ENGINEERING MECHANICS - STATIC
CHAPTER4

[STRUCTURES]

الأستاذ المساعد :علي خالد الدليمي
جامعة تكريت – كلية الهندسة – قسم الهندسة الميكانيكية
eng_ali_khalid@tu.edu.iq

Assist. Professor Engineer: ALI KHALID ALDULAIMY
Eng_ali_khalid@tu.edu.iq

يرجى عدم اعادة نشر أو طبع أو أستنساخ هذه الملازم بدون موافقة الناشر

Introduction

In Chapter 4, we analyze the internal forces acting in several structures, namely, trusses, frames, and machines. In this treatment, we only consider *statically determined* structures, which do not have more supporting constraints necessary to maintain an equilibrium configuration.

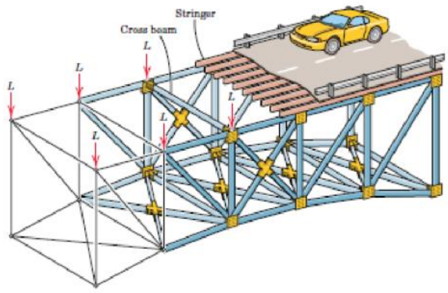


Figure 4/1

4/2 PLANE TRUSSES

A framework composed of members joined at their ends to form a rigid structure is called a *truss*. Bridges, roof supports, derricks, and other such structures are common examples of trusses. Structural members commonly used are I-beams, channels, angles, bars, and special shapes, which are fastened together at their ends by welding, riveted connections, or large bolts or pins. When the members of the truss lie essentially in a single plane, the truss is called a *plane truss*.

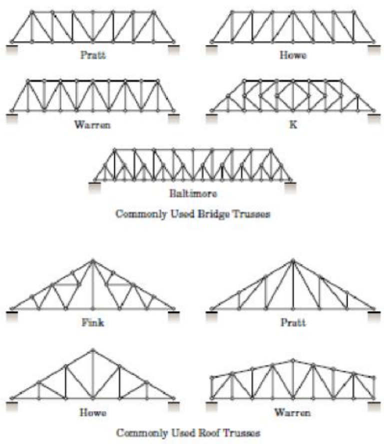


Figure 4/2

Simple Trusses

Structures built from a basic triangle in the manner described are known as *simple trusses*.

Each truss member is normally a straight link joining the two points of application of force. The two forces are applied at the ends of the member and are necessarily equal, opposite, and *collinear* for equilibrium. The member may be in tension or compression.

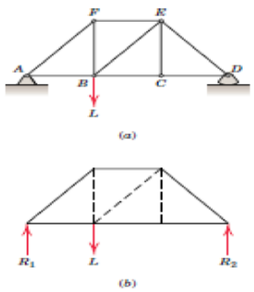


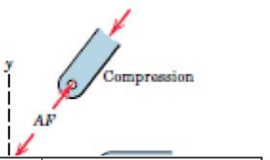
Figure 4/6

Truss Connections and Supports

Two methods for the force analysis of simple trusses will be given. Each method will be explained for the simple truss shown in Fig. 4/6*a*. The free-body diagram of the truss as a whole is shown in Fig. 4/6*b*. The external reactions are usually determined first by applying the equilibrium equations to the truss as a whole.

4/3 METHOD OF JOINTS

We begin the analysis with any joint where at least one known load exists and where not more than two unknown forces are present. With the joints indicated by letters, we usually designate the force in each member by the two letters defining the ends of the member. The free-body diagrams of portions of members *AF* and *AB* are also shown to indicate the mechanism of the action and reaction clearly. The magnitude of *AF* is obtained from the equation $\Sigma F_y = 0$ and *AB* is then found from $\Sigma F_x = 0$.



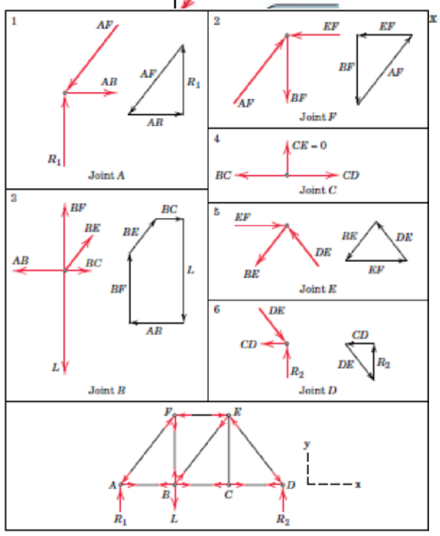


Figure 4/8

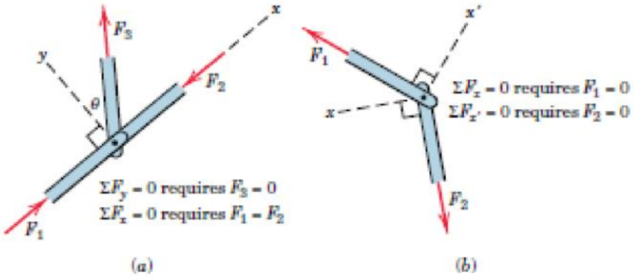
Internal and External Redundancy

If a plane truss has more external supports than are necessary to ensure a stable equilibrium configuration, the truss as a whole is statically indeterminate, and the extra supports constitute *external* redundancy.

If a truss has more internal members than are necessary to prevent collapse when the truss is removed from its supports, then the extra members constitute *internal* redundancy and the truss is again statically indeterminate.

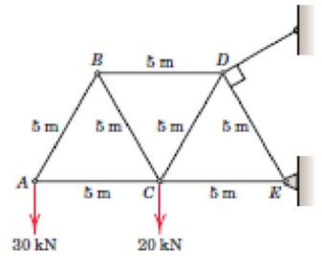
Special Conditions

When two collinear members are under compression, the third member must be zero and from the x-direction that $F_1 = F_2$.
When two noncollinear members are joined as shown in Fig. 4/9b, then in the absence of an externally applied load at this joint, the forces in both members must be zero.

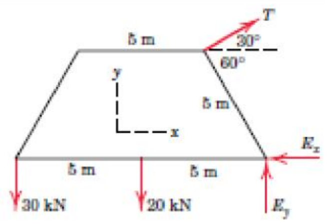


Sample Problem 4/1

Compute the force in each member of the loaded cantilever truss by the method of joints.

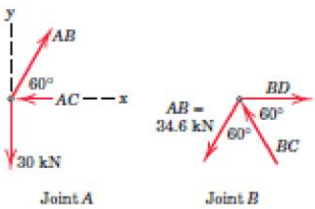


Solution. If it were not desired to calculate the external reactions at D and E, the analysis for a cantilever truss could begin with the joint at the loaded end.
However, this truss will be analyzed completely, so the first step will be to compute the external forces at D and E from the free-body diagram of the truss as a whole. The equations of equilibrium give



$[\Sigma M_E = 0]$ $5T - 20(5) - 30(10) = 0$ $T = 80$ kN
$[\Sigma F_x = 0]$ $80 \cos 30^o - E_x = 0$ $E_x = 69.3$ kN
$[\Sigma F_y = 0]$ $80 \sin 30^o + E_y - 20 - 30 = 0$ $E_y = 10$ kN

Next we draw free-body diagrams showing the forces acting on each of the connecting pins. The correctness of the assigned directions of the forces is verified when each joint is considered in sequence. There should be no question about the correct direction of the forces on joint A. Equilibrium requires



$[\Sigma F_y = 0]$ $0.866AB - 30 = 0$ $AB = 34.6$ kN T *Ans.*
$[\Sigma F_x = 0]$ $AC - 0.5(34.6) = 0$ $AC = 17.32$ kN C *Ans.*

where T stands for tension and C stands for compression.
Joint B must be analyzed next, since there are more than two unknown forces on joint C. The force BC must provide an upward component, in which case BD must balance the force to the left. Again the forces are obtained from

$[\Sigma F_y = 0]$ $0.866BC - 0.866(34.6) = 0$ $BC = 34.6$ kN C *Ans.*
$[\Sigma F_x = 0]$ $BD - 2(0.5)(34.6) = 0$ $BD = 34.6$ kN T *Ans.*

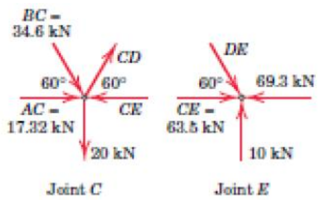
Joint C now contains only two unknowns, and these are found in the same way as before:

$[\Sigma F_y = 0]$ $0.866CD - 0.866(34.6) - 20 = 0$
$CD = 57.7$ kN T *Ans.*
$[\Sigma F_x = 0]$ $CE - 17.32 - 0.5(34.6) - 0.5(57.7) = 0$
$CE = 63.5$ kN C *Ans.*
Finally, from joint E there results

$[\Sigma F_y = 0]$ $0.866DE = 10$ $DE = 11.55$ kN C *Ans.*
and the equation $\Sigma F_x = 0$ checks.

Helpful Hint

1- It should be stressed that the tension compression designation refers to the *member*, not the joint. Note that we draw the force arrow on the same side of the joint as the member which exerts the force. In this way tension (arrow away from the joint) is distinguished from compression (arrow toward the joint)



EXAMPLE 6.1

Determine the force in each member of the truss shown in Fig. 6–8 *a* and indicate whether the members are in tension or compression.

SOLUTION

Since we should have no more than two unknown forces at the joint and at least one known force acting there, we will begin our analysis at joint *B* .

Joint *B*. The free-body diagram of the joint at *B* is shown in Fig. 6–8 *b* .

Applying the equations of equilibrium, we have

$\overset{+}{\rightarrow}\sum F_x = 0$; $500\text{ N} - F_{BC}\sin 45^\circ = 0$ $F_{BC} = 707.1\text{ N (C)}$ *Ans.*

$+\uparrow \sum F_y = 0$; $F_{BC}\cos 45^\circ - F_{BA} = 0$ $F_{BA} = 500\text{ N (T)}$ *Ans.*

Since the force in member *BC* has been calculated, we can proceed to analyze joint *C* to determine the force in member *CA* and the support reaction at the rocker.

Joint *C*. From the free-body diagram of joint *C* , Fig. 6–8 *c* , we have

$\overset{+}{\rightarrow}\sum F_x = 0$; $-F_{CA} + 707.1\cos 45^\circ\text{ N} = 0$ $F_{CA} = 500\text{ N (T)}$ *Ans.*

$+\uparrow\sum F_y = 0$; $C_y - 707.1\sin 45^\circ\text{ N} = 0$ $C_y = 500\text{ N}$ *Ans.*

Joint *A*. Although it is not necessary, we can determine the components of the support reactions at joint *A* using the results of F_{CA} and F_{BA} . From the free-body diagram, Fig. 6–8 *d* , we have

$\overset{+}{\rightarrow}\sum F_x = 0$; $500\text{ N} - A_x = 0$ $A_x = 500\text{ N}$

$+\uparrow\sum F_y = 0$; $500\text{ N} - A_y = 0$ $A_y = 500\text{ N}$

NOTE: The results of the analysis are summarized in Fig. 6–8 *e* . Note that the free-body diagram of each joint (or pin) shows the effects of all the connected members and external forces applied to the joint, whereas the free-body diagram of each member shows only the effects of the end joints on the member.

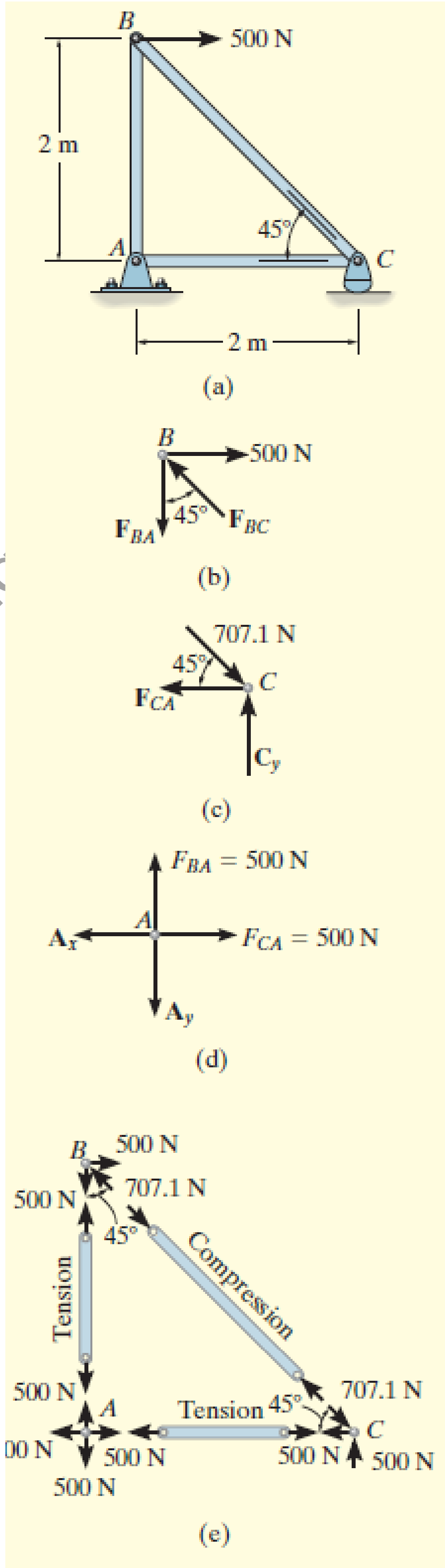


Fig. 6–8

EXAMPLE 6.2

Determine the forces acting in all the members of the truss shown in Fig. 6–9 *a* .

SOLUTION

By inspection, there are more than two unknowns at each joint. Consequently, the support reactions on the truss must first be determined.

Show that they have been correctly calculated on the free-body diagram in Fig. 6–9 *b* . We can now begin the analysis at joint *C*. Why?

Joint *C*. From the free-body diagram, Fig. 6–9 *c* ,

$+\rightarrow\sum F_x = 0;\ -F_{CD}\cos 30\_ + F_{CB}\sin 45^\circ = 0$

$+\uparrow\sum F_y = 0;\ 1.5\text{ kN} + F_{CD}\sin 30^\circ - F_{CB}\cos 45^\circ = 0$

These two equations must be solved *simultaneously* for each of the two unknowns. Note, however, that a *direct solution* for one of the unknown forces may be obtained by applying a force summation along an axis that is *perpendicular* to the direction of the other unknown force. For example, summing forces along the *y_* axis, which is perpendicular to the direction of $\mathbf{F}_{CD}$, Fig. 6–9 *d* , yields a *direct solution* for F_{CB}.

$+\nearrow\sum F_{y\_} = 0;$ $\quad 1.5\cos 30^\circ\text{ kN} - F_{CB}\sin 15^\circ = 0$

$F_{CB} = 5.019\text{ kN} = 5.02\text{ kN (C)}$ *Ans.*

Then,

$+\searrow F_{x\_} = 0;$

$-F_{CD} + 5.019\cos 15^\circ - 1.5\sin 30^\circ = 0;\ F_{CD} = 4.10\text{ kN (T)}$ *Ans.*

Joint *D*. We can now proceed to analyze joint *D* . The free-body diagram is shown in Fig. 6–9 *e* .

$+\rightarrow\sum F_x = 0;$ $\quad -F_{DA}\cos 30^\circ + 4.10\cos 30\_\text{ kN} = 0$

$F_{DA} = 4.10\text{ kN (T)}$ *Ans.*

$+\uparrow F_y = 0;$ $\quad F_{DB} - 2(4.10\sin 30^\circ\text{ kN}) = 0$

$F_{DB} = 4.10\text{ kN (T)}$ *Ans.*

NOTE: The force in the last member, *BA* , can be obtained from joint *B* or joint *A*. As an exercise, draw the free-body diagram of joint *B* , sum the forces in the horizontal direction, and show that $F_{BA} = 0.776\text{ kN (C)}$.

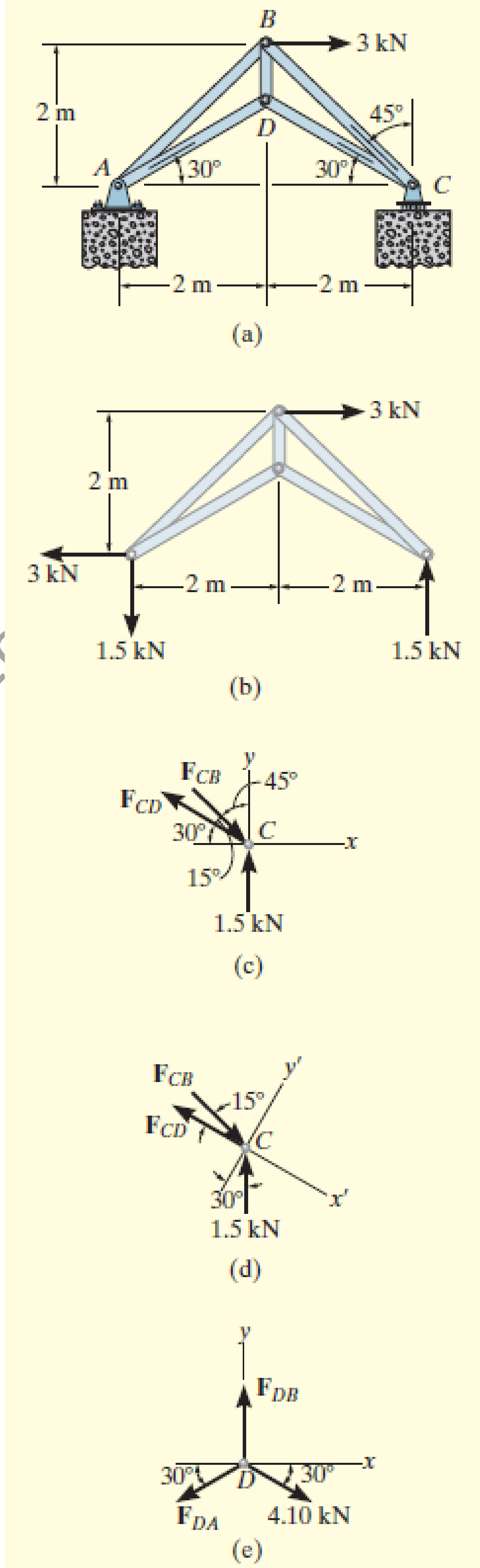


Fig. 6–9

EXAMPLE 6.3

Determine the force in each member of the truss shown in Fig. 6–10 *a* . Indicate whether the members are in tension or compression.

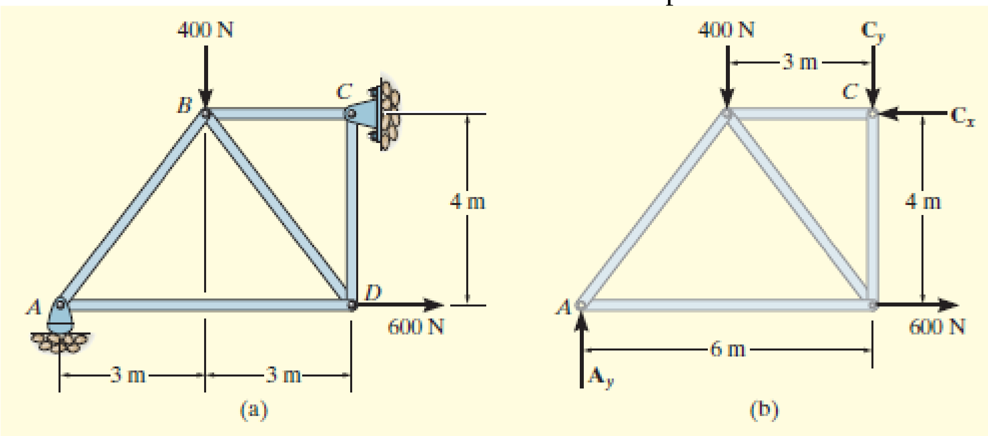


Fig. 6–10

SOLUTION

Support Reactions. No joint can be analyzed until the support reactions are determined, because each joint has at least three unknown forces acting on it. A free-body diagram of the entire truss is given in Fig. 6–10 *b* . Applying the equations of equilibrium, we have

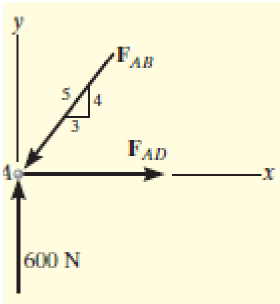
$+\rightarrow \sum F_x = 0;$ 600 N - $C_x = 0$ $\qquad C_x = 600$ N

$+\circlearrowleft \sum M_C = 0;$ $\qquad -A_y(6\text{ m}) + 400\text{ N}(3\text{ m}) + 600\text{ N}(4\text{ m}) = 0$

$A_y = 600$ N

$+\uparrow F_y = 0;$ 600 N - 400 N - $C_y = 0$ $C_y = 200$ N

The analysis can now start at either joint *A* or *C* . The choice is arbitrary since there are one known and two unknown member forces acting on the pin at each of these joints.

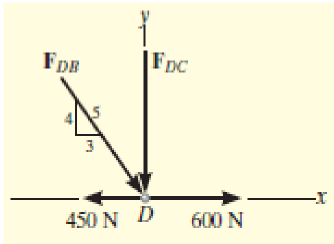


(c)

Joint *A*. (Fig. 6–10 *c*). As shown on the free-body diagram, **F***AB* is assumed to be compressive and **F***AD* is tensile. Applying the equations of equilibrium, we have

$+\uparrow \sum F_y = 0;$ $\qquad 600\text{ N} - (4/5)\, F_{AB} = 0$ $\qquad F_{AB} = 750$ N (C) *Ans.*

$+\rightarrow \sum F_x = 0;$ $\qquad F_{AD} - (3/5)\,(750\text{ N}) = 0$ $\qquad F_{AD} = 450$ N (T) *Ans.*



(d)

Joint *D*. (Fig. 6–10 *d*). Using the result for *FAD* and summing forces in the horizontal direction, Fig. 6–10 *d* , we have

$+\rightarrow \sum F_x = 0;$ $\qquad -450\text{ N} + (3/5)F_{DB} + 600\text{ N} = 0$ $\qquad F_{DB} = -250$ N

The negative sign indicates that **F***DB* acts in the *opposite sense* to that shown in Fig. 6–10 *d* . * Hence,

$F_{DB} = 250$ N (T) *Ans.*

To determine $\mathbf{F}_{DC}$, we can either correct the sense of $\mathbf{F}_{DB}$ on the freebody diagram, and then apply $\sum F_y = 0$, or apply this equation and retain the negative sign for F_{DB}, i.e.,

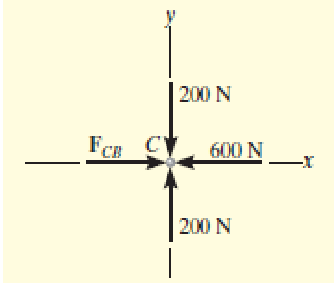
$+\uparrow \sum F_y = 0;$ $-F_{DC} - (4/5)\,(-250\text{ N}) = 0$ $\qquad F_{DC} = 200$ N (C) *Ans.*

Joint *C*. (Fig. 6–10 *e*).

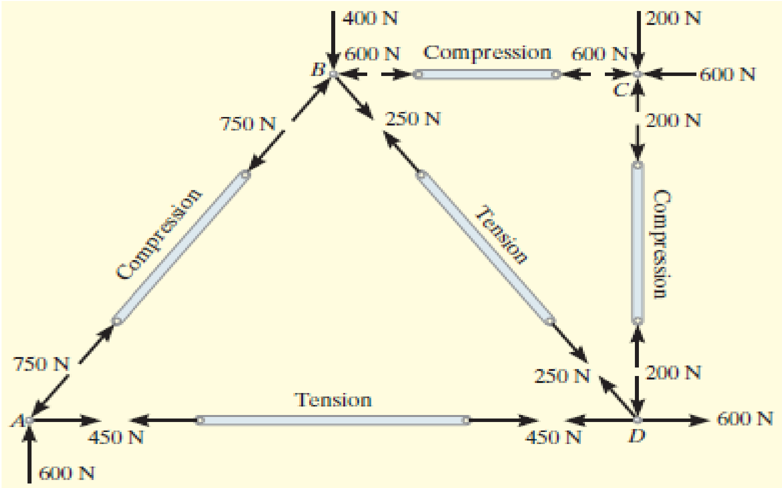
$+\rightarrow \sum F_x = 0;$ $\qquad F_{CB} - 600\text{ N} = 0$ $\qquad F_{CB} = 600$ N (C) *Ans.*

$+\uparrow \sum F_y = 0;$ $\qquad 200\text{ N} - 200\text{ N} = 0$ (check)

NOTE: The analysis is summarized in Fig. 6–10 *f* , which shows the freebody diagram for each joint and member.



(e)

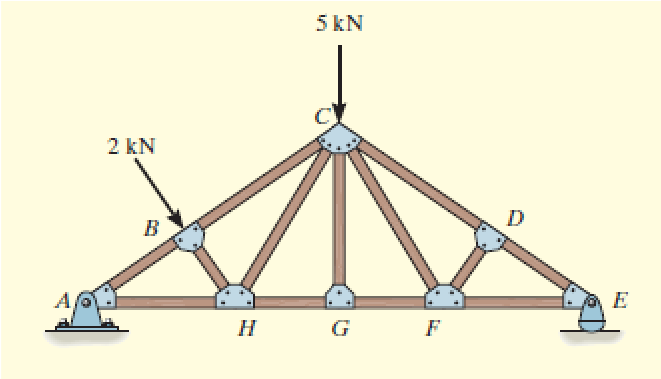


(f)

Fig. 6–10 (cont.)

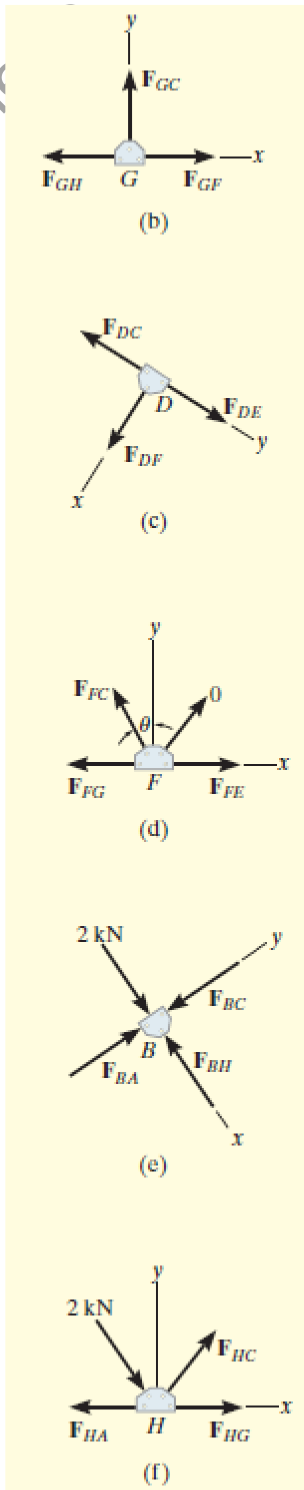
EXAMPLE 6.4

Using the method of joints, determine all the zero-force members of the *Fink roof truss* shown in Fig. 6–13 *a* . Assume all joints are pin connected.



(a)

Fig. 6–13



SOLUTION

Look for joint geometries that have three members for which two are collinear. We have

Joint *G*. (Fig. 6–13 *b*).

$+\uparrow \sum F_y = 0;$ $F_{GC} = 0$ *Ans.*

Realize that we could not conclude that *GC* is a zero-force member by considering joint *C* , where there are five unknowns. The fact that *GC* is a zero-force member means that the 5-kN load at *C* must be supported by members *CB* , *CH* , *CF* , and *CD.*

Joint *D*. (Fig. 6–13 *c*).

$\xrightarrow{+} \sum F_x = 0;$ $F_{DF} = 0$ *Ans.*

Joint *F*. (Fig. 6–13 *d*).

$+\uparrow \sum F_y = 0;$ $F_{FC} \cos u = 0$ Since $\square \neq 90^\circ$, $F_{FC} = 0$ *Ans.*

NOTE: If joint *B* is analyzed, Fig. 6–13 *e* ,

$+\searrow \sum F_x = 0;$ $2\text{ kN} - F_{BH} = 0$ $F_{BH} = 2\text{ kN (C)}$

Also, F_{HC} must satisfy $\sum F_y = 0$, Fig. 6–13 *f* , and therefore *HC* is *not* a zero-force member.

4/4 METHOD OF SECTIONS

We can take advantage of the third or moment equation of equilibrium by selecting an entire section of the truss for the free body in equilibrium under the action of a nonconcurrent system of forces. This *method of sections* has the basic advantage that the force in almost any desired member may be found directly from an analysis of a section which has cut that member.

Let us determine the force in the member *BE*, for example. An imaginary section, indicated by the dashed line.

For simple trusses composed of straight two-force members, these forces, either tensile or compressive, will always be in the directions of the respective members.

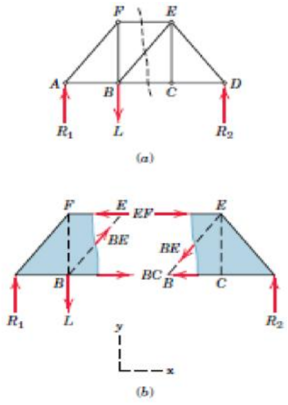


Figure 4/12

Procedure for Analysis

The forces in the members of a truss may be determined by the method of sections using the following procedure.

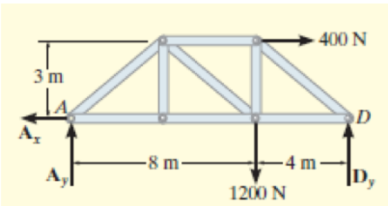
Free-Body Diagram.

• Make a decision on how to "cut" or section the truss through the members where forces are to be determined.

• Before isolating the appropriate section, it may first be necessary to determine the truss's support reactions. If this is done then the three equilibrium equations will be available to solve for member forces at the section.

• Draw the free-body diagram of that segment of the sectioned truss which has the least number of forces acting on it.

• Use one of the two methods ($\sum F_x$ or $\sum F_y$) for establishing the sense of the unknown member forces.



(b)

Equations of Equilibrium.

• Moments should be summed about a point that lies at the intersection of the lines of action of two unknown forces, so that the third unknown force can be determined directly from the moment equation.

The forces in selected members of this Pratt truss can readily be determined using the method of sections.

Simple trusses are often used in the construction of large cranes in order to reduce the weight of the boom and tower.

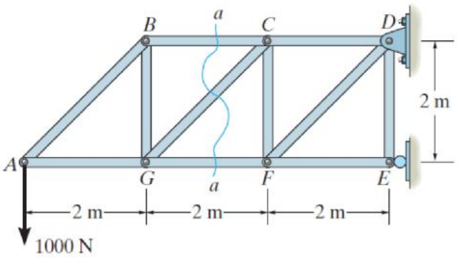
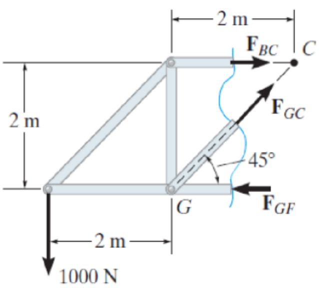


Fig. 6–15



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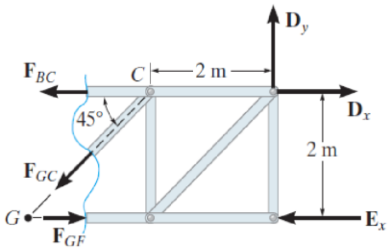
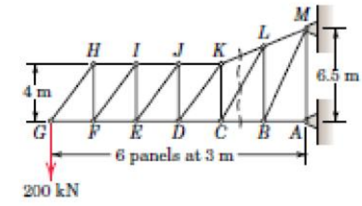


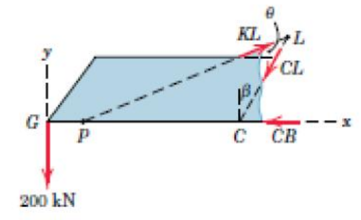
(c)

Fig. 6–15 (cont.)

Sample Problem 4/3

Calculate the forces induced in members *KL*, *CL*, and *CB* by the 200-kN load on the cantilever truss.





Solution. Although the vertical components of the reactions at *A* and *M* are statically indeterminate with the two fixed supports, all members other than *AM* are statically determinate. We may pass a section directly through members *KL*, *CL*, and *CB* and analyze the portion of the truss to the left of this section as a statically determinate rigid body.

The free-body diagram of the portion of the truss to the left of the section is shown. A moment sum about *L* quickly verifies the assignment of *CB* as compression, and a moment sum about *C* quickly discloses that *KL* is in tension. The direction of *CL* is not quite so obvious until we observe that *KL* and *CB* intersect at a point *P* to the right of *G*. A moment sum about *P* eliminates reference to *KL* and *CB* and shows that *CL* must be compressive to balance the moment of the 200-kN force about *P*. With these considerations in mind the solution becomes straightforward, as we now see how to solve for each of the three unknowns independently of the other two.

Summing moments about *L* requires finding the moment arm $\underline{BL}$= 4 + (6.5 - 4)/2 = 5.25 m. Thus,

$[\Sigma M_L = 0]$ 200(5)(3) - *CB*(5.25) = 0 *CB* = 571 kN *C* *Ans.*

Next we take moments about *C*, which requires a calculation of cosθ. From the given dimensions we see $\theta = \tan^{-1}\theta$ (5/12) so that cos θ= 12/13. Therefore,

$[\Sigma M_C = 0]$ $200(4)(3) - \frac{12}{13}KL(4) = 0$ *KL* = 650 kN *T* *Ans.*

Finally, we may find *CL* by a moment sum about *P*, whose distance from *C* is given by $\frac{PC}{4}$= 6/(6.5 - 4) or $\underline{PC}$= 9.60 m. We also need β , which is given by

$\beta = \tan^{-1}(\underline{CB}/\underline{BL}) = \tan^{-1}(3/5.25) = 29.7^{o}$ and cos β = 0.868. We now have

$[\Sigma M_p = 0]$ 200(12 - 9.60) - *CL*(0.868)(9.60) = 0

CL = 57.6 kN *C* *Ans.*

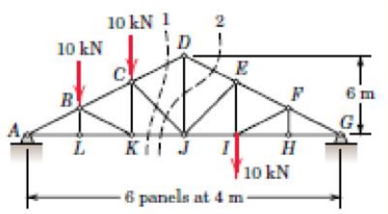
Helpful Hint

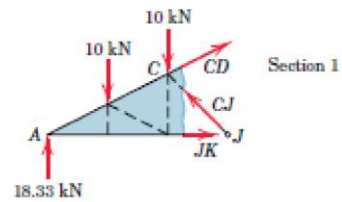
1- We note that analysis by the method of joints would necessitate working with eight joints in order to calculate the three forces in question. Thus, the method of sections offers a considerable advantage in this case.

2- We could have started with moments about *C* or *P* just as well.

3- We could also have determined *CL* by a force summation in either the *x*- or

Sample Problem 4/4





Calculate the force in member *DJ* of the Howe roof truss illustrated. Neglect any horizontal components of force at the supports.

Solution. It is not possible to pass a section through *DJ* without cutting four members whose forces are unknown. Although three of these cut by section 2 are concurrent at *J* and therefore the moment equation about *J* could be used to obtain *DE*, the force in *DJ* cannot be obtained from the remaining two equilibrium principles. It is necessary to consider first the adjacent section 1 before analyzing section 2.

The free-body diagram for section 1 is drawn and includes the reaction of 18.33 kN at *A*, which is previously calculated from the equilibrium of the truss as a whole. In assigning the proper directions for the forces acting on the three cut members, we see that a balance of moments about A eliminates the effects of CD and JK and clearly requires that CJ be up and to the left. A balance of moments about C eliminates the effect of the three forces concurrent at C and indicates that JK must be to the right to supply sufficient counterclockwise moment.

Again it should be fairly obvious that the lower chord is under tension because of the bending tendency of the truss. Although it should also be apparent that the top chord is under compression, for purposes of illustration the force in CD will be arbitrarily assigned as tension.

By the analysis of section 1, CJ is obtained from

$[\Sigma M_A = 0]$ $\quad 0.707\ CJ\ (12) - 10(4) - 10(8) = 0 \qquad CJ = 14.14$ kN C

In this equation the moment of CJ is calculated by considering its horizontal and vertical components acting at point J. Equilibrium of moments about J requires

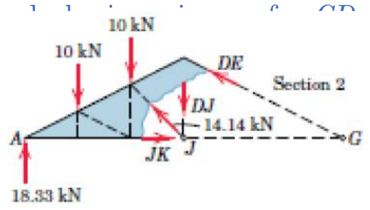
$[\Sigma M_J = 0]$ $\quad 0.894\ CD\ (6) + 18.33(12) - 10(4) - 10(8) = 0$

$CD = -18.63$ kN

Helpful Hint

1- There is no harm in assigning one or more of the forces in the wrong direction, as long as the calculations are consistent with the assumption. A negative answer will show the need for reversing the direction of the force.

2- If desired, the direction of CD may be changed on the free-body diagram and the



The moment of CD about J is calculated here by considering its two components as acting through D. The minus sign indicates that CD was assigned in the wrong direction.

Hence, $\qquad CD = 18.63$ kN C

From the free-body diagram of section 2, which now includes the known value of CJ, a balance of moments about G is seen to eliminate DE and JK. Thus,

$[\Sigma M_G = 0]$ $\quad 12DJ + 10(16) + 10(20) - 18.33(24) - 14.14(0.707)(12) = 0$

$DJ = 16.67$ kN T $\qquad$ *Ans.*

Again the moment of CJ is determined from its components considered to be acting at J. The answer for DJ is positive, so that the assumed tensile direction is correct.

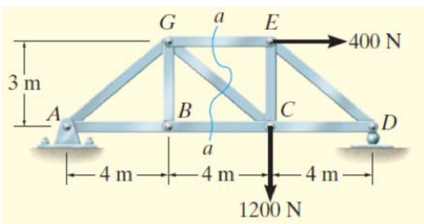
An alternative approach to the entire problem is to utilize section 1 to determine CD and then use the method of joints applied at D to determine DJ.

Helpful Hint

3- Observe that a section through members *CD*, *DJ*, and *DE* could be taken which would cut only three unknown members. However, since the forces in these three members are all concurrent at *D*, a moment equation about *D* would yield no information about them. The remaining two force equations would not be sufficient to solve for the

EXAMPLE 6.5

Determine the force in members *GE*, *GC*, and *BC* of the truss shown in Fig. 6–16 *a* . Indicate whether the members are in tension or compression.



(a)

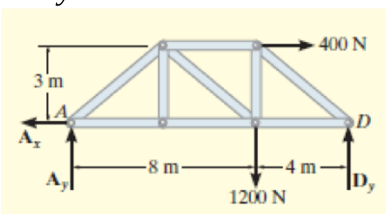
SOLUTION

Section *aa* in Fig. 6–16 *a* has been chosen since it cuts through the *three* members whose forces are to be determined. In order to use the method of sections, however, it is *first* necessary to determine the external reactions at *A* or *D* . Why? A free-body diagram of the entire truss is shown in Fig. 6–16 *b* . Applying the equations of equilibrium, we have

$\xrightarrow{+} \sum F_x = 0; \qquad 400\text{ N} - A_x = 0 \qquad A_x = 400\text{ N}$

$\circlearrowleft + \sum M_A = 0; \qquad -1200\text{ N}(8\text{ m}) - 400\text{ N}(3\text{ m}) + D_y(12\text{ m}) = 0 \qquad D_y = 900\text{N}$

$+\uparrow \sum F_y = 0; \qquad A_y - 1200\text{ N} + 900\text{ N} = 0 \qquad A_y = 300\text{ N}$



(b)

Free-Body Diagram. For the analysis the free-body diagram of the left portion of the sectioned truss will be used, since it involves the least number of forces, Fig. 6–16 *c* .

Equations of Equilibrium. Summing moments about point *G* eliminates $\mathbf{F}_{GE}$ and $\mathbf{F}_{GC}$ and yields a direct solution for F_{BC} .

$\circlearrowleft + \sum M_G = 0; \qquad -300\text{ N}(4\text{ m}) - 400\text{ N}(3\text{ m}) + F_{BC}(3\text{ m}) = 0$

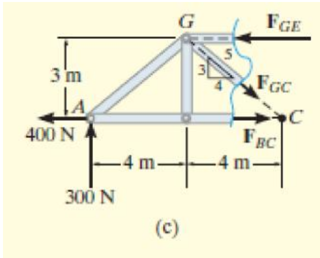


Fig. 6–16

F_{BC} = 800 N (T) *Ans.*

In the same manner, by summing moments about point *C* we obtain a direct solution for F_{GE}.

$\circlearrowleft + \sum M_C = 0$; $-300 \text{ N}(8 \text{ m}) + F_{GE}(3 \text{ m}) = 0$ $F_{GE} = 800$ N (C) *Ans.*

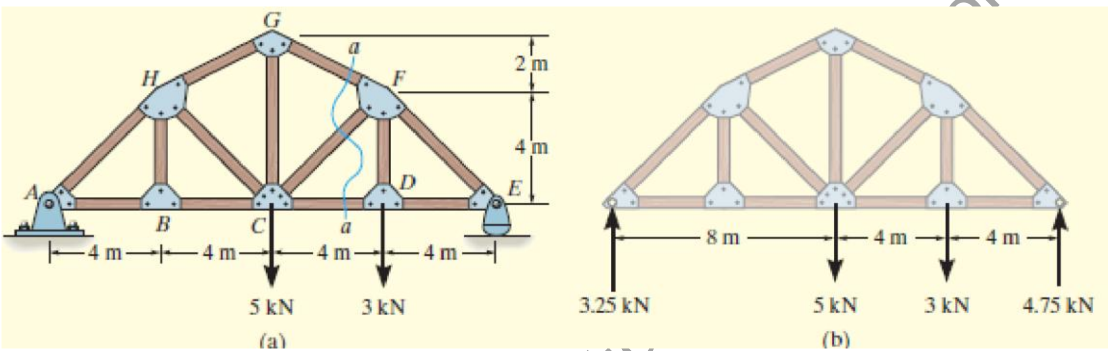
Since $\mathbf{F}_{BC}$ and $\mathbf{F}_{GE}$ have no vertical components, summing forces in the *y* direction directly yields F_{GC}, i.e.,

$+\uparrow \sum F_y = 0$; 300 N – (3/5) $F_{GC} = 0$ $F_{GC} = 500$ N (T) *Ans.*

NOTE: Here it is possible to tell, by inspection, the proper direction for each unknown member force. For example, $\sum M_C = 0$ requires $\mathbf{F}_{GE}$ to be *compressive* because it must balance the moment of the 300-N force about *C* .

EXAMPLE 6.6

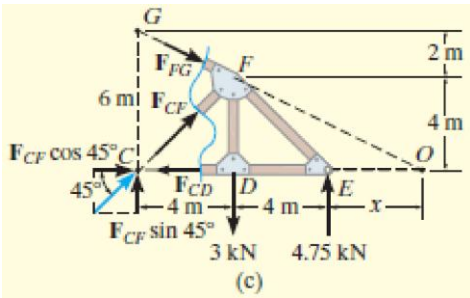
Determine the force in member *CF* of the truss shown in Fig. 6–17 *a* . Indicate whether the member is in tension or compression. Assume each member is pin connected.



SOLUTION

Free-Body Diagram. Section *aa* in Fig. 6–17 *a* will be used since this section will “expose” the internal force in member *CF* as “external” on the free-body diagram of either the right or left portion of the truss. It is first necessary, however, to determine the support reactions on either the left or right side. Verify the results shown on the free-body diagram in Fig. 6–17 *b* .

The free-body diagram of the right portion of the truss, which is the easiest to analyze, is shown in Fig. 6–17 *c* . There are three unknowns, F_{FG}, F_{CF}, and F_{CD}.



Equations of Equilibrium. We will apply the moment equation about point *O* in order to eliminate the two unknowns F_{FG} and F_{CD} .

The location of point *O* measured from *E* can be determined from proportional triangles, i.e., $4/(4 + x) = 6/(8 + x)$, $x = 4$ m. Or, stated in another manner, the slope of member *GF* has a drop of 2 m to a horizontal distance of 4 m. Since *FD* is 4 m, Fig. 6–17 *c* , then from *D* to *O* the distance must be 8 m.

An easy way to determine the moment of $\mathbf{F}_{CF}$ about point *O* is to use the principle of transmissibility and slide $\mathbf{F}_{CF}$ to point *C* , and then resolve $\mathbf{F}_{CF}$ into its two rectangular components. We have

$\circlearrowleft + \sum M_O = 0$; $-F_{CF}$ sin 45_(12 m) + (3 kN)(8 m) - (4.75 kN)(4 m) = 0

$F_{CF} = 0.589$ kN (C) *Ans*

EXAMPLE 6.7

Determine the force in member *EB* of the roof truss shown in Fig. 6–18 *a* . Indicate whether the member is in tension or compression.

SOLUTION

Free-Body Diagrams. By the method of sections, any imaginary section that cuts through *EB* , Fig. 6–18 *a* , will also have to cut through three other members for which the forces are unknown. For example, section *aa* cuts through *ED*, *EB*, *FB*, and *AB*. If a free-body diagram of the left side of this section is considered, Fig. 6–18 *b* , it is possible to obtain $\mathbf{F}_{ED}$ by summing moments about *B* to eliminate the other three unknowns; however, $\mathbf{F}_{EB}$ cannot be determined from the remaining two equilibrium equations. One possible way of obtaining $\mathbf{F}_{EB}$ is first to determine $\mathbf{F}_{ED}$ from section *aa*, then use this result on section *bb*, Fig. 6–18*a*, which is shown in Fig. 6–18*c*. Here the force system is concurrent and our sectioned free-body diagram is the same as the free-body diagram for the joint at *E*.

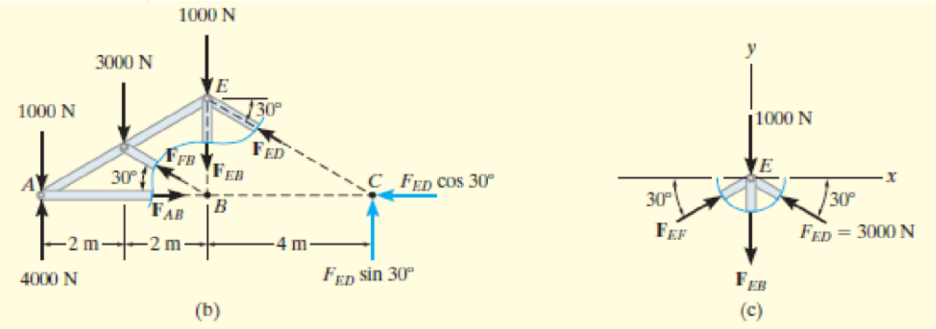


Fig. 6–18

Equations of Equilibrium. In order to determine the moment of $\mathbf{F}_{ED}$ about point *B* , Fig. 6–18 *b* , we will use the principle of transmissibility and slide the force to point *C* and then resolve it into its rectangular components as shown. Therefore,

$\curvearrowleft + \quad M_B = 0;$

$1000\text{ N}(4\text{ m}) + 3000\text{ N}(2\text{ m}) - 4000\text{ N}(4\text{ m}) + F_{ED}\sin 30^{o}(4\text{ m}) = 0$

$F_{ED} = 3000\text{ N (C)}$

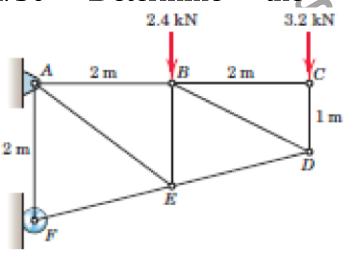
Considering now the free-body diagram of section *bb* , Fig. 6–18 *c* , we have

$+\rightarrow\sum F_x = 0;\qquad F_{EF}\cos 30^{o} - 3000\cos 30^{o}\text{ N} = 0 \qquad F_{EF} = 3000\text{ N (C)}$

$+\uparrow\sum F_y = 0;\qquad 2(3000\sin 30\_\text{ N}) - 1000\text{ N} - F_{EB} = 0 \qquad F_{EB} = 2000\text{ N (T)}$ *Ans.*

Problems (H.W.)

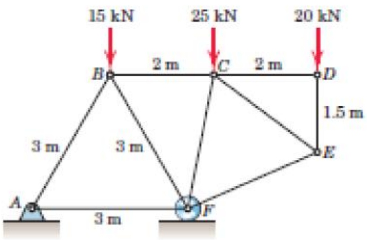
4/30 Determine the force in member AE of the loaded truss.



Problem 4/30

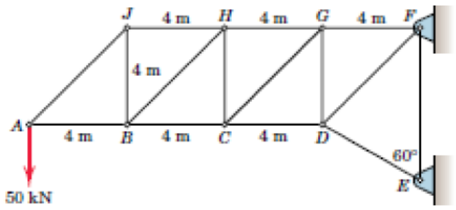
4/31 Determine the force in member BC of the loaded truss.

Ans. BC = 24.1 kN *T*



Problem 4/31

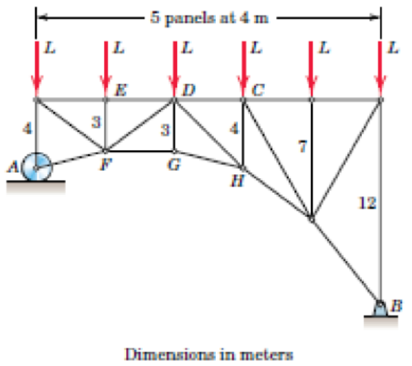
4/32 Determine the forces in members GH and CG for the truss loaded and supported as shown. Does the statical indeterminacy of the supports affect your calculation?



Problem 4/32

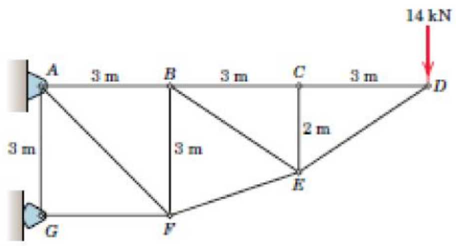
4/33 Determine the force in member DG of the loaded truss.

Ans. DG = L T



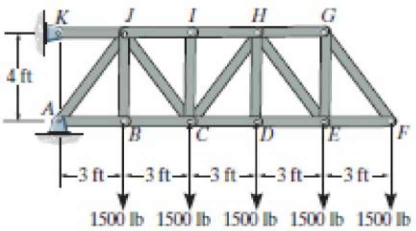
Problem 4/33

4/36 Calculate the forces in members BC, BE, and EF. Solve for each force from an equilibrium equation which contains that force as the only unknown.



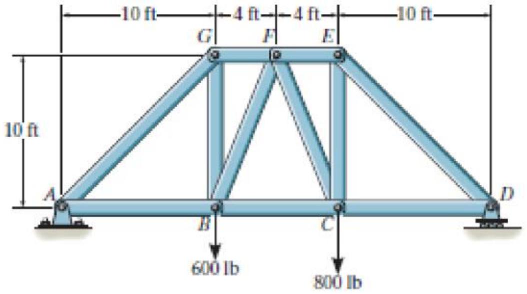
Problem 4/36

6–27. Determine the force in members *HG* , *HE* , and *DE* of the truss, and state if the members are in tension or compression.



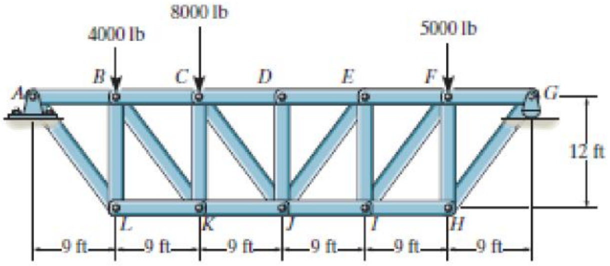
Probs. 6–27/28

6–29. Determine the force developed in members *GB* and *GF* of the bridge truss and state if these members are in tension or compression.



Probs. 6–29/30

6–31. Determine the force in members *CD* , *CJ* , *KJ* , and*DJ* of the truss which serves to support the deck of a bridge. State if these members are in tension or compression.



Probs. 6–31/32