - \frac{4}{5}CD = 0$$

$$\underline{CD = 6.25 \text{ kips } C}$$

Step 11. Solve for *CE,* using

$\Sigma F_x = 0$

$$CE - \frac{3}{5}CD - 3.75 \text{ kips} = 0$$

$$CE = \frac{3}{5}(6.25 \text{ kips}) + 3.75 \text{ kips}$$

$$\underline{CE = 7.5 \text{ kips } T}$$

Step 12. Reduce your possibility of error.

At this point, approximately one-half of the truss member loads have been determined. Each calculated value depends on our having calculated the previous value correctly. If we now go to joint H and work back toward the center of the truss, the possibility of an error being perpetuated through the complete calculation is lessened. The problem solution is, in essence, broken into two halves, and we can conclude with a final check, using a free-body diagram of a joint near the center of the truss.

Step 13. Show R_H = 7 kips on a free-body diagram of H (Figure 5–8).

Free-Body Diagram of H

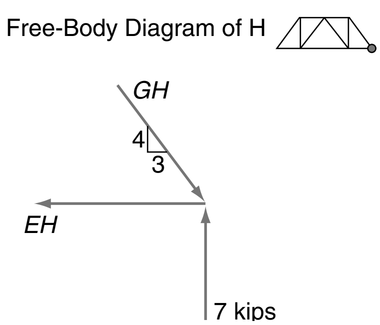

FIGURE 5–8

Step 14. Solve for *GH,* using

$\Sigma F_y = 0$

$$\frac{4}{5}GH = 7 \text{ kips}$$

$$\underline{GH = 8.75 \text{ kips } C}$$

Step 15. Solve for *EH,* using

$\Sigma F_x = 0$

$$\frac{3}{5}GH - EH = 0$$

$$\frac{3}{5}(8.75 \text{ kips}) - EH = 0$$

$$\underline{EH = 5.25 \text{ kips } T}$$

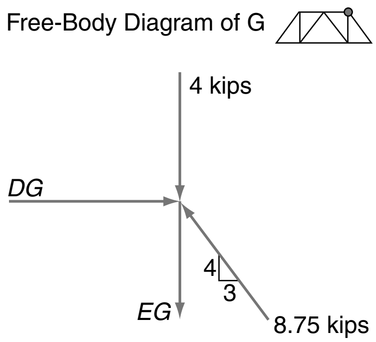

FIGURE 5–9

Step 16. Knowing GH = 8.75 kips C, move from pin H to a free-body diagram of G (Figure 5–9).

Do not forget to include the external 4-kip load in the free-body diagram of G (Figure 5–9).

Step 17. Solve for *EG,* using

$\Sigma F_y = 0$

$$\frac{4}{5}(8.75 \text{ kips}) - EG - 4 \text{ kips} = 0$$

$$EG = 7 - 4$$

$$\underline{EG = 3 \text{ kips } T}$$

Step 18. Solve for *DG,* using

$\Sigma F_x = 0$

$$DG - \frac{3}{5}(8.75 \text{ kips}) = 0$$

$$\underline{DG = 5.25 \text{ kips } C}$$

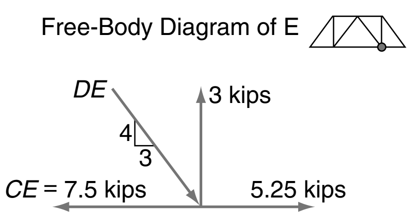

FIGURE 5–10

Step 19. Draw a free-body diagram of E showing CE = 7.5 kips, EG = 3 kips, and EH = 5.25 kips (Figure 5–10).

Step 20. Solve for *DE,* using

$\Sigma F_y = 0$

$$3 \text{ kips} - \frac{4}{5}DE = 0$$

$$\underline{DE = 3.75 \text{ kips } C}$$

Step 21. Check accuracy of calculations, using

$\Sigma F_x = 0$

$$\frac{3}{5}(3.75 \text{ kips}) + 5.25 \text{ kips} - 7.5 \text{ kips} = 0$$

$$2.25 + 5.25 - 7.5 = 0$$

$$\underline{7.5 = 7.5 \textit{ check}}$$

Since $CE = 7.5$ kips was calculated in the first half of the solution and now gives us a balance of horizontal forces at joint E, it would seem to indicate that all values calculated are correct.

Step 22. Label forces for all truss members.

It is suggested that you conclude the solution with a sketch of the truss, labeling all member loads. Such a sketch is shown in Figure 5–11. This is useful not only as a final summary of all answers but, if you fill it in as you progress through the problem solution, it also serves as a quick and easy way to find formerly calculated values when required for a new free-body diagram.

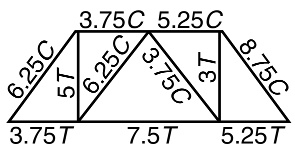

FIGURE 5–11

EXAMPLE 5–2

Use the method of joints to solve for the loads in members AB and CE of the truss shown in Figure 5–12.

This truss will illustrate that some truss members are needed to maintain alignment of other members but may not carry a load, depending upon how the external forces act on the truss.

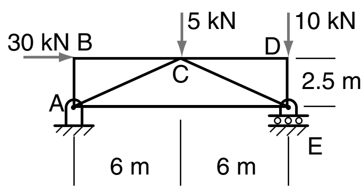

FIGURE 5–12

Step 1. Draw a free-body diagram of B (Figure 5–13).

A free-body diagram of joint B shows the load of member AB. Tension has been assumed but, since there is no other vertical force present, the load in member AB is zero.

$$\underline{AB = 0}$$

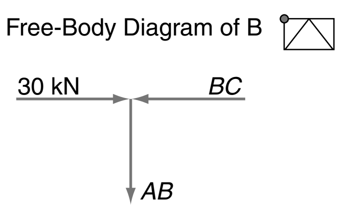

FIGURE 5–13

Step 2. Analyze the truss to select the next free-body diagram.

The load in member CE can be found from a free-body diagram of either joint C or E. The solution of joint C may be more difficult because of the joint's two members being sloped and unknown. Joint E will be easier to solve, but the load in member DE and the reaction at E must be found first.

Perhaps the best method of solution will not be readily apparent to you until you have solved several problems; so until that time, you may simply have to draw many free-body diagrams and use some trial-and-error methods. There is usually more than one method of solution, and experience will teach you the shortest one.

Step 3. Draw a free-body diagram of D (Figure 5–14).

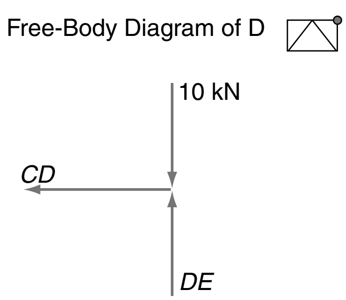

FIGURE 5–14