Problems

4.96 Gears A and B are attached to a shaft supported by bearings at C and D. The diameters of gears A and B are 150 mm and 75 mm, respectively, and the tangential and radial forces acting on the gears are as shown. Knowing that the system rotates at a constant rate, determine the reactions at C and D. Assume that the bearing at C does not exert any axial force, and neglect the weights of the gears and the shaft.
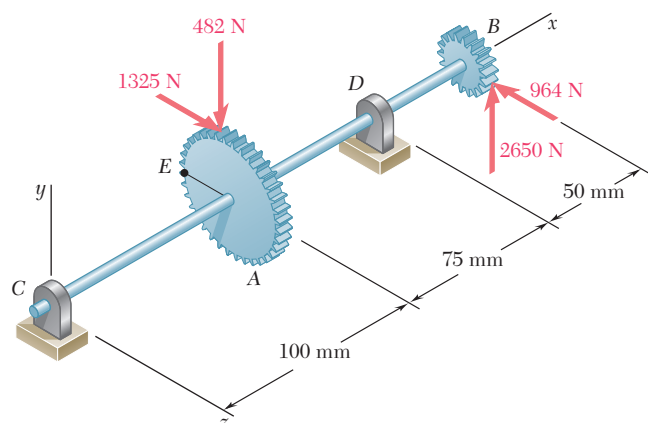

Fig. P4.96 and P4.97

4.97 Solve Prob. 4.96 assuming that for gear A the tangential and radial forces are acting at E, so that $\mathbf{F}_A = (1325 \text{ N})\mathbf{j} + (482 \text{ N})\mathbf{k}$.

4.98 Two transmission belts pass over sheaves welded to an axle supported by bearings at B and D. The sheave at A has a radius of 50 mm, and the sheave at C has a radius of 40 mm. Knowing that the system rotates with a constant rate, determine (a) the tension T, (b) the reactions at B and D. Assume that the bearing at D does not exert any axial thrust and neglect the weights of the sheaves and the axle.
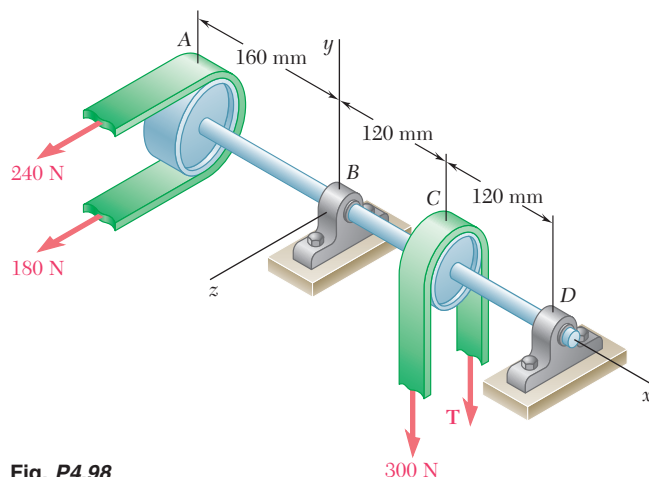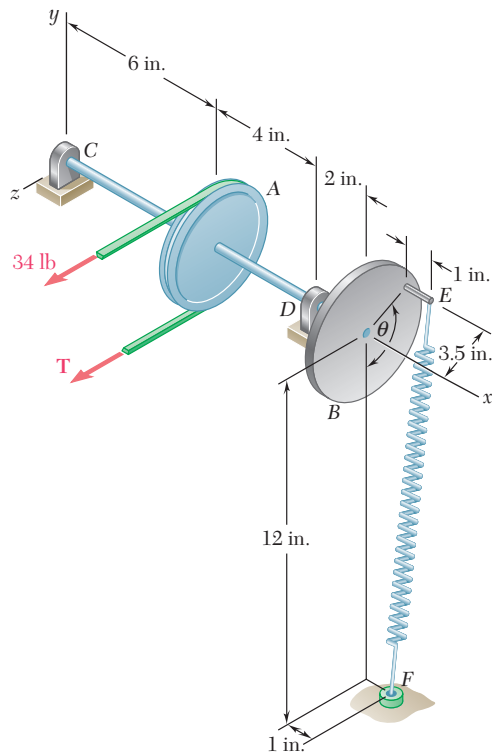

Fig. P4.98

4-41

Fig. P4.99

Fig. P4.101

4.99 For the portion of a machine shown, the 4-in.-diameter pulley A and wheel B are fixed to a shaft supported by bearings at C and D. The spring of constant 2 lb/in. is unstretched when $\theta = 0$, and the bearing at C does not exert any axial force. Knowing that $\theta = 180°$ and that the machine is at rest and in equilibrium, determine (*a*) the tension T, (*b*) the reactions at C and D. Neglect the weights of the shaft, pulley, and wheel.

4.100 Solve Prob. 4.99 for $\theta = 90°$.

4.101 A 1.2 × 2.4-m sheet of plywood having a mass of 17 kg has been temporarily placed among three pipe supports. The lower edge of the sheet rests on small collars A and B and its upper edge leans against pipe C. Neglecting friction at all surfaces, determine the reactions at A, B, and C.

4.102 The 200 × 200-mm square plate shown has a mass of 25 kg and is supported by three vertical wires. Determine the tension in each wire.

4.103 The 200 × 200-mm square plate shown has a mass of 25 kg and is supported by three vertical wires. Determine the mass and location of the lightest block which should be placed on the plate if the tensions in the three cables are to be equal.
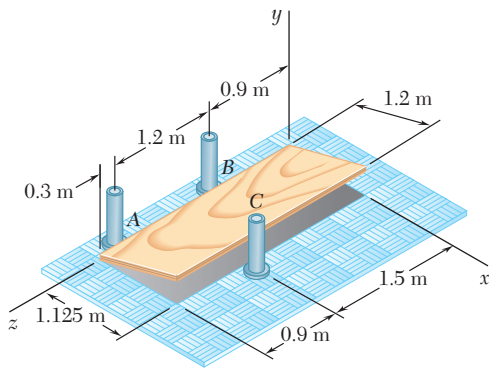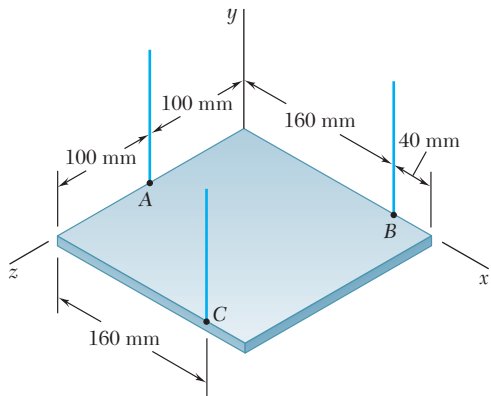

Fig. P4.102 and P4.103

4.104 A camera of mass 240 g is mounted on a small tripod of mass 200 g. Assuming that the mass of the camera is uniformly distributed and that the line of action of the weight of the tripod passes through D, determine (a) the vertical components of the reactions at A, B, and C when $\theta = 0$, (b) the maximum value of θ if the tripod is not to tip over.
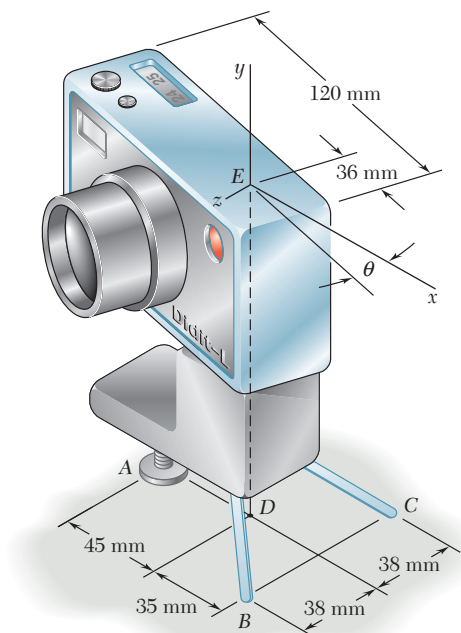

Fig. P4.104

4.105 Two steel pipes AB and BC, each having a weight per unit length of 5 lb/ft, are welded together at B and are supported by three wires. Knowing that $a = 1.25$ ft, determine the tension in each wire.
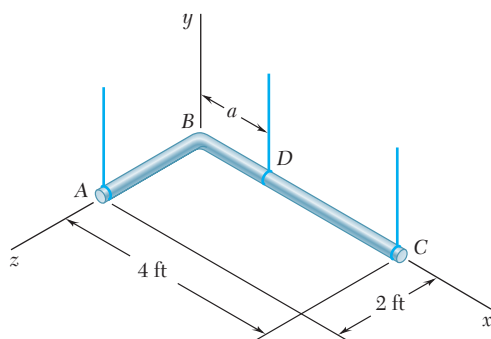

Fig. P4.105

4.106 For the pile assembly of Prob. 4.105, determine (a) the largest permissible value of a if the assembly is not to tip, (b) the corresponding tension in each wire.

4.107 A uniform aluminum rod of weight W is bent into a circular ring of radius R and is supported by three wires as shown. Determine the tension in each wire.
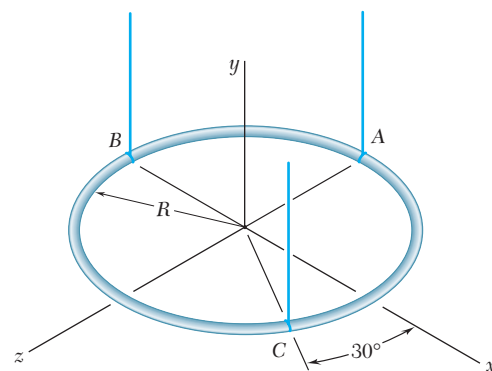

Fig. P4.107 and P4.108

4.108 A uniform aluminum rod of weight W is bent into a circular ring of radius R and is supported by three wires as shown. A small collar of weight W' is then placed on the ring and positioned so that the tensions in the three wires are equal. Determine (a) the position of the collar, (b) the value of W', (c) the tension in the wires.

4.109 An opening in a floor is covered by a 3 × 4-ft sheet of plywood weighing 12 lb. The sheet is hinged at A and B and is maintained in a position slightly above the floor by a small block C. Determine the vertical component of the reaction (a) at A, (b) at B, (c) at C.
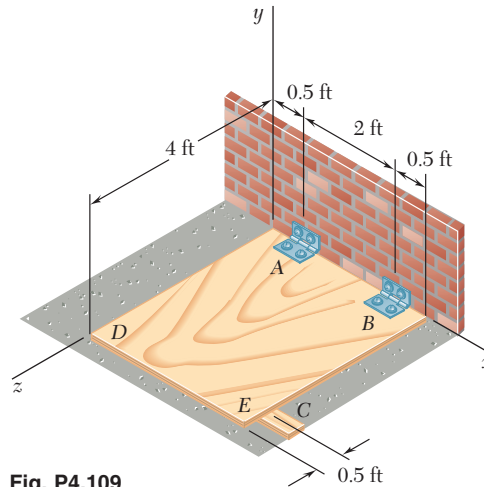

Fig. P4.109

4.110 Solve Prob. 4.109 assuming that the small block C is moved and placed under edge DE at a point 0.5 ft from corner E.

4.111 The 10-kg square plate shown is supported by three vertical wires. Determine (a) the tension in each wire when $a = 100$ mm, (b) the value of a for which tensions in the three wires are equal.

Fig. P4.111

4.112 The 3-m flagpole AC forms an angle of 30° with the z axis. It is held by a ball-and-socket joint at C and by two thin braces BD and BE. Knowing that the distance BC is 0.9 m, determine the tension in each brace and the reaction at C.

4.113 A 3-m boom is acted upon by the 4-kN force shown. Determine the tension in each cable and the reaction at the ball-and-socket joint at A.
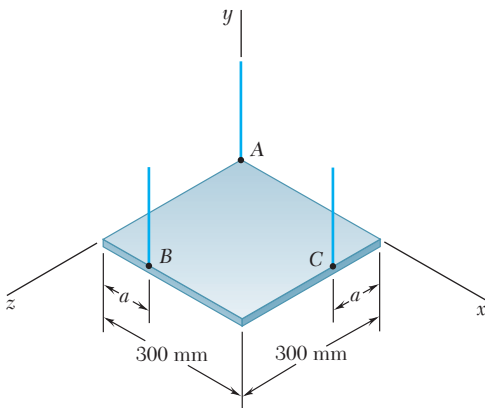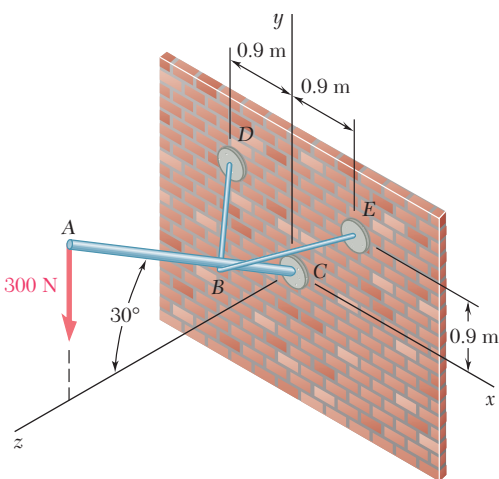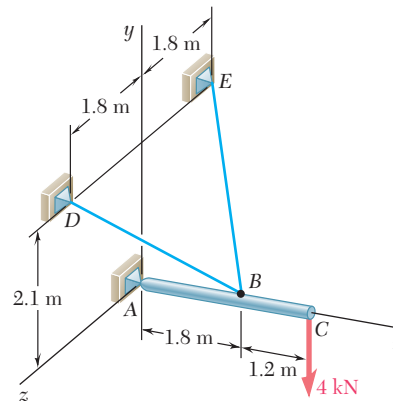

Fig. P4.112

Fig. P4.113

4.114 An 8-ft-long boom is held by a ball-and-socket joint at C and by two cables AD and BE. Determine the tension in each cable and the reaction at C.

4.115 Solve Prob. 4.114 assuming that the given 198-lb load is replaced with two 99-lb loads applied at A and B.

4.116 The 18-ft pole ABC is acted upon by a 210-lb force as shown. The pole is held by a ball-and-socket joint at A and by two cables BD and BE. For $a = 9$ ft, determine the tension in each cable and the reaction at A.

4.117 Solve Prob. 4.116 for $a = 4.5$ ft.

4.118 Two steel pipes $ABCD$ and EBF are welded together at B to form the boom shown. The boom is held by a ball-and-socket joint at D and by two cables EG and $ICFH$; cable $ICFH$ passes around frictionless pulleys at C and F. For the loading shown, determine the tension in each cable and the reaction at D.
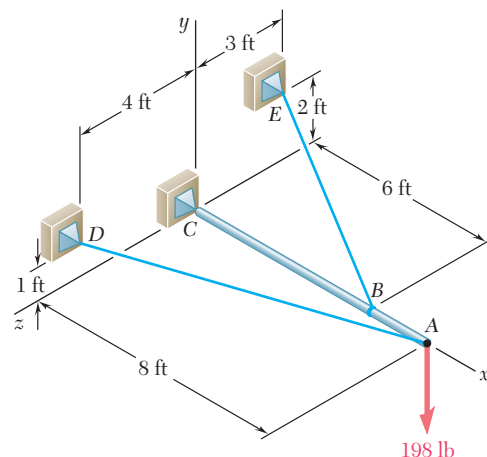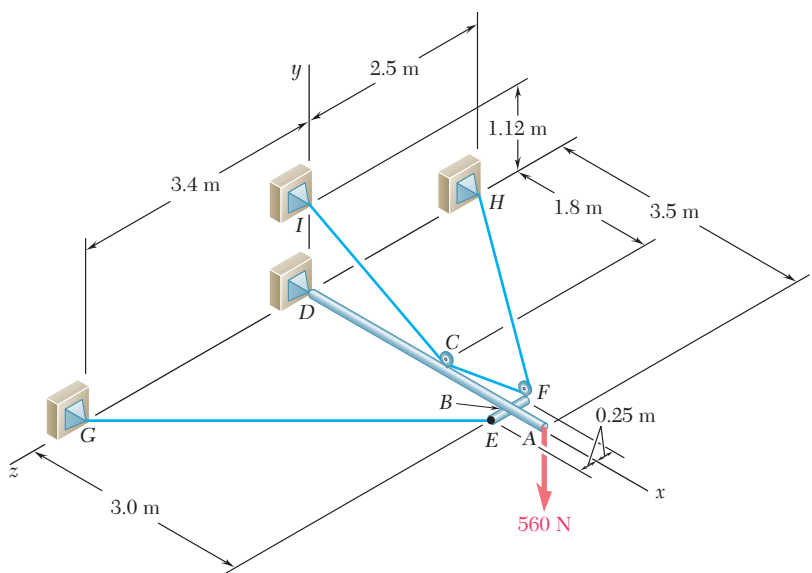

Fig. P4.114

Fig. P4.118

Fig. P4.116

4.119 Solve Prob. 4.118 assuming that the 560-N load is applied at B.

4.120 The lever AB is welded to the bent rod BCD which is supported by bearings at E and F and by cable DG. Knowing that the bearing at E does not exert any axial thrust, determine (a) the tension in cable DG, (b) the reactions at E and F.
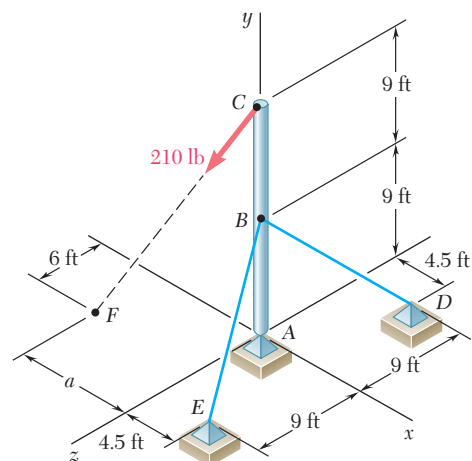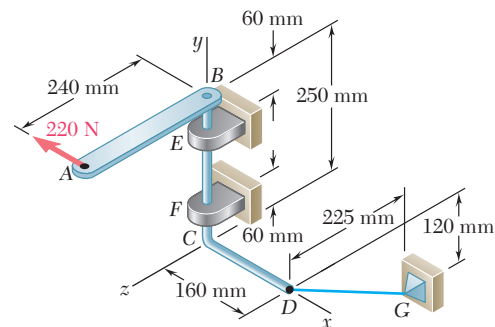

Fig. P4.120

4.121 A 30-kg cover for a roof opening is hinged at corners A and B. The roof forms an angle of 30° with the horizontal, and the cover is maintained in a horizontal position by the brace CE. Determine (a) the magnitude of the force exerted by the brace, (b) the reactions at the hinges. Assume that the hinge A does not exert any axial thrust.
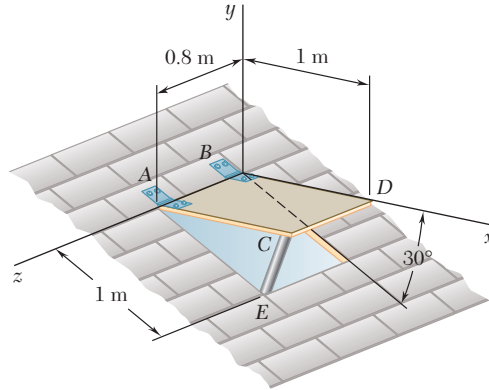
Fig. P4.121

4.122 The rectangular plate shown has a mass of 15 kg and is held in the position shown by hinges A and B and cable EF. Assuming that the hinge at B does not exert any axial thrust, determine (a) the tension in the cable, (b) the reactions at A and B.
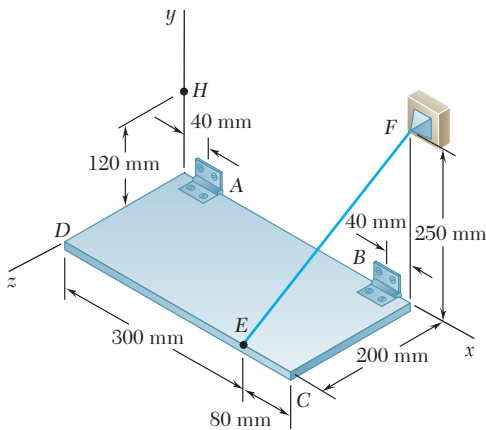
4.123 Solve Prob. 4.122 assuming that cable EF is replaced by a cable attached at points E and H.

4.124 A small door weighing 16 lb is attached by hinges A and B to a wall and is held in the horizontal position shown by rope EFH. The rope passes around a small, frictionless pulley at F and is tied to a fixed cleat at H. Assuming that the hinge at A does not exert any axial thrust, determine (a) the tension in the rope, (b) the reactions at A and B.
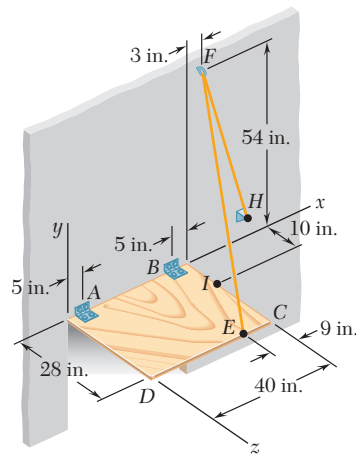
Fig. P4.122

Fig. P4.124

4.125 Solve Prob. 4.124 assuming that the rope is attached to the door at I.

4.126 A 285-lb uniform rectangular plate is supported in the position shown by hinges A and B and by cable DCE, which passes over a frictionless hook at C. Assuming that the tension is the same in both parts of the cable, determine (a) the tension in the cable, (b) the reactions at A and B. Assume that the hinge at B does not exert any axial thrust.
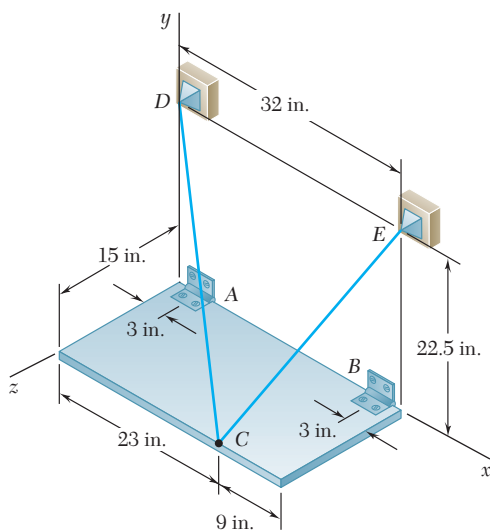

Fig. P4.126

4.127 Solve Prob. 4.126 assuming that cable DCE is replaced by a cable attached to point E and hook C.

4.128 The tensioning mechanism of a belt drive consists of frictionless pulley A, mounting plate B, and spring C. Attached below the mounting plate is slider block D which is free to move in the frictionless slot of bracket E. Knowing that the pulley and the belt lie in a horizontal plane, with portion F of the belt parallel to the x axis and portion G forming an angle of $30°$ with the x axis, determine (a) the force in the spring, (b) the reaction at D.
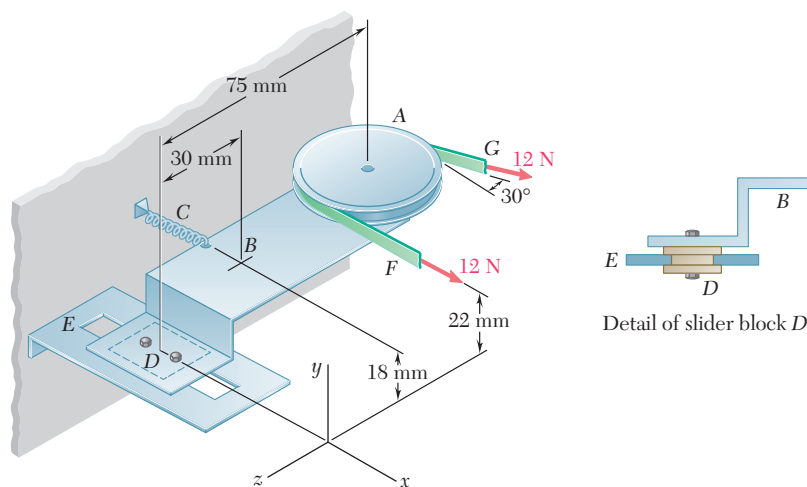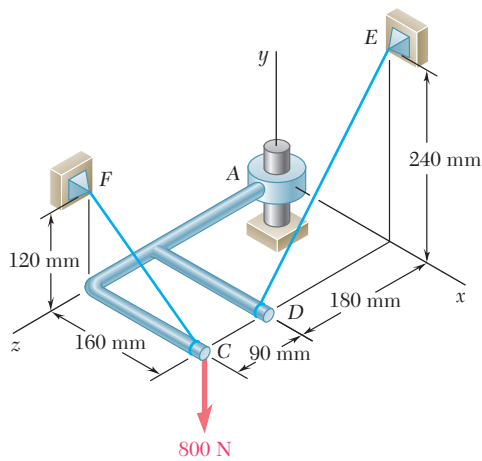

Fig. P4.128

Fig. P4.129

4.129 The assembly shown is welded to collar A which fits on the vertical pin shown. The pin can exert couples about the x and z axes but does not prevent motion about or along the y axis. For the loading shown, determine the tension in each cable and the reaction at A.

4.130 The lever AB is welded to the bent rod BCD which is supported by bearing E and by cable DG. Assuming that the bearing can exert an axial thrust and couples about axes parallel to the x and z axes, determine (a) the tension in cable DG, (b) the reaction at E.
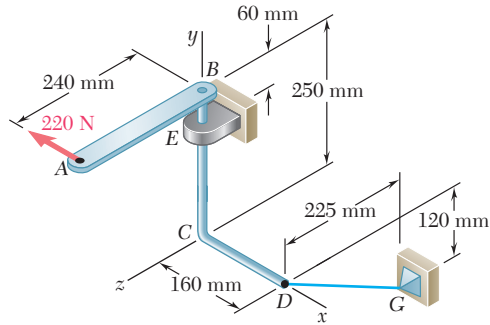

Fig. P4.130

4.131 Solve Prob. 4.124 assuming that the hinge at A is removed and that the hinge at B can exert couples about the y and z axes.

4.132 The frame shown is supported by three cables and a ball-and-socket joint at A. For **P** = 0, determine the tension in each cable and the reaction at A.

Fig. P4.132 and P4.133

4.133 The frame shown is supported by three cables and a ball-and-socket joint at A. For P = 50 N, determine the tension in each cable and the reaction at A.
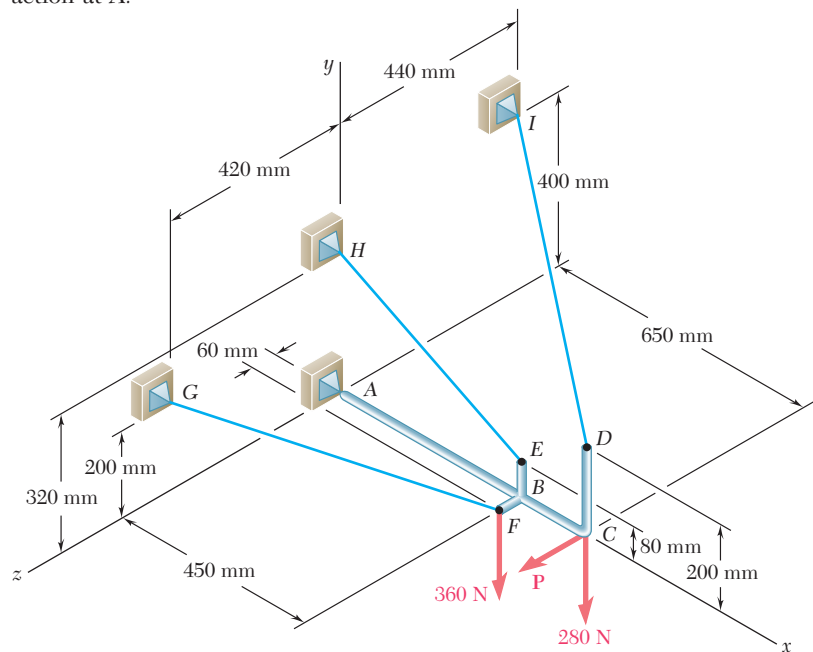
4.134 The rigid L-shaped member *ABF* is supported by a ball-and-socket joint at *A* and by three cables. For the loading shown, determine the tension in each cable and the reaction at *A*.
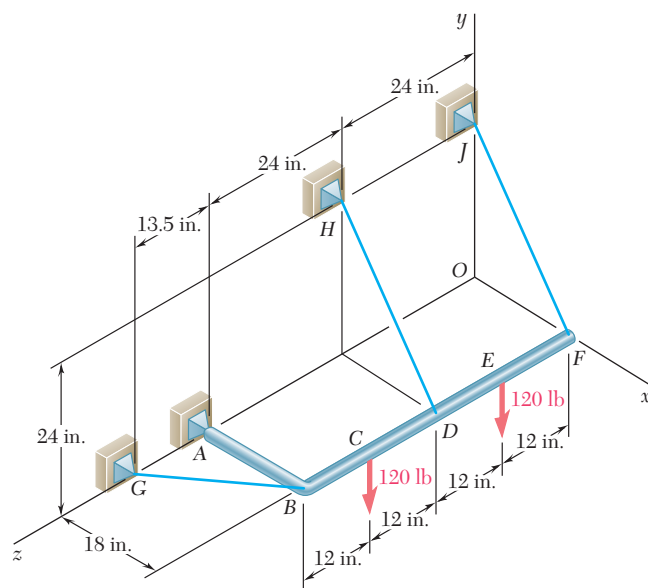

Fig. *P4.134*

4.135 Solve Prob. 4.134 assuming that the load at *C* has been removed.

4.136 In order to clean the clogged drainpipe *AE*, a plumber has disconnected both ends of the pipe and inserted a power snake through the opening at *A*. The cutting head of the snake is connected by a heavy cable to an electric motor which rotates at a constant speed as the plumber forces the cable into the pipe. The forces exerted by the plumber and the motor on the end of the cable can be represented by the wrench $\mathbf{F} = -(60 \text{ N})\mathbf{k}$, $\mathbf{M} = -(108 \text{ N} \cdot \text{m})\mathbf{k}$. Determine the additional reactions at *B*, *C*, and *D* caused by the cleaning operation. Assume that the reaction at each support consists of two force components perpendicular to the pipe.
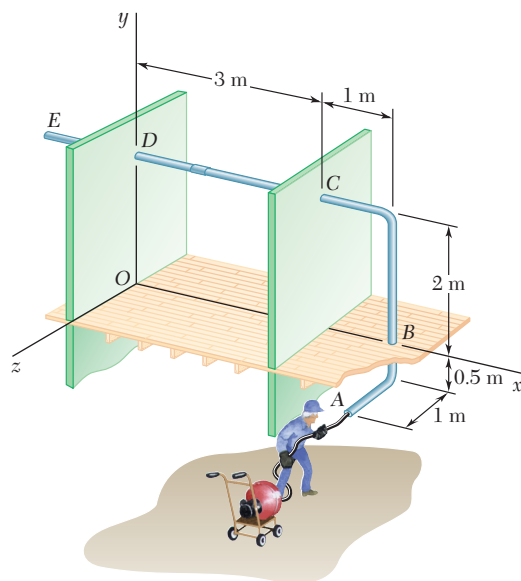

Fig. P4.136

4.137 Solve Prob. 4.136 assuming that the plumber exerts a force $\mathbf{F} = -(60 \text{ N})\mathbf{k}$ and that the motor is turned off ($\mathbf{M} = 0$).

4.138 Three rods are welded together to form a "corner" which is supported by three eyebolts. Neglecting friction, determine the reactions at A, B, and C when $P = 240$ N, $a = 120$ mm, $b = 80$ mm, and $c = 100$ mm.
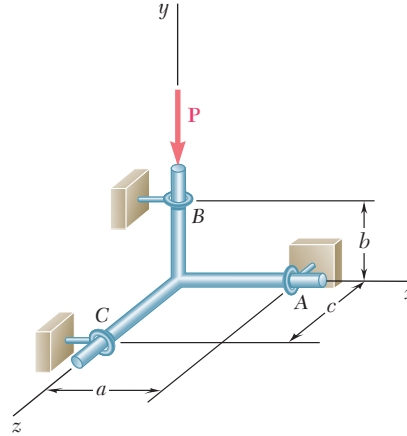

Fig. P4.138

4.139 Solve Prob. 4.138 assuming that the force $\mathbf{P}$ is removed and is replaced by a couple $\mathbf{M} = +(6 \text{ N} \cdot \text{m})\mathbf{j}$ acting at B.

4.140 The uniform 10-lb rod AB is supported by a ball-and-socket joint at A and leans against both the rod CD and the vertical wall. Neglecting the effects of friction, determine (a) the force which rod CD exerts on AB, (b) the reactions at A and B. (*Hint:* The force exerted by CD on AB must be perpendicular to both rods).
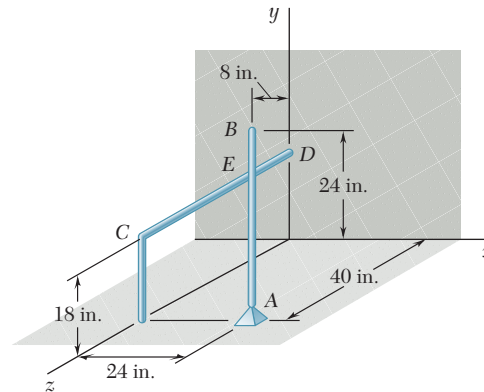

Fig. P4.140

4.141 A 21-in-long uniform rod AB weighs 6.4 lb and is attached to a ball-and-socket joint at A. The rod rests against an inclined frictionless surface and is held in the position shown by cord BC. Knowing that the cord is 21 in. long, determine (a) the tension in the cord, (b) the reactions at A and B.
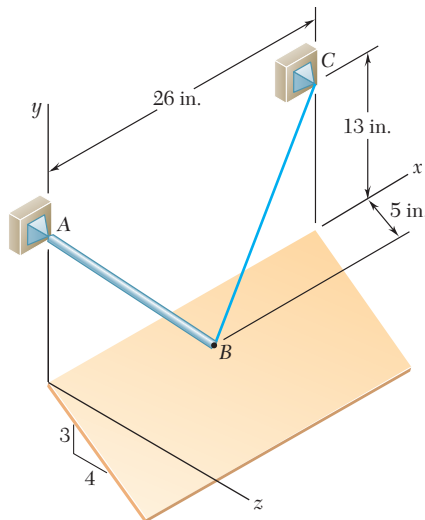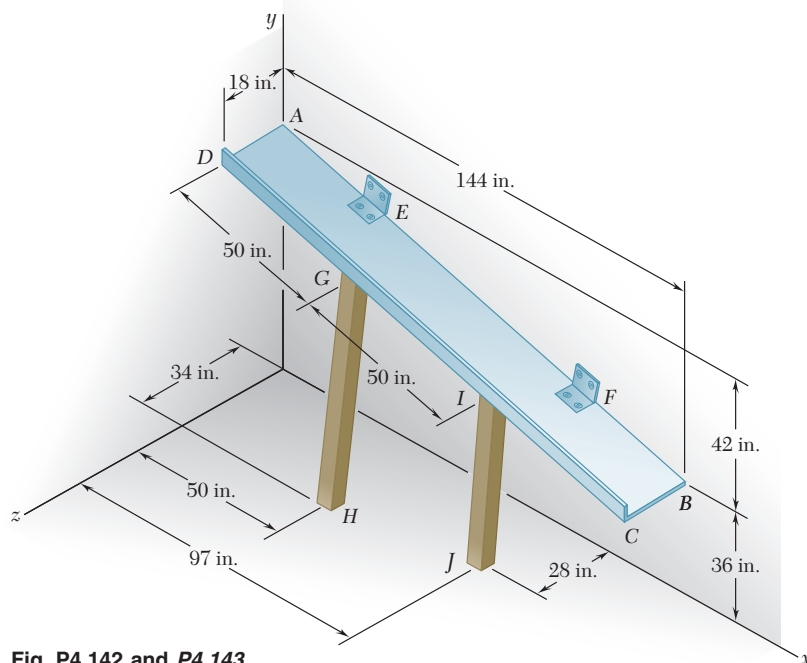
4.142 While being installed, the 56-lb chute $ABCD$ is attached to a wall with brackets E and F and is braced with props GH and IJ. Assuming that the weight of the chute is uniformly distributed, determine the magnitude of the force exerted on the chute by prop GH if prop IJ is removed.

Fig. P4.141

Fig. P4.142 and *P4.143*

4.143 While being installed, the 56-lb chute *ABCD* is attached to a wall with brackets *E* and *F* and is braced with props *GH* and *IJ*. Assuming that the weight of the chute is uniformly distributed, determine the magnitude of the force exerted on the chute by prop *IJ* if prop *GH* is removed.

4.144 The bent rod *ABDE* is supported by ball-and-socket joints at *A* and *E* and by the cable *DF.* If a 600-N load is applied at *C* as shown, determine the tension in the cable.

4.145 Solve Prob. 4.144 assuming that cable *DF* is replaced by a cable connecting *B* and *F.*

4.146 To water seedlings, a gardener joins three lengths of pipe, *AB*, *BC*, and *CD*, fitted with spray nozzles and suspends the assembly using hinged supports at *A* and *D* and cable *EF.* Knowing that the pipe weighs 0.85 lb/ft, determine the tension in the cable.
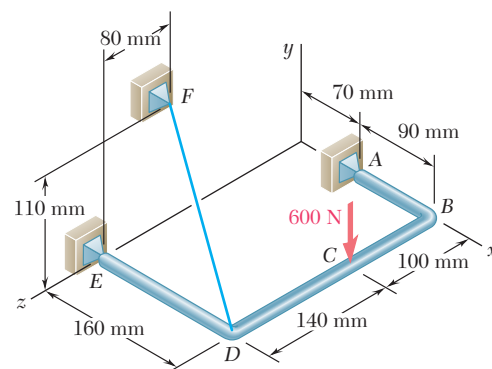
Fig. P4.144
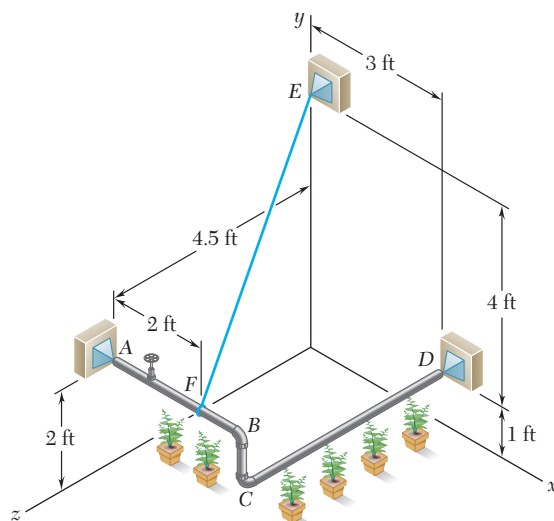
Fig. P4.146

4.147 Solve Prob. 4.146 assuming that cable *EF* is replaced by a cable connecting *E* and *C*.

4.148 Two rectangular plates are welded together to form the assembly shown. The assembly is supported by ball-and-socket joints at *B* and *D* and by a ball on a horizontal surface at *C*. For the loading shown, determine the reaction at *C*.
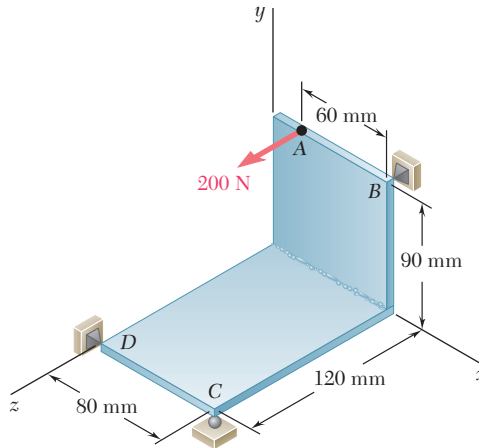

Fig. P4.148

4.149 Two 1 × 2-m plywood panels, each of mass 15 kg, are nailed together as shown. The panels are supported by ball-and-socket joints at *A* and *F* and by the wire *BH*. Determine (*a*) the location of *H* in the *xy* plane if the tension in the wire is to be minimum, (*b*) the corresponding minimum tension.

4.150 Solve Prob. 4.149, subject to the restriction that *H* must lie on the *y* axis.

4.151 A uniform 20 × 30-in. steel plate *ABCD* weighs 85 lb and is attached to ball-and-socket joints at *A* and *B*. Knowing that the plate leans against a frictionless vertical wall at *D*, determine (*a*) the location of *D*, (*b*) the reaction at *D*.
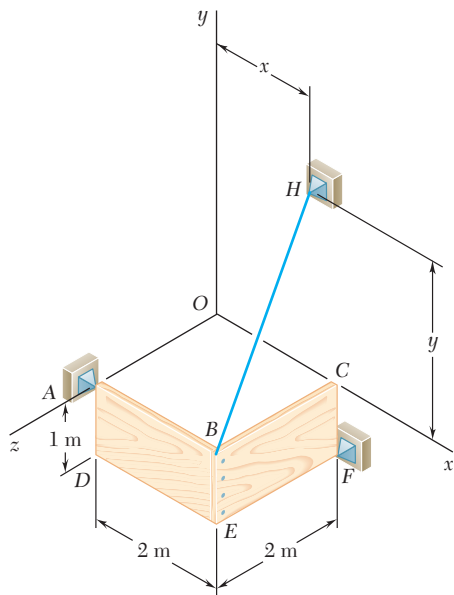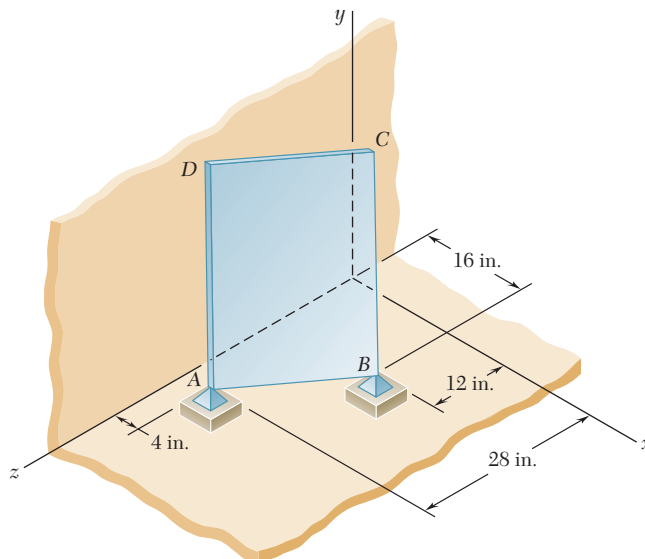

Fig. P4.149

Fig. P4.151