GLOBAL EDITION

Statics and Mechanics of Materials

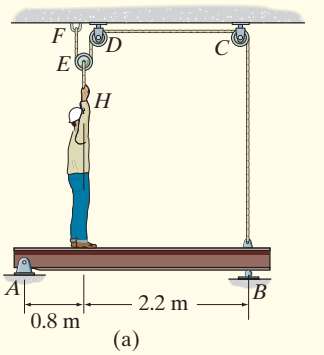
SIXTH EDITION IN SI UNITS

R. C. Hibbeler

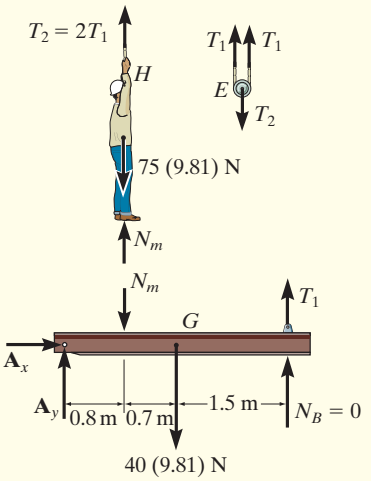
STATICS AND MECHANICS OF MATERIALS

SIXTH EDITION IN SI UNITS

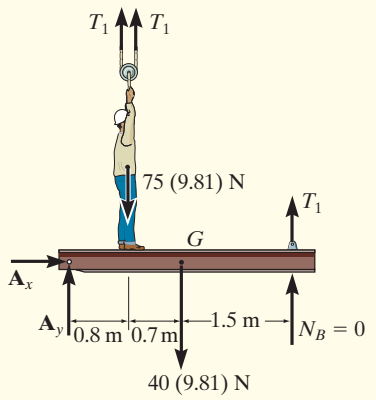
EXAMPLE 5.13



(a)



(b)



(c)

Fig. 5–24

The 75-kg man in Fig. 5–24*a* attempts to lift the 40-kg uniform beam off the roller support at B. Determine the tension developed in the cable attached to B and the normal reaction of the man on the beam when this is about to occur.

SOLUTION

Free-Body Diagrams. The tensile force in the cable will be denoted as T_1. The free-body diagrams of the pulley E, the man, and the beam are shown in Fig. 5–24*b*. Since the man must lift the beam off the roller B then $N_B = 0$. When drawing each of these diagrams, it is very important to apply Newton's third law.

Equations of Equilibrium. Using the free-body diagram of pulley E,

$$+\uparrow \Sigma F_y = 0; \qquad 2T_1 - T_2 = 0 \quad \text{or} \quad T_2 = 2T_1 \tag{1}$$

Referring to the free-body diagram of the man using this result,

$$+\uparrow \Sigma F_y = 0; \qquad N_m + 2T_1 - 75(9.81)\ \text{N} = 0 \tag{2}$$

Summing moments about point A on the beam,

$$\circlearrowleft + \Sigma M_A = 0;\ T_1(3\ \text{m}) - N_m(0.8\ \text{m}) - [40(9.81)\ \text{N}](1.5\ \text{m}) = 0 \tag{3}$$

Solving Eqs. 2 and 3 simultaneously for T_1 and N_m, then using Eq. (1) for T_2, we obtain

$$T_1 = 256\ \text{N} \quad N_m = 224\ \text{N} \quad T_2 = 512\ \text{N} \qquad \textit{Ans.}$$

SOLUTION II

A direct solution for T_1 can be obtained by considering the beam, the man, and pulley E as a *single system*. The free-body diagram is shown in Fig. 5–24*c*. Thus,

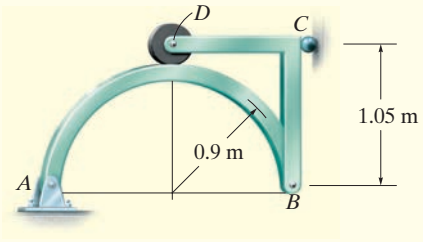
$$\circlearrowleft + \Sigma M_A = 0; \qquad 2T_1(0.8\ \text{m}) - [75(9.81)\ \text{N}](0.8\ \text{m}) - [40(9.81)\ \text{N}](1.5\ \text{m}) + T_1(3\ \text{m}) = 0$$

$$T_1 = 256\ \text{N} \qquad \textit{Ans.}$$

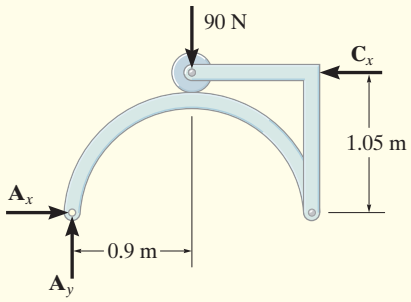
With this result Eqs. 1 and 2 can then be used to find N_m and T_2.

EXAMPLE 5.14

The smooth disk shown in Fig. 5–25*a* is pinned at *D* and has a weight of 90 N. Neglecting the weights of the other members, determine the horizontal and vertical components of reaction at pins *B* and *D*.



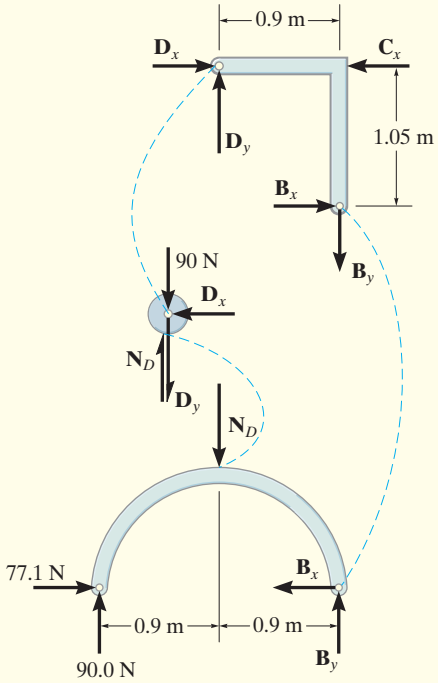
(a)



SOLUTION

Free-Body Diagrams. The free-body diagrams of the entire frame and each of its members are shown in Fig. 5–25*b*.

Equations of Equilibrium. The eight unknowns can of course be obtained by applying the eight equilibrium equations to each member—three to member *AB*, three to member *BCD*, and two to the disk. (Moment equilibrium is automatically satisfied for the disk.) If this is done, however, all the results can be obtained only from a simultaneous solution of some of the equations. (Try it and find out.) To avoid this situation, it is best first to determine the three support reactions on the *entire* frame; then, using these results, the remaining five equilibrium equations can be applied to two other parts in order to solve successively for the other unknowns.



(b)

Fig. 5–25

Entire Frame

$$\circlearrowleft +\Sigma M_A = 0;\ -(90\text{ N})(0.9\text{ m}) + C_x(1.05\text{ m}) = 0 \qquad C_x = 77.1\text{ N}$$

$$\overset{+}{\rightarrow}\Sigma F_x = 0;\qquad A_x - 77.1\text{ N} = 0 \qquad A_x = 77.1\text{ N}$$

$$+\uparrow \Sigma F_y = 0;\qquad A_y - 90\text{ N} = 0 \qquad A_y = 90.0\text{ N}$$

Member *AB*

$$\overset{+}{\rightarrow}\Sigma F_x = 0;\qquad 77.1\text{ N} - B_x = 0 \qquad B_x = 77.1\text{ N}\ \textit{Ans.}$$

$$\circlearrowleft +\Sigma M_B = 0;\ -(90.0\text{ N})(1.8\text{ m}) + N_D(0.9\text{ m}) = 0 \qquad N_D = 180.0\text{ N}$$

$$+\uparrow \Sigma F_y = 0;\quad 90.0\text{ N} - 180.0\text{ N} + B_y = 0 \qquad B_y = 90.0\text{ N}\ \textit{Ans.}$$

Disk

$$\overset{+}{\rightarrow}\Sigma F_x = 0;\qquad D_x = 0 \qquad \textit{Ans.}$$

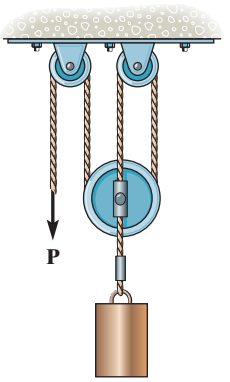
$$+\uparrow \Sigma F_y = 0;\quad 180.0\text{ N} - 90.0\text{ N} - D_y = 0 \qquad D_y = 90.0\text{ N}\ \textit{Ans.}$$

Refer to the companion website for a self quiz of these Example problems.

FUNDAMENTAL PROBLEMS

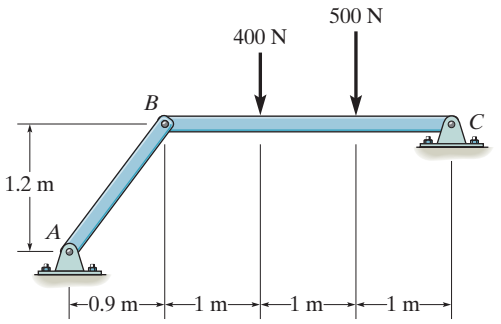
All solutions must include a free-body diagram.

F5–13. Determine the force P needed to hold the 300-N weight in equilibrium.



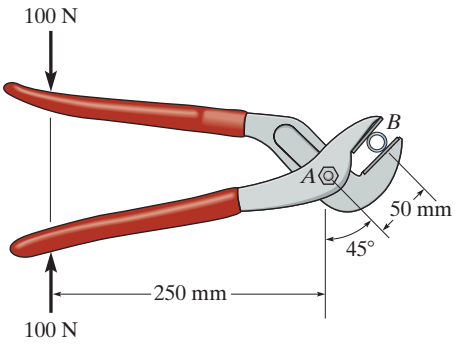
Prob. F5–13

F5–14. Determine the horizontal and vertical components of reaction at pin C.



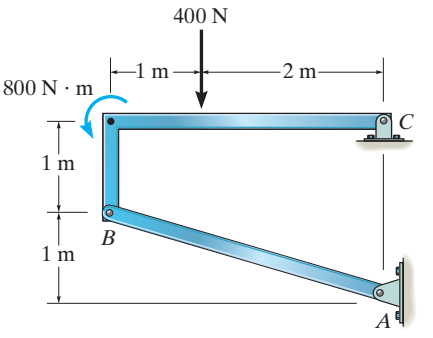
Prob. F5–14

F5–15. If a 100-N force is applied to the handles of the pliers, determine the clamping force exerted on the smooth pipe B and the magnitude of the resultant force that one of the members exerts on pin A.



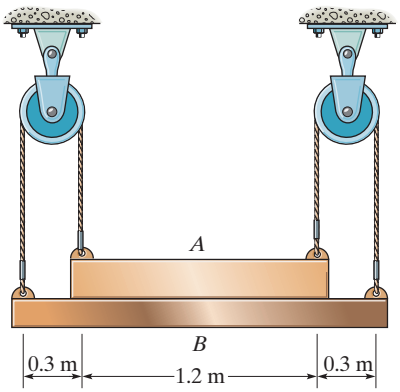
Prob. F5–15

F5–16. Determine the horizontal and vertical components of reaction at pin C.



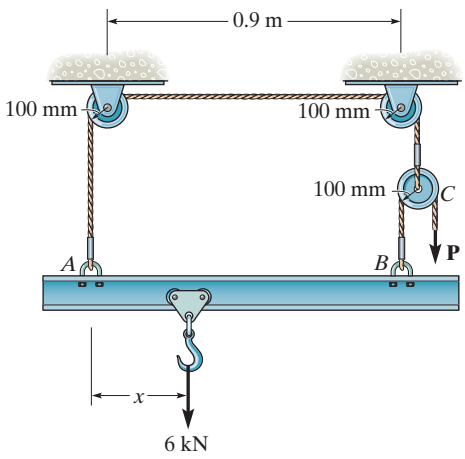
Prob. F5–16

F5–17. Determine the normal force that the 500-N plate A exerts on the 150-N plate B.



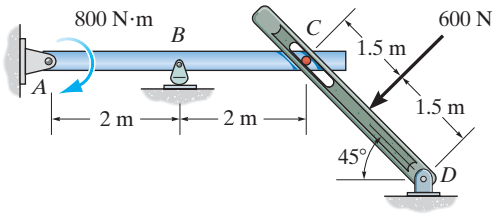
Prob. F5–17

F5–18. Determine the force P needed to lift the load. Also, determine the proper placement x of the hook for equilibrium. Neglect the weight of the beam.



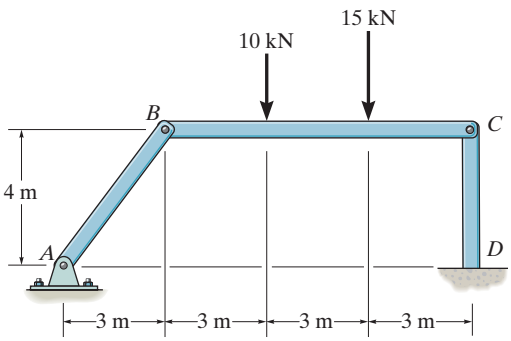
Prob. F5–18

F5–19. Determine the components of reaction at A and B.



Prob. F5–19

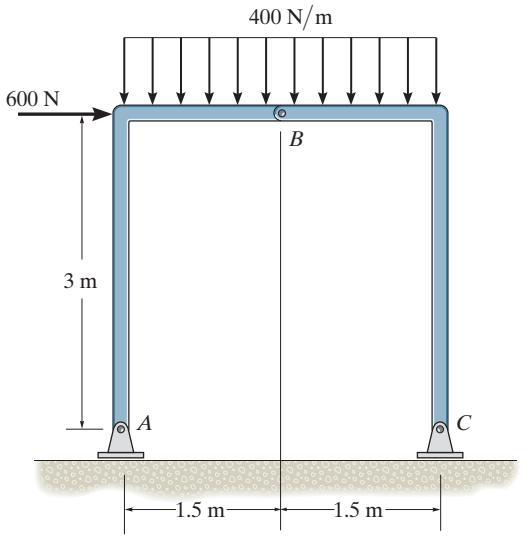
F5–20. Determine the reactions at D.



Prob. F5–20

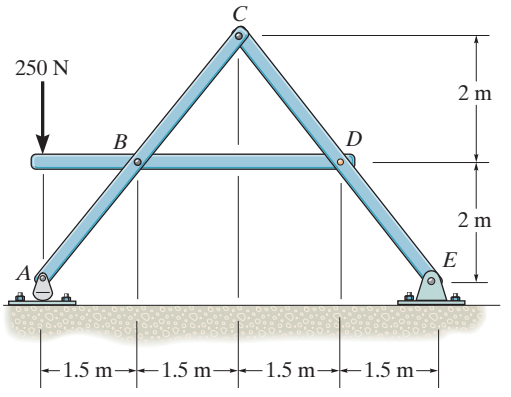
5

F5–21. Determine the components of reaction at A and C.



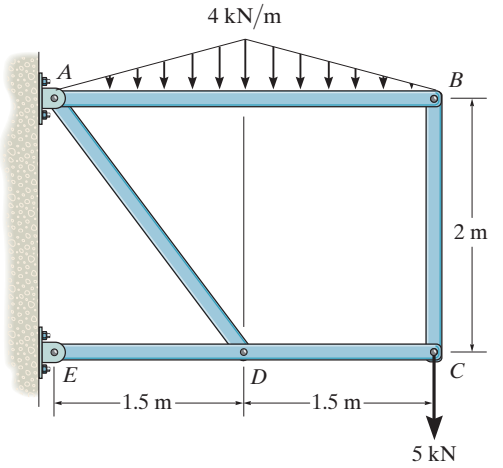
Prob. F5–21

F5–22. Determine the components of reaction at C.



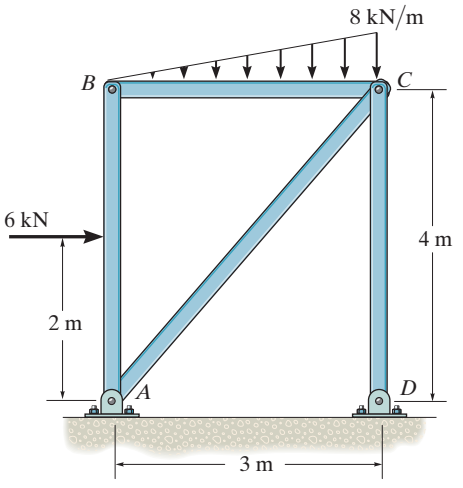
Prob. F5–22

F5–23. Determine the components of reaction at E.



Prob. F5–23

F5–24. Determine the components of reaction at D and the components of reaction the pin at A exerts on member BA.

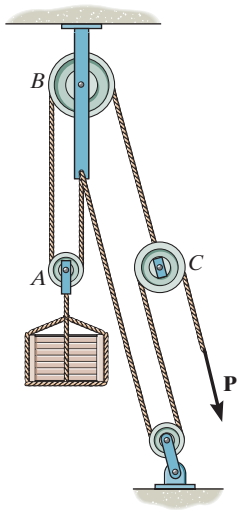


Prob. F5–24

PROBLEMS

All solutions must include a free-body diagram.

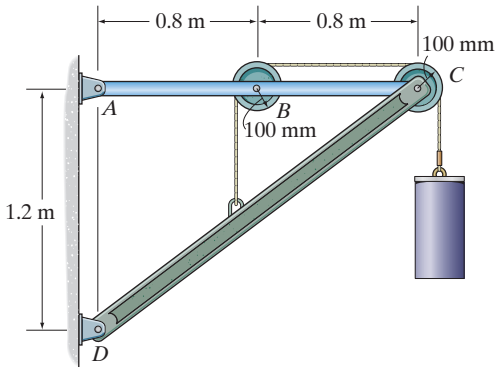
***5–28.** Determine the force **P** required to hold the 150-kg crate in equilibrium.



Prob. 5–28

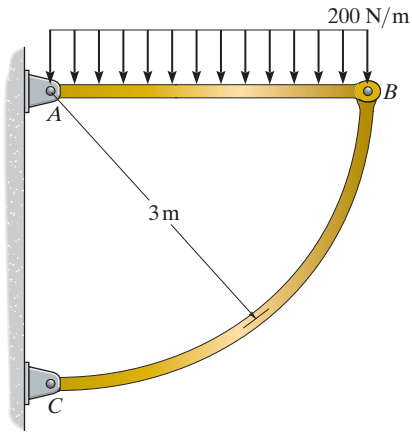
5–29. The frame is used to support the 50-kg cylinder. Determine the horizontal and vertical components of reaction at *A* and *D*.

5–30. The frame is used to support the 50-kg cylinder. Determine the force of the pin at *C* on member *ABC* and on member *CD*.



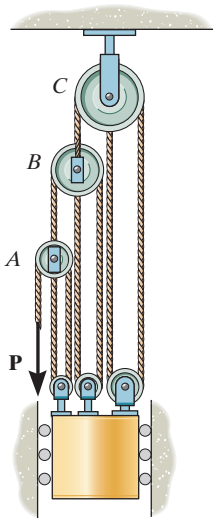
Probs. 5–29/30

5–31. Determine the horizontal and vertical components of force at pins *A* and *C* of the two-member frame.



Prob. 5–31

***5–32.** Determine the force **P** required to hold the 50-kg mass in equilibrium.



Prob. 5–32